

**LANGUAGE AS A CONTRIBUTING FACTOR TO THE ACADEMIC
PERFORMANCE OF SOUTHERN SESOTHO PHYSICS LEARNERS**

by

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Declaration

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I, Erasmos Charamba, student number 48166413 declare that **Language as a contributing factor to the academic performance of Southern Sesotho Physics learners** is my work and all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE:

A handwritten signature in black ink, appearing to read 'Erasmos', with a horizontal line underneath.

DATE: 28th March 2017

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- Over and above I give glory and honour to the most High for He always gives me strength, pardon and wisdom (Isaiah 54: 10).

Dedication

To all 21st century Physics learners and teachers:

“If you talk to a man in a language he understands, that goes to his head. If you talk to him in his language, that goes to his heart.

Education is the most powerful weapon which you can use to change the world. It seems impossible until it's done” (Nelson Mandela).

Abstract

Language is a crucial means of gaining comprehension of Physics content as well as providing correct answers to Physics questions and explanations of Physics phenomena. Therefore language determines the academic achievement of Physics learners. Consequently, language diversity plays a pivotal role in the outcomes of education in a multicultural society such as South Africa.

The research reports on the role played by language in the academic performance of learners whose language of instruction is different from their home language. A mixed method approach was used in which the participants were assigned to either the control or experimental group. Intervention was provided to the experimental group in form of Physics lessons in the learners' home language.

The mixed method approach was used to elicit responses from a sample of 40 learners on the role of language in the learning and teaching of Physics to learners whose home language is different from the language of learning and teaching. Data was collected from 3 written tests (an English Language Proficiency test, pre- and post- tests) and interview responses. The sample comprised 24 girls and 16 boys aged between 15 and 17 years. Quantitative data was analysed using R- computing while interview responses were analysed using Gläser and Laudel's model.

A paired *t*- test revealed statistically significant difference in the academic performance of the two groups in the post- test in favour of the experimental group which had been afforded intervention. The results of this study show that translanguaging approaches, where languages of input and output are deliberately interchanged, proved to be a valuable pedagogical strategy as learners got the chance to learn in their home language leading to an improvement in their academic performance in Physics.

The findings of this research are in line with some previous research which demonstrated that the use of learners' home language is a social practice that goes beyond the four walls of the classroom. The use of pedagogies that embrace multilingualism is therefore highly recommended in 21st century Physics classes.

Key terms: Home language, language of instruction, academic language, proficiency, multilingualism, translanguaging, Physics education, academic achievement, language acquisition, monolingual, assessment, Southern Sesotho.

List of Abbreviations

ANA	Annual National Assessment
BICS	Basic Interpersonal Communicative Skills
CALP	Cognitive Academic Language Proficiency
CAPS	Curriculum Assessment and Policy Statements
DoE	Department of Education
EFAL	English as a First Additional Language
EHL	English Home Language
LiEP	Language- in- Education Policy
LMi	English Language Minority learners
LoLT	Language of Learning and Teaching
MBT	Mechanics Baseline Test

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CHAPTER 1: ORIENTATION

1.1 Introduction

Language and education are interrelated (Fortanet-Gomez, 2013) because all teaching is provided through the medium of language (Botes & Mji 2010). Language is considered both a precondition for thought (Miller, 2008) and a bearer of thought (Makalela, 2015) and therefore influences the extent to which a learner's comprehension is actualised (McNamara, 2007).

A primary challenge in the multicultural school (these are the majority in South Africa, see Torres & Zeidler, 2010) is to meet the needs of learners from linguistically diverse backgrounds who have a limited English proficiency (Makalela, 2014a). Recent studies suggest that one of the key factors associated with learners' achievement gap is home language, which is the language used at home that is different from the language of instruction (Baker, 2011; Van Laere, Aesaert and van Braak 2014). These learners (who learn in a different language to their home language) experience greater difficulty attaining the same level in Physics education than language majority learners (those who are taught in their home language), write Martin, Mullis, Foy, and Stanco (2012).

Most high schools in South Africa offer English as a First Additional language (EFAL) whereas the Physics textbooks and assessments are in English Home language (EHL). This is a disadvantage to the Physics learner, as can be seen in the comparison between their performances in EFAL and Physics below:

Table 1.1: Grade 12 performance in English First Additional Language 2011-2014

YEAR	Number wrote	Number achieved at 40% and above	% achieved at 40% and above
2011	414 480	315 313	76.1
2012	420 039	348 261	82.9
2013	454 666	403 081	88.7
2014	432 933	358 373	82.8

Table 1.2: Grade 12 performance in Physical Sciences 2011-2014

Year	Number wrote	Number achieved at 40 % and above	% achieved at 40 % and above
2011	180 585	61 109	33.8
2012	179 194	70 076	39.1
2013	184 383	78 677	42.7
2014	167 997	62 032	36.9

(National Senior Certificate 2014 Diagnostic Report, DoE 2015: 55- 142)

Considering the two learning areas, their performance in EFAL does not correlate with the performance in Physical Science which is assessed in EHL. Language

minority learners are not only learning a second language to add to their repertoire of language they speak, they are also called upon to partially or entirely use the second language as the language of learning (Melby-Lervag & Lervag, 2014). Hence these minority learners face a dual task: learning a second language while at the same time having to use this language which they are still not proficient in to access academic content (Msimanga & Lelliott, 2014).

As a result, it is not surprising that the majority of language minority learners run a greater risk of underachievement or worse drop out of school (Sierens & Van Avermaet, 2010). An educational analyst Govender in the *Sunday Times* (January 10, 2010) reports that poor language skills (in this case English) are the major contributing factors to the poor matriculation results, as the majority of learners have to study in English which is not their mother tongue. He goes on to argue that the South African government believes there must be an improvement in teaching English to learners at a younger age.

Consequently there have been policy changes in the South African Education system with the introduction of the Curriculum and Assessment Policy Statement (CAPS) in 2011, which stipulates that learners should be exposed to English at an earlier stage by introducing the language as a fourth subject in Grades R to 3. Evidently the blame for the current poor academic performance of matriculants across the board has been attached to low English language proficiency.

While analysing the Annual National Assessment (ANA) results of the examinations written by Grade 3, 6, and 9 learners in 2012 Masondo in the *City Press* (July 21, 2013) concluded that most of the learners were functionally illiterate. The Diagnostic Report on the Annual National Assessments 2012 (Department of Education, 2012) hints the majority of learners in grades 3, 6, and 9 could not understand what they read, produce meaningful sentences, and produce correct answers. They could not comprehend printed matter, and their knowledge of grammar was also shallow.

These learners (who learn in a different language to their home language) experience greater difficulty attaining the same level in Physics education than language majority learners (those who are taught in their home language), write Martin, Mullis, Foy, and Stanco (2012).

A research by Van den Branden (2010) on the effects of language on academic achievement in science education concluded that learners taught in their home language outperformed those taught in a different language. The researcher suggested that this might be due to the fact that all learners must acquire scientific knowledge and skills through gradually mastering a new kind of language, characterised by a specific vocabulary, a high level of abstraction, and limited contextual support (Van den Branden, 2010).

This is particularly challenging for minority learners (those who learn in a language different from their home language), not only do they have to acquire these new literacy skills- just like home language learners- but they must do so also in the language of instruction, which they have often not yet fully mastered (Rowe, 2013).

In this context, research suggests that proficiency in the language of instruction influences learners' performance in Physics (Taboada, 2012). The question one might ask is the applicability of this assertion in cases where indigenous African languages are used as the language of instruction in the Physics class, hence the need for this study. Indeed, the relationship between academic performance and language of instruction has been found to come to the fore as early as primary school level (Maerten- Rivera, Myers, Lee and Penfield, 2010), where reading ability is found to play a particularly significant role. Reading comprehension entails knowledge of specific vocabulary, text structures, and strategies, which especially have to be applied in content area texts.

As these texts are used more frequently from late primary school onwards, the ability to comprehend content area texts is crucial for learners to succeed in their school career (Shanahan & Shanahan, 2008, Taboada, 2012). For example, in another research, O'Reilly and McNamara (2007) found that next to Physics knowledge, Physics achievement scores can be predicted by the individual's reading skills.

Research also demonstrates that speaking a home language that is different from the language of instruction has a negative correlation with Physics achievement (Janssen & Crauwels, 2011, Martin et al., 2012). According to Goldenberg (2008), this is due to the double challenge language minority learners are faced with: they must acquire academic knowledge and skills through a decontextualized school

language and they must do this through a language that they have often not yet fully mastered.

In this context, language can become a significant barrier to perform well in Physics (Cremer & Schoonen, 2013), particularly since many language minority learners keep on struggling to meet the academic demands of content area texts in high school. In a way, research shows that learners' proficiency in the language of instruction and particularly their reading abilities are related to Physics achievement.

These factors become more critical when learners speak a home language that is different from the language of instruction. Indeed, several studies have demonstrated the relationship between language of instruction and academic achievement (Fraser, 2012).

Physics education reform initiatives in most countries promote a vision of Physics for all learners. According to the UNESCO evaluation on Physics education "science teachers should recognise the diversity of their classes and organise the classroom so that all learners have the opportunity to participate fully". However research indicates that many Physics teachers have not developed teaching strategies to support the learning of an increasing percentage of the learner population- those whose home language differs from the language of instruction (Msimanga & Lelliott, 2014).

Physics education begins in language, it advances and stumbles because of language (Howe & Lisi, 2014) and its outcomes are often assessed in language (Fleisch 2008: 105). Scientific literacy for all learners has been a major educational goal worldwide (Miller, 2009), South Africa included. According to Torres and Zeidler (2010) an understanding of Physics makes it possible to discuss scientific issues that affect society, to use scientific knowledge and processes in making personal decisions, and to share in the excitement of scientific discovery and comprehension.

Often this understanding of Physics has proven to be very elusive to non- native speakers of English (Woolfolk 2010), if it is the language of teaching and learning, in the world and in South Africa (Barton & Neville-Barton, 2003). In the South African context linguistic diversity is a complex issue (Landsberg, Kruger and Swart 2011: 39) and affects the teaching and learning process on a daily basis (Madiba, 2014).

It has, no doubt increasingly become the task and responsibility of Physics teachers to develop strategies in an attempt to facilitate quality Physics education for their learners (Botes & Mji, 2010) whose home language differs from the language of instruction (Fleisch, 2008) in a bid to make up for the shortcomings of using a language that is different from their home languages.

1.2 Background

It has been stated that to neglect the Physics education of learners is to deprive them of basic survival knowledge (Bowering 2005), handicap them for life (Fang, 2006) and deprive the nation of talented workers and informed citizens (Torres & Zeidler, 2010). In most classrooms in South Africa the English language is used as the medium of instruction (Landsberg et al., 2011), following the end of the apartheid era, in Physics classes (Edwards 2010: 250). This happens even if, as in most cases, there are no native speakers of English (Garcia, 2009).

The critical period of language acquisition, according to linguists, is when it takes place effortlessly in natural setting (Cummins 2008). This acquisition of language, inevitably influences the acquired language skills and vocabulary of monolingual learners as compared to bilingual (Evans, Ganton, Kaschula, Prinsloo and Ramagoshi, 2010: 2) and multilingual ones (Cenoz, 2009). The acquisition of language by a learner is not only associated with the expansion of the learners' world of meaning (Botes & Mji, 2010), but is also attuned to it (Madiba, 2014).

Inadequate language acquisition then results in inefficient actualisation of intelligence (Howe & Lisi 2014: 253). In the same vein, it has been argued by several researchers that learners who are taught in a non- mother tongue language probably do not achieve academic excellence in Physics (Barton & Neville- Barton ,2003), not because they are less able (Fang, 2006), but due to an artificially created linguistic problem (Fleisch &Shindler, 2007).

This argument prompted the researcher to investigate the effect of language in Physics education looking at learners whose home language is Southern Sesotho and are taught Physics in English language. The theoretical foundation to investigate this is Cummins' (2008) work on cognitive academic language proficiency, which

relates both cognitive and linguistic processes to the academic success of learners (Bowering 2005), more specifically non- native English language learners.

According to Cummins (2008), there are two levels of language proficiency (Fortanet-Gomez 2013: 147): the basic interpersonal communicative skills (BICS) and the cognitive- academic language proficiency (CALP). The basic interpersonal communicative skills (BICS) concept represents the language of natural, informal conversation (Howe & Lisi, 2014). BICS are used by learners when talking about everyday things in concrete situations (Landsberg et al., 2011), that is, situations in which the context provides cues that make understanding not really dependent on verbal interaction alone (Torres & Zeidler, 2010). These authors refer to this everyday conversational ability as context embedded or contextualised.

CALP, on the other hand, is the type of language proficiency needed to read textbooks (Evans et al., 2010), to participate in dialogue and debate (Du Plessis & Louw, 2008), and to provide written responses to tests (Fleisch & Shindler, 2007). Learners who have not yet developed their cognitive- academic language proficiency (CALP) could be, according to these researchers, at a disadvantage in learning science or other academic subject matter (Miller, 2009).

Teachers in the mainstream South African classrooms encounter increasing numbers of English as an Additional Language (EAL) learners (Landsberg et al., 2011), most of whom have limited literacy (CALP) which is essential for academic success in Physics (Maerten-Rivera, Myers, Lee and Penfield, 2010). The CALP concept is related to literacy skills in the first or second language (Van Laere et al., 2014) and according to Cummins (2008), requires both higher levels of language and cognitive processes in order to develop the language proficiency needed for success and achievement in Physics.

Cummins conceptualised the relationship of language proficiency and academic achievement by using an iceberg representation (see Figure 1 below). In this representation, BICS, or skills, which depend on the surface features of language and lower levels of cognitive processes, are represented above the waterline while the CALP, or skills related to the meaning of language and higher level of cognitive processes are represented below the water line (Rowe 2013)

**Basic Interpersonal
Communication Skills
(BICS)**

COGNITIVE PROCESS LANGUAGE PROCESS

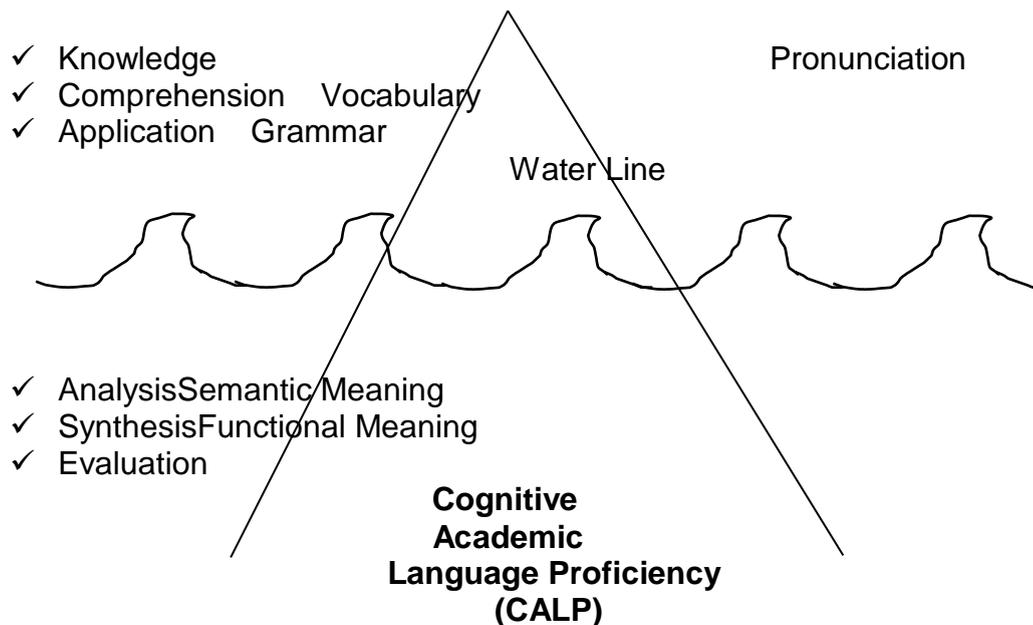


Figure 1.1: Relationship between language proficiency and academic performance. (Source Cummins, 2008)

Cummins (2008) contends that all learners develop BICS and learn to communicate in their native or first language (also called the home language) and that CALP reflects a combination of language proficiency and cognitive processes that determine a learner's success in school.

Time- constraints, institutional constraints, along with gaps in teacher education and limited targeted professional development, mean that many teachers are struggling to deal with the challenges of meeting the needs of those learners whose language proficiency is low (Miller, 2009), particularly within mixed-ability classes, as is the case in most South African schools. Such learners, with low language proficiency, need high levels of teacher intervention (Howe & Lisi, 2014) in order to produce meaningful work (Gibbons, 2009).

Without the proper intervention, these learners are likely to be left bewildered by unfamiliar content and incomprehensible tests (McCallum & Miller, 2013), and having limited opportunities to utilise skills and knowledge they do have or to practice new language structures (Fang, 2006). The challenges in teaching these learners are significant, particularly given the range of reading ages in most of our classes (Fortanet-Gomez 2013: 147) and the need for differentiation in South Africa's (Woolfolk 2010) heterogeneous Physics classes.

Language and cultural differences are much in evident in South Africa's heterogeneous population (Landsberg et al., 2011: 39) that has eleven official languages (Makalela 2014b). Personal characteristics, cognitive styles and learning styles of different cultural groups differ widely (Evans et al., 2010: 15).

The South African education system is largely based on Western culture that promotes English and Afrikaans as the only languages of instruction in secondary schools. Consequently, learners whose mother tongue language, traditions, values, and norms differ from those of the school culture might underachieve because the existing Physics curriculum has nothing in common with their own cultural milieu (Landsberg et al., 2011).

Most black Physics learners in South Africa attend schools where the language of instruction is English (McNamara, 2007) and teachers should be aware that this usually leads to learning problems and underachievement in these learners (Landsberg et al., 2011: 40). But how does the difference in one's mother tongue language and the medium of instruction affect one's academic performance in Physics?

Rowe (2005) responds that learning and teaching Physics in multicultural classrooms where the medium of instruction is not the learner's home language is a complicated matter and in most cases language minority learners underachieve. But to what extent is Rowe's assertion applicable to Physics learners in the Fezile- Dabi district where the home language of about 90% of them is Southern Sesotho (Fleisch 2008).

1.3 Motivation for the research

Raising the academic attainments of all Physics learners is a key challenge for policy and practice. There are continuing debates about the most appropriate ways to meet the educational needs of language minority learners due to the diversity and complexity of language and culture (Fraser, 2012). There is consensus, however, from research that Physics learners whose home language differs from the language of instruction are at a disadvantage as they tend to perform lower than those taught in their mother tongue (Melby- Lervag & Lervag, 2014).

Research into academic achievement of learners is often concerned with literacy and numeracy, leaving other outcomes, such as Physics education lower on the agenda (Bellens & De Fraine, 2012). This is problematic, as different countries worldwide are faced with a serious and persistent gap in academic achievement in science subjects, Physics inclusive (Duschl, Schweingruber and Shouse, 2007), particularly where the home language differs from the language of instruction (Van Laere et al., 2014).

Studies (for example Legotlo, Maaga and Sebego, 2002; Mashile, 2001; Mji & Makgato, 2006) in South Africa have investigated and reported on different factors that affect the teaching and learning of science, chief among them being the difference between home language and the language of instruction. The recurring poor performance in this subject calls for a concerted effort on measures that will improve the status quo (Mji & Makgato, 2006).

In another research by Lemmer (2010) it is reported that attrition rates among linguistically diverse school populations show that learners with a limited proficiency in the language of instruction are most at risk of underachievement.

Language minority learners in multicultural schools are not only learning a second language to add to their repertoire of languages spoken, they are also called upon to partially or entirely use the second language as language of learning (Madiba, 2014).

Thus, language minority learners face a dual challenge: learning a second language while at the same time having to use this language which they are in the process of acquiring to access academic content. It is therefore not surprising that the overall

majority of language minority learners run a greater risk of underachievement, notes another researcher (Makalela, 2015).

Researchers exploring the causes of underachievement among language minority learners have distinguished between the use of language in informal everyday situations and the language used in most academic situations (Lemmer, 2010). In another research on the effect of language on learner achievement in South Africa, Howe (2005) reported that learners whose home language was either English or Afrikaans (also being the medium of instruction) achieved higher scores than those whose home language was different.

What is illuminating is that in the same research learners who spoke other languages at home (for example Greek, Portuguese, or Tamil), and therefore also learned in a second language (either English or Afrikaans), scored only 20 points on average less than first language speakers, with learners speaking 'African' languages at home scoring 100 points less than the other group of second language learners (Howe, 2005).

The present research was based on the findings of such researchers as well as those of Makalela (2013; 2015), Van den Braden (2010), and Van Laere et al. (2014) who concluded that collaborative learning (allowing learners to use several languages in class) has significantly greater success rate than individual engagement.

Brijlall (2008) in particular goes on to recommend further research on his findings on collaborative learning advising future researchers to take cognisance of different South African languages. In this research, therefore, the effect of language on the academic performance of Southern Sesotho Physics learners was investigated, because research suggests that proficiency in the language of instruction plays a significant role in Physics education (Van Laere et al., 2014).

From studies conducted by researchers such as Brijlall (2008), Howe (2005), Van den Braden (2010), and Van Laere et al. (2014), most of the researchers concluded that the difference in academic achievement of Physics learners is largely due to the difference in their home language and the language of instruction. They go on to suggest that if language minority learners are taught in their mother tongue their

academic performance in Physics is likely to improve. Considering the poor academic achievement of Physics learners in Fezile- Dabi district, the research sought to establish if mother tongue instruction can make any difference in the performance of these Southern Sesotho learners in Physics education.

This is against the background that most, if not all, of these learners are taught Physics using the English language, which happens to be their second, third or even fourth language of communication, by a teacher whose mother tongue also happens not to be the language of instruction (Landsberg et al., 2011), as fewer than one in ten learners in South Africa speaks English as their home language, yet by the end of grade 3 the majority of them have to be taught and assessed in English language (Fleisch, 2008).

Despite an increased interest by researchers in the use of learners' home language in Physics education, it is surprising that so little empirical research has actually been conducted on the use of African languages especially from the perspectives of Southern Sesotho. Very few studies have focused on how teachers use African languages to interact strategically with Physics learners during lessons and what this means descriptively and conceptually.

From literature surveyed, there seems to be lack of or insufficient literature and research on the usefulness of any one of South Africa's African languages, particularly Southern Sesotho in the teaching of Physics. Besides being concerned about the use of a different language in the teaching and learning of Physics, the present research also sought to establish the impact of using a common language among the teachers and learners in the teaching and learning of Physics.

Fezile- Dabi district is in the Free State province where the majority of the learners' home language is Southern Sesotho. Considering the National Senior Certificate (NCS) results in Physical Science, the district had a 55.21% pass rate in 2011, 68% in 2012, 72% in 2013, and 63% in 2014. Its average for these results in the subject was the lowest compared to those of other districts in the province, such as Thabo Mafutsanyana, Motheo, Xhariep, and Lejweleputswa (DoE NCS booklet, 2015).

The district's target is to attain a 90% pass rate for Physics by the year 2017, which, considering these results seems an impossible target. This is the other reason why

the researcher was interested in determining how language affects the academic performance of Physics learners in this district and also investigate the role mother tongue can play in their performance as Physics education in the district is offered in either English or Afrikaans languages only.

The thrust for this study was to establish if there really existed a correlation between proficiency in the language of instruction and academic performance in Physics. The research also sought to establish whether or not Southern Sesotho could be effectively used as a language of instruction in the Physics class.

1.4 Theoretical Framework

The theories considered for this research look at the role of literacy in the language of instruction on Physics achievement, and the challenge of having a home language which is different from the language of instruction. The new literacy that learners need to acquire in order to perform well in Physics is known under different but related names: disciplinary literacy, decontextualized language, and cognitive academic language proficiency (Van Laere et al., 2014).

While 'basic literacy' refers to the relatively simple process of decoding words (Rowe, 2013), and 'intermediate literacy' relates to basic fluency, broad word knowledge and comprehension strategies to deal with texts (Van Laere et al., 2014), 'disciplinary literacy' concerns the mastery of specific concepts and discourses used in subjects such as science and mathematics (Fang, 2006). Disciplinary literacy is closely related to the concept of decontextualized language, which refers to abstract language that is distant from the *here* and *now* (Rowe, 2013).

While children use highly contextualised language in their early development (for example through pointing, labelling, and facial expressions), they gradually develop the capacity to produce more decontextualized language, particularly once they enter school (Van Laere et al., 2014). Learning to master decontextualized language is often very challenging due to associated skills required, such as abstract thinking (Fang, 2006), and underlying assumption of causality (Van Laere et al., 2014), and mastering a relatively complex vocabulary and grammar, all of which imply an advanced level of language proficiency (Garcia, 2011; Gu, 2015).

A distinguished researcher in the relationship between language of instruction and academic achievement, Cummins (2008) has made a distinction between ‘basic interpersonal communicative skills’ (BICS) and ‘cognitive academic language proficiency’ (CALP). While BICS deals with the social use of language in daily activities, which is context- embedded and characterised by non- verbal support (for example conversations), CALP on the other hand refers to the more complex and cognitively demanding language used at school (Landsberg et al., 2011).

In the early 1980s, Cummins refined the distinction between BICS and CALP, resulting in a theory represented by four quadrants along two (2) dimensions (see Figure 2 below).

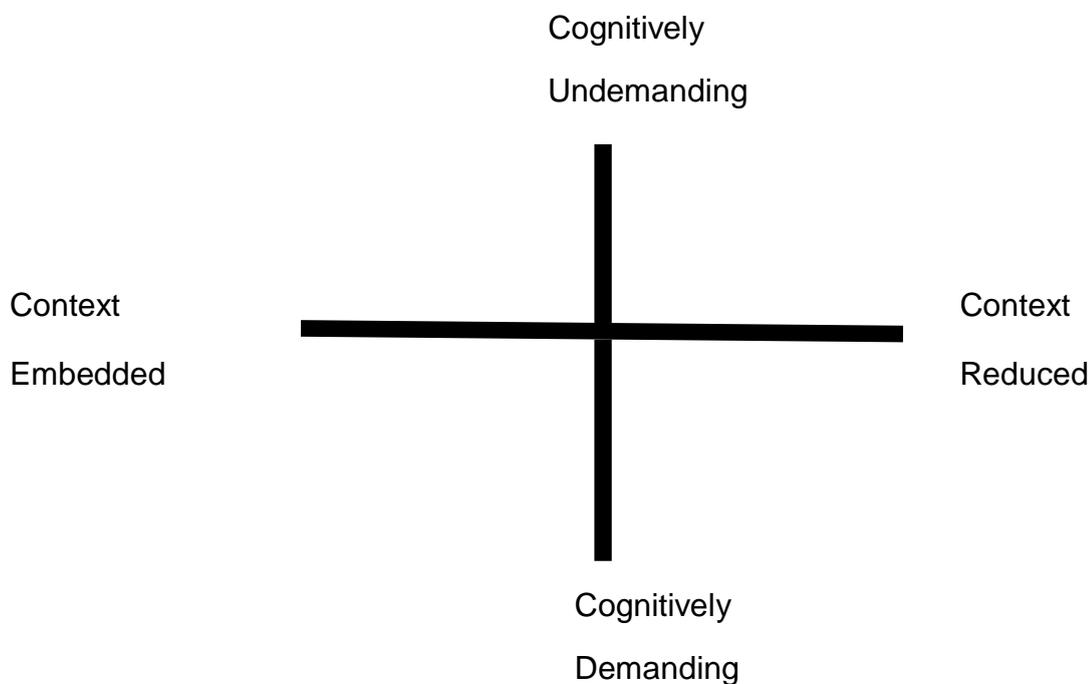


Figure 1.2: Distinction between BICS and CALP

(Torres & Zeidler, 2010)

The dimension ‘amount of contextual support’ (Cummins, 2008) runs along a continuum from context- embedded communication (that is much support is available during communication, for example through body language) to context- reduced communication (that is very limited, or no support is available to understand the content), the dimension ‘level of cognitive demand’ (Fraser, 2012) runs from a

cognitively undemanding (communication does not require a high level of language proficiency) to a cognitively demanding form of communication (that is much complex information needs to be processed quickly through higher- order thinking skills). Classroom activities are mostly characterised by context- reduced and cognitively demanding communication, with Physics education as one of the most obvious examples: Physics is concerned with describing phenomena, conceptual reasoning, as well as organising, applying, and evaluating new information (Van den Braden, 2010).

In this context, research suggests that proficiency in the language of instruction influences learners' performance in science education (Taboada, 2012). Indeed, this relationship has been found to come to the fore as early as primary school level (Maerten- Rivera et.al, 2010), where reading ability is found to play a particularly significant role (Van Laere et al., 2014). Reading comprehension entails knowledge of specific vocabulary (Bowering, 2005), text structures, and strategies (Gu, 2015), which especially have to be applied in content areas texts (Garcia, 2011). As these texts are used more frequently from late primary school onwards, the ability to comprehend content area texts is crucial for learners to succeed in their school work (Shanahan & Shanahan, 2008; Taboada, 2012).

For example O'Reilly and McNamara (2007) found that next to Physics knowledge, Physics achievement scores can be predicted by the learner's reading skills. Moreover, Taboada (2012) shows that knowledge of vocabulary significantly contributes to comprehension of Physics texts with both learners who learn in their mother tongue as well as those who learn in a language different from their mother tongue, even after accounting for proficiency in the language of instruction (Van Laere et al., 2014).

Research demonstrates that speaking a home language that is different from the language of instruction has negative correlation with academic achievement in Physics (Janssen & Crauwels, 2011; Martin et al., 2012). According to another research on science achievement, Goldenberg (2008) concluded that this (low achievement in Physics) is due to the double challenge that learners who learn in a different language are faced with: they must acquire academic knowledge and skills

through a decontextualized school language and they must do this through a language that they have often not yet fully mastered.

In this context, language can become a significant barrier to perform well in Physics (Fraser, 2012), particularly since many language minority learners (those who learn in a language different to their home language) keep on struggling to meet the academic demands of content area texts in high school (Setati, 2011). Learners who learn Physics in a different language to their mother tongue do not so much fail on the foundation skills of the language of instruction, such as word decoding (Cremer & Schoonen, 2013), but fall behind in comprehension skills, namely vocabulary knowledge and reading comprehension (Gu, 2015).

Furthermore, their word knowledge is more context- specific and less meaning based than that of those learners who learn in their mother language (Cremer & Schoonen, 2013). As a result, a large gap in academic performance levels exists between these two groups of learners for reading comprehension (Baker, 2011). In a nutshell research shows that learners' proficiency in the language of instruction is related to academic achievement in Physics (Msimanga & Lelliott, 2014; Van Laere et al., 2014). This factor becomes more critical when learners speak a home language that is different from the language of instruction (Taboada, 2012).

In the Fezile- Dabi district the home language for more than 90% of the learners is Southern- Sesotho. However, these learners are taught Physics in a language that is different from their home language, mostly in English language. As suggested by Janks and Makalela (2013), these learners are faced with a dual task when they attend Physics lessons (Van Laere et al., 2014): to learn the language of instruction as well as the subject itself and this normally results in underachievement.

The majority of schools in the district offer English as an additional language (EFAL) whereas the Physics textbooks found in the classroom and question papers for the Physics examination are in English home language, another anomaly. However, achievement in Physics can be improved if the learners are proficient in the language of instruction (Msimanga & Lelliott, 2014; Taboada, 2012).

In this research the experimental group was taught Physics in their home language since they have a high proficiency in it than in the language of instruction (English).

This was in a bid to investigate the applicability of assertions by Makalela (2015); Msimanga and Lelliott (2014) and Taboada (2012), to learners in Fezile- Dabi whose home language is Southern Sesotho.

Taboada (2012) also suggests that knowledge and understanding of content vocabulary significantly contributes to the comprehension of science texts. To test this suggestion in this research, the participants in the experimental group were given an English- Southern Sesotho Physics dictionary that had Southern Sesotho translations and explanations of key words found in the topic *Mechanics* (Grade 11).

1.5 Problem statement

This research sought to establish the effect of language on the academic performance of Grade 11 Physics learners and come up with workable suggestions as how to improve the learners' performance in the subject, paying particular attention to Southern Sesotho speakers who learn Physics in a language different from their home language.

This follows findings by several researchers cited earlier on who concluded that there is a close link between a learner's language proficiency in the language of instruction and academic performance in Physics. Some of the researchers also advocate for the use of one's home language as the language of instruction (Botes & Mji, 2010; Howe & Lisi, 2014; Osborne, 2010; Mji & Makgato, 2006).

In the district in which the research was carried out all learners are taught Physics either in English or Afrikaans despite the fact that the two languages are not the home language for more than 90% of the learners. These Grade 11 learners are faced with the task of learning the language of instruction as well as the language of Physics. This research sought to establish the effectiveness of using learners' home language in Physics lessons, when the official language of instruction is English Home Language and the learners' home language is Southern Sesotho.

The research investigated the effect of language on the academic performance of Grade 11 learners whose home language is different from the language of instruction. According to the English language Annual National Assessment (ANA) results for 2014 for the district in question, the pass rate was 23% (DoE, 2015). This

alone speaks volumes about the language proficiency of the group that was under study and is expected to learn and master Physics in English language so that they will solve the world's scientific problems.

1.6 Research questions

The main research question for the study:

1.6.1 What is the role of language in the teaching/learning of Physics?

Subquestions:

1.6.2 How does language affect the academic performance of Grade 11 Physics learners?

1.6.3 To what extent can Southern Sesotho be used as a medium of instruction in the teaching/learning of Physics to Grade 11 learners?

1.7 Hypothesis

Sometimes dissertations and theses should include both research questions and research hypotheses. If the research hypotheses build on and are different from the research questions, it is recommended to use both research questions and research hypotheses (Hambrick, 2007).

In mixed method research, having research questions as well as hypotheses helps to explore the problem at hand to the fullest (Creswell, 2014).

1.7.1 Research hypothesis: There is no relationship between language and academic performance in Physics.

1.7.2. Null hypothesis: There is no significant difference between the academic performance of the control and experimental groups in Physics.

1.8 Aim of the research

To investigate the effect of language on the academic performance of Grade 11 Physics learners whose home language is Southern Sesotho.

1.9 Definition of concepts

In the research, for consistency and clarity, the following terms were taken to mean:

1.9.1 African language: any of the official languages used in South Africa other than English and Afrikaans (Landsberg et al., 2011: 39).

1.9.2 Bilingualism: the ability to use more than one language (Makalela, 2014a).

1.9.3 Language: a code whereby ideas about the world are expressed through a conventional system of arbitrary signals for communication (Madiba, 2014).

1.9.4 Multilingualism: the maintenance of more than one language in a certain context (Makalela, 2014a; 2015).

1.9.5 Performance: the extent to which learners are meeting the stated standards (Department of Education CAPS document Grade 10 to 12, 2011).

1.9.6 Physics: is the natural science that involves the study of matter and its motion and behaviour through space and time, along with related concepts such as energy and force (Department of Education CAPS document Grade 10 to 12, 2011).

1.9.7 Science: a subject that investigates physical and chemical phenomena through scientific enquiry, application of scientific models, theories and laws in order to explain and predict events in the physical environment, that is Physics in this case (Department of Education CAPS document Grade 10 to 12, 2011: 8).

1.9.8 Southern Sesotho: A language spoken by Basotho people in the Republic of South Africa and is part of the Ntu (Bantu) language family, and is also one of the country's official languages (Evans et al., 2010).

1.10 Limitations of the study

The study focused on Grade 11 Physics learners from only two schools in Fezile-Dabi district. Only 40 learners took part in the study, making it a relatively small sample. The learners were taught during the afternoons and weekends only so as not to disturb the smooth running of the schools involved in the study. They could

have been tired or lacked focus bearing the tuition times in mind. The English language proficiency test done on the learners revealed that they have a low proficiency in the language, which happens to be the language of instruction at the two schools.

1.11 Research design and methodology

The following summaries the research methodology and design used during the present study.

1.11.1 Research design

Every research is like a journey which needs detailed and careful planning about how one is going to reach their destination, after how long, and the action to be taken in case of eventualities. The purpose of this research design and methodology was to specify a plan for generating empirical evidence that would be analysed and used to answer the research questions. The research method and design were therefore responsible for the drawing of the most valid, credible conclusions from the answers to research questions (McMillan & Schumacher, 2010: 257).

Creswell (2014) defines research design as a procedure for collecting, analysing, and mixing both qualitative and quantitative data at some stage of the research process within a single study to understand a research problem more completely. A research design is a specification of the most adequate operations to be performed in order to test a specific hypothesis or theory under given conditions (Gray, 2011). A research can either be qualitative, quantitative, or can encompass both designs (mixed method).

This research made use of both methods (mixed). The qualitative design used in this study was just as systematic as the quantitative design, though emphasis was on gathering data on naturally occurring phenomena. The qualitative data presented in this research is in the form of words, rather than numbers, and the researcher searched and explored with a variety of methods until a deep understanding of the data was achieved (Cohen, Manion & Morrison, 2011).

To study this problem, the researcher used an emerging qualitative approach to inquiry, the collection of data in a nature setting sensitive to the people and places under study, and data analysis that is inductive and establishes patterns or themes.

The final written report presented herein includes the voices of participants, the reflectivity of the researcher, and a complex description and interpretation of the problem (Killen, 2010).

The quantitative design followed during this research on the other hand established relationships between measured variables and the sequential steps to be followed (McMillan & Schumacher 2010: 12). The two major sub classifications of this design are experimental and non- experimental (Babbie, 2010). In this research the researcher used an experimental design and intervened with a procedure that determined what the participants would experience (Killen, 2010). The intervention used in this research was Physics lessons being taught in learners' home language.

In other words the researcher had control over what happened to the participants by systematically imposing (to the experimental group), and withholding (from the control group) the specified intervention (McMillan & Schumacher, 2010). The researcher then made comparisons between participants who had and others who did not have the interventions (McMillan & Schumacher, 2010).

In this research comparison was made between one group of participants (the experimental) that received intervention in the form of Physics lessons being taught in their home language (Southern Sesotho) and were accorded the use of the English- Southern Sesotho Physics dictionary as intervention and the other group (the control) which did not receive any intervention. Experimental designs come to a conclusion by varying some condition and observing its effect on the participants (Cohen et al., 2011).

The researcher used triangulation design in which both qualitative and quantitative data was collected at about the same time. Triangulation is used when the strengths of one method offset the weaknesses of the other, so that together, they provide a more comprehensive set of data (Cohen et al., 2011; Punch, 2011). Theoretically, the triangulation design is used because the strengths of each approach can be

applied to provide not only a more complete result but also one that is more valid (McMillan & Schumacher, 2010).

In this research quantitative data was collected from learners' performance in the English Language Proficiency test, the pre- test, the post- test while qualitative data was collected from responses from interviews that were held with participants who were in the experimental group. All Grade 11 Physics learners in the two schools wrote the English Language Proficiency test and the best 40 learners were then invited to participate in the last four phases of the study (the pre- testing, intervention, post- testing, and interviews).

As stated earlier, in this research one group (the experimental) received intervention in the form of Physics lessons in their home language and made use of English- Southern- Sesotho Physics dictionary (cause). The researcher determined the effectiveness of the intervention basing on the experimental group's performance in the post- test compared to that of the control group (effect).

This is because the purpose of using this design was to determine cause and effect of the intervention provided by the researcher (McMillan &Schumacher, 2010). In this research intervention was provided in the form of Physics lessons that were taught in the learners' home language (Southern Sesotho) as well as the provision of a basic English- Southern Sesotho Physics dictionary.

Those learners with a high proficiency in the language of instruction (English) were then invited to participate in the last four phases (writing a pre- test; intervention; post-test, and interviews) of the study. The 40 learners who had the highest proficiency in English language were given a Physics pre- test. This was done so as to compare their language proficiency against their performance in Physics.

The pre- test and post-test they wrote was the Mechanics Baseline Test (MBT) designed by David Hestenes and Malcolm Wells of Arizona University while the English Language Proficiency test used was drawn up by Yeditepe University. Before using the tests the researcher evaluated them and saw that they complied with the South African Department of Education's requirements on assessing learners in the two subjects. The researcher also carried out a pilot study using the two tests as well as the interview schedule that was to be used in the study.

These 40 learners (with a high proficiency in English language) were then assigned equally into one of the two groups, experimental or control after writing the pre- test. Both groups were taught the same topic (*Mechanics*) during afternoons and on Saturdays so that the smooth running of the two schools was not affected.

The only difference was that those in the experimental group were also taught Physics in Southern Sesotho (their home language) and were also given translations to key Physics concepts in their home language through the provision of an English-Southern Sesotho Physics dictionary which was compiled by qualified and experienced multi- linguists.

Learners from the experimental group were also interviewed by the researcher on their experiences with the dictionary as well as the Physics lessons delivered to them in their home language. The learners were asked the same questions in the same order so as to avoid any bias or researcher influence. The researcher tape recorded the interviews with the learners' permission and transcribed them as soon as the interviews were over.

1.11.2 Sampling

The sources of information used by qualitative researchers include individuals, groups, documents, reports, and sites. Regardless of the form of data, purposeful sampling is used. Qualitative sampling is “selecting information-rich cases for study in-depth (Punch, 2011) when one wants to understand something about those cases without needing or desiring to generalise to all such cases”. Qualitative sampling is done to increase the utility of information obtained from small samples (Gay, 2010).

In this research Physics learners were chosen because they were knowledgeable and informative about the phenomena the researcher was investigating: the effect of language in Physics education. The power and logic of qualitative sampling is that a few cases studied in depth yield many insights about the topic, whereas the logic of probability sampling depends on selecting a random or statistically representative sample for generalisation to a larger population (McMillan & Schumacher (2010:326).

For quantitative research random sampling is advisable (Cohen et al., 2011). The sample can be drawn from a larger group of participants, or can just refer to the

group of participants from whom data are collected (McMillan & Schumacher, 2010). Random sampling was used in this study, thereby affording each participant an equal chance of being in either of the groups, and bias was avoided since there was a high probability that all the population characteristics were represented in the sample (Punch, 2011).

The researcher used simple random sampling in this research. Physics learners were chosen because they were knowledgeable and informative about the phenomena the researcher was investigating: the effect of language in Physics education. Before all the Grade 11 Physics learners at the two schools had written the language proficiency test, they were assigned numbers from 01 to 98.

These are the numbers with which the learners were referred to during the entire study. After writing the English Language Proficiency test the best 40 learners were invited to participate in the last four stages of the study. The 40 learners were then given a Physics pre- test to write. After writing the pre- test the learners were then assigned to either the control or experimental group. In assigning them to the research group, the learners' numbers were drawn into one of the two groups (experimental or control), having an equal number of participants in each group.

This technique (simple random sampling) had the advantage that all participants had an equal opportunity to be in either of the two groups. Since the population used in this study was small, this also justified the use of simple random sampling. The use of this sampling technique in this research eradicated sampling bias.

1.11.3 Data collection and analysis

The data was collected through writing tests (the English proficiency test, a science pre-test as well as a post-test) as well as interviews. Interviews were carried out with the learners who had lessons in their home language and had access to the English-Southern Sesotho Physics dictionary (experimental group). Questions for the interviews centred on trying to find out the learners' experiences and views on the treatment given to them (Physics lessons in their home language as well as the English- Southern Sesotho Physics dictionary).

The interviews held in this research were in the form of a dialogue between the assessment agent (the researcher in this case) and the participant (Gray, 2011).

The interviews combined the two forms of assessment methods, viz observation and questioning. They provided the researcher with the opportunity to formulate a variety of questions and allowed the participants to prepare the answers to the questions that were asked. The interviews held can also be viewed as a two way conversation in which the interviewer asked the respondents questions to collect data and to learn about ideas, beliefs, views, opinion, and behaviours of the respondents (Cohen et.al ,2011).

The research design used in this research relied heavily on numbers in reporting results, sampling, and providing estimates of score reliability and validity (McMillan & Schumacher, 2010). The numbers were accompanied by strange words and even stranger symbols, and are manipulated by statistics (McMillan & Schumacher, 2010).

Statistics are methods of organising and analysing quantitative data. These methods assisted the researcher in organising and interpreting numbers derived from the measured variable (Gray, 2011; McMillan & Schumacher, 2010). There are two broad categories of statistical techniques: descriptive and inferential. Descriptive statistics are concerned with the transformation of a set of numbers into indices that describe the respective data (Cohen et al., 2011). Descriptive statistics therefore focus on *what* is with respect to the sample data (McMillan & Schumacher, 2010).

This set of statistics is also referred to as summary statistics as it reduces (Gay, 2010), summarises (Punch, 2011), and organises large number of observations. The use of descriptive statistics is the most fundamental way of summarising research data, hence it is indispensable in interpreting the results obtained in any research that incorporates quantitative research (McMillan & Schumacher, 2010). Inferential statistics on the other end of the analysis continuum are used to make inferences or predictions about the similarity of a sample to the population from which the research sample is drawn.

Answering my research questions required the estimation of population characteristics from the available sample of participants, this research made use of inferential statistics in reporting the respective research results (McMillan &Schumacher, 2010). Inferential statistics, however, depend largely on descriptive statistics.

Table 1.3: Difference between Descriptive statistics and Inferential statistics

Population	Sample	Descriptive Statistics	Inferential Statistics
All grade 11 Physics learners write the English Language Proficiency test	Researcher selects the top 40 learners in the Proficiency test to participate in the study	Used to describe sample of the Physics learners	Based on descriptive statistics to estimate scores of the entire population

(McMillan & Schumacher, 2010)

In analysing the data for this study descriptive and inferential statistics were used by the researcher.

Descriptive statistics can be grouped as either univariate or bivariate (McMillan & Schumacher, 2010). The difference between the two is that univariate analysis is used to summarise data on a single variable (Cohen et al., 2011). Bivariate analysis, on the other hand is used when there is a correlation among variables or when different groups are being compared (McMillan & Schumacher, 2010), and this includes correlation, comparing frequencies, comparing percentages, comparing means, and comparing medians (Cohen et al., 2011, McMillan & Schumacher, 2010).

In this research bivariate analysis was used as the researcher compared the frequencies, effect size indices, p- values, learning gain, and means obtained in the different tests by the learners participating in the research. A frequency distribution table showing how often each option was drawn per question (McMillan & Schumacher, 2010), see Table1.4 below.

Table1. 4: EXAMPLE OF FREQUENCY DISTRIBUTION TABLE

Pre-test and Post-test results of Motion questions per question(Experimental)																							
Question 1 Pre-test			Question 1 Post-test			Question 2 Pre-test			Question 2 Post-test			Question 3 Pre-test			Question 3 Post-test			Question 4 Pre-test			Question 4 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %			
A	3	15	A	1	5	A	3	15	A	4	20	A	3	15	A	2	10	A	4	20			
B	12	60	B	11	55	B	4	20	B	2	10	B	3	15	B	3	15	B	3	15			
C	3	15	C	1	5	C	3	15	C	2	10	C	2	10	C	4	20	C	6	30			
D	1	5	D	4	20	D	9	45	D	11	55	D	5	25	D	0	0	D	3	15			
E	1	5	E	3	15	E	1	5	E	1	5	E	7	35	E	11	55	E	4	20			
Total	00		Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100			

(Adapted from McMillan & Schumacher, 2010)

The effect size, p- value, mean, and learning gain for the tests were calculated and presented in table form (see Table 3 below). The same data was then presented on a bar graphs for easy comparison. On the bar graphs drawn, the vertical component on the graph (y- axis) represented the learning gain while the horizontal component (x- axis) represented the questions answered.

Table1. 5: EXAMPLE OF MARKS OBTAINED IN PRE- TEST AND POST TEST

Dependent t-test statistics Motion(experimental)						
Question		Mean	Std deviation	p- value	Effect sizes	Gain
1	Pre	60	49.24	0.375	0.20	-0.125
	Post	55	50			
2	Pre	45	50	0.63	0.20	0.182
	Post	55	50			
3	Pre	35	47.94	0.097	0.42	0.308
	Post	55	50			
4	Pre	30	46.06	0.054	0.54	0.357
	Post	55	50			

The means, pass rates, frequency, p- value, effect size indices, and learning gain were calculated for each group and compared.

In order not to disadvantage learners who were in the control, the researcher also gave them the same intervention accorded to the experimental group when the research was over. They were then given the same post-test to write though the questions had been jumbled up.

1.11.4 Statement on research ethics

Research ethics are concerned with beliefs about what is right or wrong from moral perspective (Booyse, Le Roux, Seroto and Wolhuter (2011: 34). Participants had the right to refuse to participate, or withdraw from the study at any point regardless of the consequences this might have to the study. Ethical rights of participants that were observed in this study are; informed consent, confidentiality, voluntary participation, and full disclosure.

The researcher sought permission to conduct the study from the Provincial Director of Education (Free State province), the District Director of Education (Fezile- Dabi district) as well as from the respective principals, and the learners' parents. The researcher also applied for permission and was cleared by the CEDU Research Ethics Review Committee (Ref: 2016/04/13/48166413/08/MC), see Appendix J.

Voluntary participation

Participating in this research was purely on voluntary basis, where the participants had the choice whether or not to participate in the research. The learners also decided whether they wanted to partake till the end of the research or pull out along the way. McMillan and Schumacher (2010) state that participants cannot be compelled, coerced, or required to participate.

Confidentiality

As is the case in all social science research, the researcher was mandated to protect the privacy of all participants. This entails that access to participants' information such as their characteristics, responses, behaviour, and any other information that can make them be identified was not made public. Gray (2011) propounds that confidentiality in research means that those studying or reading the research results

will not be able to establish the identity of those who participated on the basis of their responses.

Confidentiality in this research was ensured by using numbers to represent participants. Learners were allocated numbers 01 to 98, and these were the numbers they were identified by during the research. This is supported by McMillan and Schumacher (2010) who say confidentiality can be attained through collecting the data anonymously using a system which does not link names to data collected such as asking the participants to use aliases or numbers, and reporting only group, not individual results.

Informed consent

The aim of the research was explained to all participants before they partook in the research. The participants were also informed of their right to withdraw from the research at any stage without fear of reprisal. Participants needed to agree in writing or to supply information after being informed of and understanding the risks that could be involved (Gay, 2010). Since the learners who were taking part in this research were minors, their parents were therefore required to co- sign the consent forms (McMillan & Schumacher, 2010).

Full disclosure

The researcher was open upfront with all participants as to how the research was to be conducted. The participants were also informed of any likely risks that could occur while taking part in the research. The only foreseeable risk was discomfort. The purpose of the research was also communicated to all participants (Woolfolk 2011: 498). During this research, therefore, no information regarding the research was withheld from the participants.

1.12 Chapter outline

Chapter 1

This consists of an introduction, background of the problem being researched on, statement of the problem, the research questions, aim of the research, motivation for the study, and definition of concepts used in the research.

Chapter 2

This chapter features the theoretical background to the study.

Chapter 3

The research design and methodology followed in this study was presented in this chapter.

Chapter 4

Data collected in the study is presented, analysed and interpreted in this chapter.

Chapter 5

This chapter consists of a summary of the study, recommendations from the researcher, and conclusion to the study.

1.13Chapter Summary

The study was carried out at two schools and a total of 40 learners took part in the study. 20 learners were in each of the two groups (experimental and control). The learners wrote an English Language Proficiency test to establish their proficiency in the language of learning and teaching used at the two schools. This was against the background of previous research which suggests that there is a correlation between the language of instruction and learners'home language.

1.14Conclusion

This chapter detailed the background of the research problem, motivation for the current study, the theoretical framework on which the study was centred, problem statement, hypotheses, research design and methodology. In this chapter limitations of the present study as well as statement on research ethics are included. For clarity some definitions of key concepts used in the study are also included in this chapter.

CHAPTER 2: LITERATURE REVIEW: RELATIONSHIP BETWEEN LANGUAGE OF INSTRUCTION AND ACADEMIC ACHIEVEMENT IN PHYSICS

There is need for schools to provide advanced Physics education to enable learners understand the world around them and be able to solve its scientific problems. This chapter explores the relationship between language of instruction and academic performance in Physics, first and second language acquisition as well as characteristics of a language friendly school.

2.1 Introduction

In science education in South African schools learners have to deal with the new terminology of the subject (Mji & Makgato, 2006) as well as the new language of instruction in which Physics is taught (Van Laere et al., 2014). Teachers are therefore tasked to develop effective ways of teaching both the language of science (Bellens & De Fraine, 2012) and the language of instruction. In a way, Physics teachers face different kinds of challenges in their bi-/multilingual classrooms from English language teachers (Botes & Mji, 2010).

Whereas English language teachers have as their goal fluency and accuracy in English (Martin et al., 2012), Physics teachers have a dual task. They are faced with a daunting task of continuously needing to teach both science and English (where it is the language of instruction) at the same time (Maerten-Rivera et. al, 2010).

In fact, it has been opined that the challenge for many teachers in multilingual South African schools is helping learners to move from where they are unable to understand English language (Rowe, 2013) to where they can communicate Physics in English (Mji & Makgato, 2006). This therefore calls for a good command in the language of instruction.

McNamara (2007) defines language as a code whereby ideas about the world are expressed through a conventional system of arbitrary signals for communications. Language can also be viewed as an arbitrary set of abstract symbols governed by a set of rules that determine how sounds, words and word parts, and phrases can be

combined to make meaning (Landsberg et al., 2011: 126) that enables a person to describe things, ideas, beliefs, and so on (Baumann & Graves, 2010).

All learners in every culture master the complicated system of their native language, unless severe deprivation or physical problems interfere (Woolfolk 2010:52). Language has four features (Baker, 2011; Duke& Carlisle, 2011; Landsberg et al., 2011). The first feature is that language is communicative (Duncan & Murnane, 2011). This means that learners transmit and receive messages through language. Language is also abstract. By this the authors suggest that language is a system of signs and meaningful symbols that represent something.

For example a 5 means there are five ones, or *d* in science means distance. The third feature of language is that it is rule governed. Specific rules have to be followed when using a particular language, for example the Shona language does not have the letters *l*, *q*, and *x*. Language is also social (Garcia & Wei, 2014).

It enables learners to interact with one another, getting to know how the one feels, thinks, and wishes for. The last feature according to these authors is that language is versatile. This means that it can be rearranged and combined limitlessly, and be used to communicate future information.

Communication on the other hand is the interchange of ideas, beliefs, thoughts, feelings, and emotions (Miller 2008: 121) and it can occur through various means, both verbal and nonverbal (Landsberg et. al, 2011). It is actually a process of sharing information between two or more individuals (Canagarajah, 2011). In order to communicate one needs to acquire language first. But how does one acquire a language, be it mother tongue language or additional language?

2.2 Language acquisition

How does one acquire a language, be it first or second language?

2.2.1 First Language acquisition

Language, undoubtedly, is critical for cognitive development because it provides a way to express ideas and ask questions (Woolfolk 2010: 44), the categories and concepts for thinking, and the links between the past and the future (Baker, 2011). A

number of theories have attempted to explain how language is acquired (Beers & Nagy, 2011). Several authors point out that two polarised positions can be adopted in the study of home language acquisition (Duke& Carlisle, 2011; Garcia, 2011 Lesaux, Kieffer, Faller & Kelley, 2010).

The extreme behaviourist position would be that children come into the world with no knowledge about language and that they are shaped by the social and physical environments in which they live (Goldman, 2012). In contrast is the position that children come into the world with a very specific innate knowledge about the nature of language and act upon their environment by developing these bodies of knowledge (Lemmer, 2010). In between these extreme positions many possibilities exist about language acquisition and development (Kieffer & Lesaux, 2012).

Generally, the child's linguistic development depends upon and is the product of the inseparable and interactive influences of maturation and learning that takes place continually in a given environment (Lesaux et.al, 2010). Given a normal developmental environment, children acquire their first language without special instruction, although not without conscious effort and attention to language on the part of the social environment (Duke& Carlisle, 2011).

By the end of the first year they make attempts to imitate words and speech sounds and about this time they utter their first 'words'. By eighteen months children begin to combine words to form two or three word sentences (Lesaux et.al, 2010). By age three children can understand a vast amount of linguistic behaviour and their speech capacity increases (Cummins, 2008).

By about age 5, most children have mastered the sounds of their native language (Owens, 2005), but a few sounds may remain unconquered (Waxman & Lidz 2006). Young children may understand and be able to use many words, but prefer to use the words they can pronounce easily (Woolfolk 2010: 53). By age 6, children's expressive vocabularies will grow to about 2600 words (Woolfolk, 2010) and their receptive vocabulary will be an impressive 20 000 plus words (Owens, 2005).

Moreover they have not only learned the structure of their language but they have learnt all the social functions of language within their own speech community- they have not only learnt what to say but how to say things (Lemmer, 2010). Different

theorists have attempted to analyse what a child learns when they learn a language (Cummins, 2008; Woolfolk, 2010).

Various theories exist which identify and describe the different competencies that are acquired when developing a language (Baker, 2011). Certainly children acquire a set of words as well as the grammatical rules needed for comprehending and producing language with those words (Janssen & Crauwels, 2011). In fact some researchers estimate that learners in the early grades learn up to 20 words a day (Woolfolk, 2010). In the early elementary years, some learners may have trouble with abstract words such as *reaction* or *atom*.

They also may not understand the subjunctive case (“If I were a butterfly”) because they lack the cognitive ability to reason about things that are not true (“But you are not a butterfly”), writes Woolfolk (2010). Learners are able to use their developing cognitive abilities to learn abstract word meanings and to use poetic, figurative language during adolescence (Beers & Nagy, 2011).

In summary salient characteristics of the process under which a child acquires his or her language are that language acquisition commences during infancy in the sphere of intimate human interaction within the parameters of the family and the culture of the child, the young child is immersed in an environment of verbal, functional and communicative language (a distinctive characteristic of middle class Euro- American caregivers is the willingness of adults to engage in communication with the youngest of infants).

The child learns through response to and in imitation of adult models thereby internalising complexities of phonology, morphology, syntax and semantics. The other characteristic is that spoken language is continually modelled and demonstrated to the child in functional and meaningful way by caregivers, and most importantly, the child retains the responsibility for language learning at his/ her own pace (Duncan & Murnane, 2011).

Caregivers convey powerful positive expectations to the young child about the child’s ability to learn language successfully. Long before the child has actually produced its first word; it is treated as if in fact it does have something to say

(Janssen & Crauwels, 2011). An approximation of the child's response is allowed while extended feedback is given by the caregiver (Janks & Makalela, 2013).

However developing a language includes more than just the achievement of grammatical competence (Duke & Carlisle, 2011). Pragmatic competence allows language users to demonstrate their attitude towards what they are hearing and/or saying as well as to adopt different varieties of language so as to fit the social situation (Baker, 2011).

For instance, pragmatic competence allows the speaker to use the appropriate language register for a particular audience and a specific purpose. In a way speakers must learn what to say, to whom and in what situations, actually, to say the right thing in a certain social set up. This is referred to as sociolinguistic competence (Janks & Makalela, 2013; Madiba, 2014). Over and above, speakers need to develop the ability to create coherent discourse whether in speech or writing (Garcia & Wei, 2014).

A competent speaker therefore knows how to start a conversation, contribute to it and to end it. In the same vein, a speaker should be able to express ideas through sentences and paragraphs that constitute a meaningful whole (Msimanga & Lelliott, 2014). This ability refers to discourse competence (Morsy, Kieffer and Snow, 2010).

Finally, speakers of a language need strategies that allow them to communicate when their linguistic resources are limited. If a speaker does not know a term, he or she must be able to paraphrase in order to explain him or herself so that a communication breakdown is avoided (Canagarajah, 2011). This is called strategic competence (Hoff, 2012). Thus when a child acquires his or her primary language, he or she acquires a number of competencies (Nagy & Townsend, 2012).

In the same way acquiring a second language involves a process of becoming competent not only in grammatical forms but in new ways of thinking and looking at the universe which enable the second language speaker to use language effectively for a variety of functions in a wide range of social contexts (Sierens & Van Avermaet, 2010).

2.2.2 First language and Physics education: Benefits and disadvantages

Science plays a central role in society, as it is a catalyst for development and the cornerstone of culture (Van Laere et al., 2014). Because this implies a need for an informed citizenry, education in this area is an important outcome of schooling (Martin et.al, 2012). This is problematic, as different countries worldwide are faced with a serious and persistent gap in academic achievement in Physics, particularly between majority learners (those learning Physics in their home language) and minority learners (Bellens & De Fraine, 2012; Maerten- Rivera et al., 2010).

Recent studies suggest that one of the key factors associated with this achievement gap in Physics education is the language spoken at home (Van Laere et al., 2014). Learners learning Physics in their first language have an advantage over minority learners in that minority learners need to master the language of instruction as well as the academic language (Shaw, Bunch and Geaney, 2010).

In line with previous research carried out, being proficient in the language of instruction and particularly in reading comprehension is positively related to Physics achievement: the higher the learners' proficiency in the language of instruction and especially their performance on reading comprehension, the higher their Physics achievement (Taboada, 2012).

Competence in the language of instruction, should not therefore, be underestimated when it comes to science achievement (Maerten- Rivera et al., 2010; Taboada, 2012; Van Laere et al., 2014): to acquire scientific knowledge and skills, learners need to master Physics literacy (Shanahan & Shanahan, 2008). Regarding the role of first language in Physics achievement, research findings show that minority learners face an extra challenge in performing highly on science subjects (Van den Branden, 2010).

Research on the language demands of Physics and Physics education, especially for learners from non-dominant cultural and linguistic backgrounds, has focused on the relationship between language practices that learners may be familiar with outside of school and those typically associated with the learning of Physics (Jansen & Crauwels, 2011; Shaw et al., 2010), lexical and grammatical features of the language of science (Taboada, 2012; Van Laere et al., 2014).

Some have focused on scientific discourse practices that learners may find alien or even alienating (Clark, Touchman, Martinez- Garza, Ramirez- Marin and Drews, 2012; Maerten- Rivera et al., 2010), and the need for teachers to integrate a focus on Physics content and language (Melby-Lervag & Lervag, 2014; Msimanga & Lelliott, 2014), and none of these have documented any disadvantages of teaching Physics learners in their home language.

2.2.3 Second language acquisition

Seldom do children learn a second or multiple languages under the natural and unstructured conditions similar to the conditions of first language acquisition (Baker, 2011; Garcia, 2011). Most children acquire a second language at an older age, within the formal classroom, in a group or worse still in a more mechanical manner (Madiba, 2014).

Although there are several different theories of second- language acquisition, which are based on a variety of research from different perspectives, certain universal characteristics of the process of second language acquisition can be identified (Garcia, 2011; Woolfolk, 2010).

The second-language learner moves towards a target form of the new language which contains fewer and fewer errors. Certain features such as negation and certain grammatical morphemes are acquired at an early stage in the acquisition of second language (Hoff, 2012), while other forms of language such as the use of prepositions and articles take much longer (Garcia & Wei, 2014).

In several ways, second language acquisition follows the natural sequence of a speaker's first language acquisition: random errors, emergent inter-language, the systematic stage, as well as the stabilisation stage (Aarts, Demir and Vallen, 2011). Firstly, children guess in an unsystematic way (Hornberger & Link, 2012). They then proceed to the second stage of second language acquisition in which they are able to show more consistency in the use of a language item (Beers & Nagy, 2011).

During the third stage the second language learner is able to correct mistakes, when the latter become conspicuous (Martin et.al, 2012). Finally, the second language

speaker is able to apply language rules in a consistent manner (Ernst-Slavit & Mason, 2011). Teachers in the classroom, regardless of the content area they teach, should recognise that children will proceed through this sequence of language acquisition at a very individual tempo (Landsberg et al., 2011), depending on individual differences (Berninger & Abbott 2010), the competencies and skills being learnt (Lemmer, 2010), contextual and situational factors and linguistic inputs (Baumann & Graves, 2010).

While it may only take a child about two years to develop second language proficiency in colloquial everyday language (Murnane, Sawhill and Snow, 2012), research indicates that it takes a significant amount of time, about five to seven years (Hoff, 2012), before second language speakers develop the full range of proficiency they need in order to be successful across all social (Nagy & Hiebert, 2010) and academic contexts (Cummins, 2008).

It must however be noted that second language acquisition does not take place in isolation from first language development (Van Houtte, 2011). Research suggests that first language proficiency and second language proficiency interact with each other (Taboada, 2012) and second language development benefits and builds (Rowe, 2013) on what children know and learn in the first language (Sierens & Van Avermaet, 2010). According to the interdependence hypothesis (Cummins, 2008), language skills learned in the first language can be transferred to the second language (O'Reilly & McNamara, 2007).

It has been posited that particular kinds of skills that are transferred include; metalinguistic knowledge about how a language works (Makalela, 2014a), the organisation and sequencing of discourse similarities (Garcia & Wei, 2014), the relationship of morpho-syntactic systems (Morsy et.al, 2010), the process of pre-literacy including the knowledge that books are to be read (Van den Branden, 2010), handled in a certain way and that they (books) may contain different genres of discourse (Garcia & Wei, 2014).

The interdependence hypothesis suggests that the more developed the primary language, the more readily will competence in the second language be developed (Garcia, 2011). Cummins (2008) propounds that individuals possess what has been

called a common underlying proficiency of knowledge and concepts that develop as they learn and formulate ideas about the universe in which they exist. Once gained this valuable knowledge can be drawn on through any language a person knows or learns (Landsberg et al., 2011).

For instance the brain does not store what is learnt in each language in different compartments (Lambert, 2015) nor does information learnt in one language have to be relearned in another in order to be useful (Lemmer, 2010). As an example, once the child has learnt the concepts of different shapes or colours, they do not have to relearn how to distinguish one colour or shape from the other in another language (Bunch, Shaw and Geaney, 2010).

They will, however, need help in learning new labels for the different shapes and colours and have to practise in incorporating (Shaw et.al, 2010) this new vocabulary into their second language repertoire (Osborne, 2010). Similarly, a child learning to read in a second language would not have to relearn the full range of skills presupposed in initial literacy acquisition (Garcia & Kleifgen, 2010) and the second process is expected to be relatively more economical (Aarts et al., 2011).

Therefore, learners who do not have developed proficiency in first language and whose first language is not supported in the social set up, tend to lose proficiency in the former as they acquire a second language (Melby- Lervag & Lervag, 2014). This is known as subtractive bilingualism (Gu, 2015; Makalela, 2015). Conversely learners who are fluent in the first language and whose first language is respected and its maintenance supported acquire a second language while retaining home language and culture (Lemmer, 2010). This is called additive bilingualism (Baker, 2011; Baumann & Graves, 2010).

Definitely the aim of effective schools should be to provide language minority learners with an additive model of education (Lambert, 2014; Msimanga & Lelliott, 2014). The disadvantages of subtractive language programmes have been extensively documented (Aarts et al., 2011; Janks & Makalela, 2013; Kieffer & Lesaux, 2012a). Consequently plunging learners into English immersion programmes where their first language is neither recognised or used (Lemmer, 2010) and expecting them to become competent users of English (as a language of

learning) in three to four years is unrealistic and irresponsible (Lyon, Bunch and Shaw, 2012).

Learning a second language for academic purposes may require up to seven years (Lambert, 2015) and is dependent on the presence of academic skills in the first language (Makalela, 2015), oral second language proficiency upon entering school (Madiba, 2014), and opportunities to interact with speakers of the second language (Garcia, 2011).

However, some children might be exposed to two or more languages at the same time (multilingual), are they at an advantage? Multilingual children who are learning two languages at once tend to have smaller vocabularies in each language compared to children learning only one (Baker, 2011), at least during childhood, but these size differences depend on the bilingual children's exposure to each language (Woolfolk, 2010) – more exposure, larger vocabulary (Hoff, 2012).

However, the vocabulary of multilingual children is linked to the context where they use each language, so learners are more likely to know more academic words in the language they use in school (Wei, 2011). There is, according to some research, no cognitive penalty for learners who learn and speak two languages (Gu, 2015). In fact, there are benefits.

Higher degrees of multilingualism are correlated with increased cognitive abilities in such areas as concept formation (Makalela, 2015), creativity, theory of mind (Madiba, 2014) cognitive flexibility, and understanding that printed words are symbols for language (Woolfolk, 2010). These findings seem to hold as long as there is no stigma attached to being bilingual and as long as children are not expected to abandon their first language to learn the second (Makalela, 2013).

2.2.4 Learning Physics in the second language: Benefits and disadvantages

As societies become more culturally and linguistically diverse, many learners enter the classroom with a home language that is different from the language of instruction used at school (Van Laere et al., 2014).

In the past, two types of studies have been performed to determine the relationship between language features of test items and concept-teaching and performance of second language learners in content domain assessments, such as Physics (Haag, Heppt, Stanat, Kuhl and Pant, 2013). Most of these investigations, however, were conducted in English-speaking countries (Dehn, 2011). The first type of studies compared the performance of native English speakers and English language learners (Skrandies, 2011) on test items with different levels of language demands (Haag et al., 2013).

The second type of studies analysed differences in item difficulty (Nagy & Townsend, 2012; Pennock- Roman & Rivera, 2011) between English language learners and native English speakers (differential item functioning). In studies of the second type, test items that were found to show differential item functioning (DIF) against English language learners were analysed in terms of their respective language features (Haag et al., 2013).

In the first type of studies mentioned above, most analyses compared the performance of English language learners with that of proficient (native) speakers of English language (Ernst- Slavit & Mason, 2011; Skrandies, 2011). Some of these studies suggest that English language learners score lower (Dehn, 2011; Nagy & Townsend, 2012) on items containing longer item stems than on language-free science items, other studies indicate that English language learners perform worse on items containing more academic language features (Lyon et.al, 2012; Pennock-Roman & Rivera, 2011) than on items with minimal linguistic demands (Haag et al., 2013).

For example given the two questions below, English language learners are more likely to do better in the first question (a) than the second one (b):

(a) Use the formula $F = ma$ to calculate m if;

$$F = 100\text{N}; \quad a = 20\text{ms}^{-1}$$

(b) A lift, with a mass of 250kg, is initially at rest on the ground floor of a tall building. Passengers with an unknown total mass, m , climb into the lift. The lift accelerates upwards at 1.6ms^{-2} . The cable supporting the lift exerts a constant upward force of 7700N. What is the maximum mass, m , of the

passengers the lift can carry in order to achieve a constant upward acceleration of $1.6\text{m}\cdot\text{s}^{-2}$.

This is an indication that performance in Physics of English language learners is affected by the amount of language present in science items, irrespective of its linguistic complexity (Lyon et al., 2012). Other studies explored the relationship of academic language with the performance of English language learners focusing on both lexical (for example unfamiliar words, words with multiple meanings such as field, concentration, pressure, and pronouns) and grammatical (for example passive voice constructions, conditional phrases, complex sentences) features (Haag et al., 2013).

The results from these studies indicated that various linguistic aspects such as grammatical features prevented English language learners from fully understanding science word problems (Van Laere et al., 2014). Similarly other studies (Ernst-Slavit & Mason, 2011; Lyon et al., 2012; Van Laere et al., 2014) demonstrated that reducing the linguistic complexity of concepts and test items in terms of lexical and grammatical features tended to improve the performance of English language learners (Haag et al., 2013).

Multilevel hierarchical regression analyses show that the home language and literacy in the language of instruction play an important role in Physics achievement at the learner level (Van Laere et al., 2014), next to gender and socioeconomic status (Gu, 2015). From studies cited earlier on, it is evident that learners with a home language that is different from the language of instruction experience difficulties with science subjects, Physics included. Moreover, the higher the learners' performance on reading comprehension and self-assessed proficiency in the language of instruction, the higher their score on Physics achievement tests (Van Laere et al., 2014).

Competence in the language of instruction should not be underestimated when it comes to Physics achievement (Maerten- Rivera et al., 2010), to acquire scientific knowledge and skills learners need to master Physics literacy (Taboada, 2012). This means that it is important to become familiar with the cognitively demanding and decontextualized language that is commonly used at

school (Van den Branden, 2010), particularly as learners will be confronted with more content area texts, such as Physics texts (Van Laere et al., 2014).

English language learners are faced with the double challenge of acquiring academic knowledge and skills through a language that they have not yet fully mastered. Although it is generally assumed that learners who are able to converse in the language of instruction can also think abstractly in that language (for example in the domain of Physics), this should not be taken for granted (Van Laere et al., 2014).

The decontextualized language needed for school is an obstacle for many learners, particularly English language learners, as the language and its vocabulary become increasingly complex and less connected to directly observable scientific contexts (Jansen & Crauwels, 2011; Martin et al., 2012).

Based on studies cited earlier on and their findings, my opinion is that English language learners have more disadvantages than benefits when learning Physics in a language different from their home language. The only benefit is that they tend to be exposed to an international language (in the case of English language). Although they can use some of their home language principles to master the second language, the same cannot be said about academic language (Lyon et al., 2012).

2.3 Bilingualism, Multilingualism and education

In order to take a more complex account of language use and match multilingual spaces, classroom language practices of multilingual learners should be characterised by a discursive practice of 'linguaging', which refers to 'social features that are called upon by speakers in a seamless and complex network of multiple semiotic signs' (Garcia, 2011: 7).

2.3.1 Introduction

A lack of exposure to the language of instruction has been put forward as one of the main causes of lower academic performance in science (Makalela, 2015; Shaw et al., 2010; Taboada, 2012; Van Laere et al., 2014). In light of schools' growing

cultural and linguistic diversity in South Africa, it is important for science teachers and schools to recognise this diversity and accommodate it (Msimanga & Lelliott, 2014).

The resistance of recognising linguistic diversity in the classroom is full proof that all controlling devices over language use are ineffective, futile and often counter-productive to content mastery, as learners constantly switch languages (Hornberger & Link, 2012). In some modern divergent science classrooms, alternative pedagogical approaches for multilingual classes have begun to recognise simultaneous use of more than one language for teaching and learning purposes (Clark et al., 2012; Hornberger & Link, 2012; Makalela, 2015).

Multilingualism is the ability to use more than one language (Garcia, 2011). The simultaneous use of more than one language is referred to as translanguaging (Garcia, 2011; Garcia & Wei, 2014; Wei, 2011). Languages previously separated on the basis of cultural and linguistic differences can converge through fluid classroom interactions and enhance learners' content mastery (Makalela, 2014b). For South African indigenous languages, translanguaging brings into focus experienced mutual intelligibility and classrooms as microcosms of social cohesion (Makalela, 2015; Msimanga & Lelliott, 2014).

The traditional language teaching profession has always treated languages as separate and bounded entities (Garcia & Wei, 2014) in order to avoid contamination of one language by the other (Makalela, 2013). This monoglossic practice is imbued by the nation building ideology that began to take shape during the European enlightenment period (Makalela, 2015) and that used separation as a strategy to control and form nation states (Makalela, 2014a).

While the resultant language policing strategy followed the separationist ideology for a long period of time, classroom research has increasingly shown that multilingual learners have always resisted monolingual policy proscriptions in favour of fluid, versatile and mobile discursive resources to accomplish their classroom communicative tasks (Hornberger & Link, 2012). This resistance is full proof that all controlling devices over language use are ineffective, futile and often counter-productive to language and content mastery (Makalela, 2014b; Makalela, 2015).

Associatively, therefore, alternative pedagogical approaches for multilingual classrooms (Madiba, 2014) have begun to recognise simultaneous use of more than one language in classrooms for either language or content subject teaching and learning (Makalela, 2015). This practice of code switching or using more than one language in the classroom is referred to as translanguaging (Garcia, 2011; Garcia & Wei, 2014).

Translanguaging is the dynamic process whereby multilingual language users mediate complex social and cognitive activities through strategic employment of multiple semiotic resources to act, to know and to be (Garcia & Wei, 2014). It is therefore the ability of multilingual speakers to shuttle between languages, treating the diverse languages that form their repertoire as an integrated system (Wei, 2011). Bi-/ multilingual learners make meaning by translanguaging all the time (Garcia, 2011).

A body of research on translanguaging has increased exponentially in recent years (Canagarajah, 2011; Creese & Blackledge, 2010), with more evidence of successful classroom practices reported worldwide (Garcia, 2011; Garcia & Wei, 2014; Makalela, 2013; Makalela, 2014a). Most of the studies focused on translanguaging spaces that are restricted to two languages in the classrooms (Makalela, 2015).

2.3.2 History of African languages separation in South Africa

The history of South African indigenous languages shows two divisive processes, namely, the missionary linguists who put the languages into writing as early as the 1820s (Janks & Makalela, 2013) and the Apartheid policy of separate development legislated in 1948 (Makalela, 2015). One of the widely reported cases of missionary involvement in the separation of African languages is with regard to the Sotho language cluster (Sepedi, Sesotho, and Setswana), notes Makalela (2014b).

Uncoordinated work among different missionary groups from different nation states resulted in the Roman Catholic missionaries working in the southern part of the country (Southern Sesotho), the London missionaries in the west (Western Sesotho) and the Lutherans in the north (Northern Sesotho) where they created divergent orthographic systems that were consequently conceived as representing three distinct Sotho languages (Janks & Makalela, 2013) : Sepedi (by the German

Lutheran missionaries), Setswana (by the London English missionaries) and Sesotho (by the Catholic Italian missionaries).

There was a further division of the Sotho cluster by colonial nation states: Lesotho, South Africa and Botswana which started with the European balkanisation of the African communities in 1884 (Makalela, 2015). The use of different orthographies by the missionary linguists further separated the three Sotho varieties of South Africa from their sister varieties in Lesotho and Botswana (Makalela, 2014b). By the early 1940s, linguistic tribalisation had already been entrenched to the extent that speakers of the same language saw themselves as bounded and separated groups (Janks & Makalela, 2013).

Secondly, the rise of Afrikaner nationalism in 1948 saw the missionary linguistic separation entrenched in tandem with the Apartheid government's adoption of a separate development ideology (Landsberg et al., 2011). Dr H.F. Verwoerd, an architect of Apartheid, developed a blue print for the Group Areas Act that ensured that Africans were separated into homeland reserves on the basis of perceived language differences (Makalela, 2015). He decreed that Africans who spoke different languages stay in separate quarters (Janks & Makalela, 2013).

The result of the decree was a legal division of the languages into ten homelands (Makalela, 2015) as follows: Sepedi (Leboa), Xitsonga (GaZankulu), Venda (Republic of Venda), Setswana (Republic of Bophutatswana), isiNdebele (KwaNdebele), isiZulu (Zululand), isiXhosa (Ciskei and Transkei), SiSwati (Kangwane), and Sesotho (QwaQwa). This separation was extended to temporary reserves (referred to as townships) where migrant Black workers had to stay in different sections based on language differences (Janks & Makalela, 2013).

Naledi in the South Western Townships (SOWETO), for example, was reserved only for Setswana speakers, whereas Shiawelo was a mini-reserve for Xitsonga migrant labourers (Makalela, 2015). Each of these homelands and townships eventually had separate language schools, policies, and radio stations (something still prevalent today), which institutionalised the differences between mutually intelligible language varieties (Makalela, 2015).

This then left English and Afrikaans as the only official languages (Landsberg et al., 2011), and viewed as “the elite languages” (Landsberg et al., 2011). After the new political dispensation in 1994, most if not all black parents strived to have their children attend former Model C schools or any such school where the language of instruction was either English or Afrikaans (Makalela, 2014b) regardless of the cultural differences between their home language and the language of instruction.

2.3.3 Bilingualism, Multilingualism and Translanguaging in education (Past and present)

Multilingualism is the ability to use more than one language (Garcia, 2011). Early scholars of multilingualism, in particular Bloomfield (Garcia & Wei, 2014), only considered native- like control of two languages as a sign of bilingualism. But later scholars, such as Einar Haugen and Uriel Weinreich, had much broader definitions of multilingualism (Baker, 2011; Makalela, 2013; 2014a), perhaps as bilinguals themselves they were aware of its complexity (Woolfolk, 2010). Multilingualism is mostly beneficial where one of the languages is the language of instruction and it can be used to refer to the maintenance of more than one language in a certain context (Makalela, 2014a).

To complete school tasks, and especially assessment tasks, different sets of language skills might be needed (Cummins, 2008). Colin Baker, one of the most perceptive scholars in the field of bilingual education (Garcia, 2011), suggests that the term bilingual education is used to refer to the education of learners who are already speakers of two languages (Hornberger & Link, 2012). Bilingual education from this view, therefore, refers to education in more than one language (Edwards, 2010), often encompassing more than two languages, referred to as translanguaging (Makalela, 2015).

Bilingual education is different from traditional language education programs in that bilingual education programs teach content through an additional language (Mji & Makgato, 2006). Bilingual education provides a general education, teaches in two or more languages (Evans et al., 2010), develops multiple understanding (Cenoz, 2009), and fosters an appreciation for human diversity (Garcia, 2009).Multilingual

education is good for all- language majorities, that is, powerful ethno linguistic groups, as well as language minorities, those without power (Cenoz, 2009).

An education system that is multilingual is good for the rich and the poor (Bellens & De Fraine, 2012), for the powerful and the lowly (Evans et al., 2010), for the indigenous peoples and immigrants, for speakers of official and /or national languages, and for those who speak regional languages (Garcia & Wei, 2014). It has been concluded, by several researchers, that multilingual learners enjoy cognitive and social advantages over monolinguals (Howe & Lisi, 2014).

The use of more than one language in education is not new (Fang 2006). Based on the 16 000 tablets unearthed in Aleppo, Syria, in 1977, it is evident that bilingual schooling is at least 4 000 to 5 000 years old (Garcia, 2009). The tablets were used to teach learners to read and write in Eblaite (a language closely related to Akkadian, spoken in Ancient Mesopotamia and written in cuneiform script) and Sumerian, which by then was a classical sacred language (Edwards, 2010).

After the people of the Mediterranean port of Ugarit developed a sequential alphabetic form of writing around 1 500 BC, bilingual education spread throughout the ancient world (Garcia, 2009). In the East, this sequential alphabet became the Aramaic alphabet which brought about the Persian, Indian, Arabic, and Hebrew scripts. In the West, it became the Greek alphabet, which gave rise to the modern Roman and Cyrillic alphabets (Cenoz, 2009, Garcia, 2009). Multilingualism, by then, was seen as a form of enrichment.

Many schools worldwide have always practised some form of translanguaging through bilingual education (Evans et al., 2010). It has always been common, for example, to offer lessons in two languages during the first years of primary school education, or for the school text to be written in a language or a register different from that spoken by the school learners. Translation of classic texts into vernaculars, one form of bilingual education (Garcia, 2009), has always been central to the notion of schooling, for example the motto for my school reads “*rebatla thuto, we need education*”.

The reading of sacred texts in one language, with the study of commentaries written in another language, and discussion in yet another language, has also been a

traditional way of schooling many ethno linguistic groups (Baker, 2011). The purpose of schooling, and the bilingual practices observed, has been often related to the oscillation between the language practices of the home and community and those of the sacred and classical texts studied in school (Garcia, 2009).

Bilingual and multilingual education has increased tremendously as schools have acknowledged the linguistic heterogeneity of learners. In supporting bilingual and multilingual education for all learners in the world, UNESCO (2003: 17) emphasised the importance of both the global and the national education institutions to consider it and declared:

“the requirements of global and national participation, and the specific needs of particular, culturally and linguistically distinct communities can only be addressed by multilingual education. In regions where the language of the learner is not the official or national language of the country, bilingual and multilingual education can make mother tongue instruction possible while providing at the same time the acquisition of languages and concepts used in the world”.

Multilingual education addresses and redresses the “*melting pot*” theory of past years (Howe & Lisi, 2014) while at the same time affording learners a chance to learn in their mother tongue or preferred language, other than the “colonial language” (Landsberg et al., 2011). Under the aegis of translanguaging approaches, recent scholarship on multilingual development has questioned the validity of perceived linguistic boundaries between languages (Wei, 2011) and argued that languages need to be understood from what speakers do with them (Hornberger & Link, 2012), rather than from their formal structures (Makalela, 2015).

Translanguaging is premised on the recognition of a full account of speakers’ discursive resources (Garcia, 2011) and it posits that languages are not hermetically sealed units (Madiba, 2014) with distinguishable boundaries nor are they capable of being placed into boxes (Makalela, 2015). Instead languages overlap one another in a continuum of discursive resources that are naturally available to multilingual speakers (Wei, 2011). While translanguaging was originally conceived as a classroom strategy for bilingual alternation between English and Welsh (Baker,

2011), another researcher in the field of bilingual education, Garcia has explained it to account for multilingual communicative practices outside the classroom.

Garcia's expansion includes a wide array of multiple discursive practices in spatial, visual, and spoken modes (Makalela, 2015). In order for her to emphasise the fluidity of these communication resources, Garcia uses a metaphor of an all-terrain vehicle 'whose wheels extend and contract, flex and stretch, making possible, over highly uneven ground, movement forward that is bumpy and irregular but also sustained and effective' (Garcia, 2011). When framed in this light, this view is inclusive of all communication styles, registers, and repertoires that characterise multilingual communication (Makalela, 2015).

In a way it emphasises versatile ways of communicating and contrasts with the conventional views of languages as bounded entities (Hornberger & Link, 2012). The advanced understanding of the notion of translanguaging spaces reveals that monolingual classroom practices in multilingual settings can be limiting and inhibiting of full creative expressions (Makalela, 2015). Research has shown negative effects of monolithic and linear approaches to language teaching as well as the teaching of other content areas globally (Garcia, 2011).

Many South African learners who come from linguistically hybrid townships where they speak a variety of languages, for example, tend to be disadvantaged educationally because they do not fit the profile of schools who think 'monolingually' (Makalela, 2013). Despite today's restrictive monolingual proscriptions in the majority of the classrooms in South Africa, bilingual and multilingual learners have shown the tenacity to transform monolingual classrooms, and achieve better results in most subject areas where translanguaging was permitted (Makalela, 2014b; Makalela, 2015).

Schools that have experimented with translanguaging as a pedagogical strategy elsewhere in the world have also shown success within their programmes (Creece & Blackledge, 2010; Garcia, 2011; Gu, 2015; Van Laere et al., 2014; Wei, 2011). Research reveals the benefits of translanguaging to include the following: ability by the learners to engage audiences through translanguaging and heteroglossia, endorsement of simultaneous literacies and languages to keep the pedagogic task

moving, establishment of identity positions, and improved academic performance (Creece & Blackledge, 2010).

Research on the success of translanguaging practices in educational contexts has provided opportunities for experimentation with indigenous African languages in South Africa (Madiba, 2014; Makalela, 2014a). The use of Tshivenda, isiXhosa, and English simultaneously in science courses at the University of Cape Town has proved effective in enhancing science literacy among the university students (Madiba, 2014). It has been observed that one of the challenges for African languages is to broaden the perceived 'standard' varieties to include the non-standard varieties that are often excluded from classroom oral and written discourses (Makalela, 2013).

In the educational fraternity, African languages have to date been treated as separate units (Makalela, 2014a), with teaching following the strict orthographic rules of the missionary linguists of the eighteenth century (Makalela, 2014a). Evidently there is a paucity of research on the use of discursive resources in African languages which could help broaden the scope of translanguaging to complex multilingual contexts where speakers have competencies in more than two languages (Makalela, 2015).

As an epistemic resource, an integrated multilingualism in the South African context resonates with the *ubuntu* continuum that is characteristic of a cultural ethos commonly shared by all citizens in the country (Makalela, 2014a; 2014b). It is on the basis of this plural way of being and seeing the world that local methodologies can be conceived for multilingual learners.

2.3.4 Translanguaging and Physics education

While South Africa presents optimal multilingual spaces for simultaneous use of more than three languages in its diverse classrooms (Makalela, 2015), research on translanguaging in Physics education is still in its infancy. Research carried out, however, points to epistemic advantages of using plural language practices in classes (Makalela, 2013; Makalela, 2014b; Wei, 2011). Translanguaging is the purposeful pedagogical alternation of languages in spoken and written, receptive and productive modes (Garcia, 2011; Garcia & Wei, 2014; Hornberger & Link, 2012).

A body of research on translanguaging, worldwide, has increased exponentially in recent years, with more evidence of successful classroom practices reported (Canagarajah, 2011; Makalela, 2014a). Recently, psycholinguistic research into translanguaging has also been carried out (Makalela, 2015). Wei (2011) has, for example, studied the psycholinguistic notion of *Languaging*, which is understood as the process of using language to gain knowledge, to make sense, to articulate one's thought and to communicate about using language (Makalela, 2013).

In this context, translanguaging refers to a process of going on between different linguistic structures and systems, including different modalities and going beyond them (Wei, 2011). This is an advantage to multilingual science learners (Shaw et al., 2010) as they make use of their discursive space in making context-sensitive and strategic choices from language systems they have at their disposal to achieve particular communicative and academic goals (Lyon et al., 2012; Madiba, 2014).

In a British monolingual schooling culture, for example, Wei (2011) investigated translanguaging spaces through a combination of observation of multilingual practices and metalanguage commentaries by Chinese- English bilingual learners. Analysis of the data, using a moment-by-moment analysis technique, revealed that the Chinese learners were able to create critical and creative spaces for themselves using the resources they had, despite the dominant monolingual context of schooling (Makalela, 2015).

The use of translanguaging in classes such as science has both cognitive and social advantages that are not typically associated with one- language medium classroom interactions (Baker, 2011; Lyon et al., 2012; Madiba, 2014). Learners tend to break down the concept and translate them into a language they understand (Shaw et al., 2010). Translanguaging presents opportunities for English learners to expand the means at their disposal to learn and demonstrate science understanding and skills and create spaces for them to further develop proficiency in English (Shaw et al., 2010).

For example, instead of having to demonstrate knowledge solely through the use of one language, translanguaging allows science learners to demonstrate what they know and can do through the use of a language they have the most proficiency

(Shaw et al., 2010). Research shows that plural orientation in the medium of learning enables multilingual learners to use all discursive resources at their disposal and allows them opportunities to perform well academically (Makalela, 2015).

One would therefore argue that translanguaging provides superior cognitive gains for multilingual learners through the simultaneous endorsement of literacies and languages by embracing all languages at the multilingual learners' disposal (Creese & Blackledge, 2010). In the academic world there are over 150 studies that show that additive bilingualism has positive effects on learners' cognitive, linguistic and academic growth (Cummins, 2008). Additive bilingualism involves the simultaneous support, development and use of learners' home language as learning takes place in a different language (Madiba, 2014).

The theory of additive bilingualism is supported by Cummins' language interdependence principle which suggests that skills gained while acquiring one's home language can be transferred and used in the acquisition of the second language (Cummins, 2008). The additive bilingualism theory asserts that bilingualism can positively affect both a learner's intellectual and linguistic progress. Several studies report that bilingual children show greater sensitivity to linguistic meanings and are more likely to be flexible in their thinking than monolingual children.

For example those carried out by Cummins and Swain (1986), Diaz and Hakuta (1985), and Diaz (1986) all cited by Cummins (2008). According to Cummins, "the development of additive bilingual and biliteracy skills entails no negative consequences for children's academic, linguistic or intellectual development. On the contrary, although not conclusive the evidence points in the direction of subtle metalinguistic, academic and intellectual benefits for bilingual children," (Cummins 2008: 6).

Beyond the affective, social, and cognitive advantages that come with translanguaging strategies (Makalela, 2015) for multilingual Physics learners (Garcia & Wei, 2014) research also reveals that the fluid use of languages can be harnessed as a methodology that is both linguistically and culturally transformative. Clearly, the scope for translanguaging in South African Physics classrooms is sufficiently wide to

include blending of several languages and multilingual spaces that cross within and between language clusters.

It is within this complex and multi-layered language mixing as a social practice that translanguaging can be seen as indexical of the plural sense of being, *ubuntu*, which is shared across a wide spectrum of speakers of indigenous African languages (Makalela, 2014b; Makalela, 2015). Hence beside academic gains, translanguaging in Physics also fosters a sense of belonging, oneness, and unity (Van Laere et al., 2014).

2.4 Language and Physics

The following literature presents a microscopic view on the relationship between proficiency in the Language of Learning and Teaching (LoLT) and academic achievement in Physics.

2.4.1 Language proficiency and Physics achievement

Language is critical for cognitive development (Woolfolk, 2010) as it provides the concepts for thinking and therefore a means for expressing ideas and asking questions (Botes & Mji, 2010). In agreement with this view, it has been argued that people use words to construct their interpretation of experience, and that our experiences shape our language (Fleisch & Shindler, 2007), and in the culture of schools a concept does not exist until it has been named and its meaning shared with others (Botes & Mji, 2010).

Several researchers (see Du Plessis & Louw, 2008, Torres & Zeidler, 2010, and Van Laere et al., 2014) emphasise that the interplay of language and the development of thinking needs serious attention, not only in language education, but also in all learning areas. These researchers are of the view that teachers can encourage learners to be aware of their own thought processes, and to engage actively in inappropriate thinking by using precise terminology, through posing critical questions, clarifying ideas and processes, as well as withholding value judgements (Botes & Mji, 2010).

Therefore, an issue pertinent to the achievement of language minority learners (those taught in a language different from their home language) is the relationship between proficiency and academic achievement (Martin et al., 2012). The focus of high school education has largely been on Physics as a practical subject, often quite rightly, for Physics is partly an empirical subject (Van Laere et al., 2014). But for many learners the greatest obstacle in learning Physics- and also the most important achievement- is in learning Physics (Shanahan & Shanahan, 2008).

One of the important features of Physics is the richness of the words and terms it uses (McCallum & Miller, 2013). The debate about language in science education goes back a long way. Two of the fashionable authors of the 1970s (Postman and Weingartner) wrote:

“almost all of what we customarily call ‘knowledge’ is language, which means that the key to understanding a subject is to understand its language. A discipline is a way of knowing, and whatever is known is inseparable from the symbols (mostly words) in which the learning is codified. What is science (for example) other than words? If all the words that scientists use were subtracted from the language, there would be no science” (Rowe, 2013).

This means, of course, that every teacher is a language teacher: teachers, quite literally, have little else to teach, but a way of talking and therefore seeing the world” (Rowe 2013). Four years later the Bullock Report was published in the United States of America, which advocated that all teachers should see themselves as teachers of language. One specific suggestion was that Physics teachers should examine the dialogues which go on in the classroom so that they can become skilful in ‘orchestrating it’ (Msimanga & Lelliott, 2014).

Hence, Physics teachers are, among other things, language teachers. It should be noted, however, that there is far more to science communication than verbal language that is the spoken and written word (O’Reilly & McNamara, 2007). Words are important, but in Physics more than any other subject, we rely on a combination and interaction of words, pictures, diagrams, images, animations, graphs, equations, tables, and charts (Taboada, 2012). The difficulty the language of Physics poses for

many low-literacy EAL learners has long been documented in the literature (see Miller, 2009).

The academic language of a textbook is far removed from the everyday conversational language use with which learners are familiar (Cummins, 2008, Gibbons, 2009), for example, momentum, electrolyte, galvanic cell, velocity (Physical Sciences CAPS document 2011: 4). Not only does the language present a huge challenge for low-literacy EAL learners, the key concepts are complex and situated within a body of assumed knowledge that these learners do not generally have due to interrupted schooling and limited previous access to print literacy (McCallum & Miller, 2013).

Researchers investigating the possible causes of underachievement among language minority learners have distinguished between the use of language in informal daily scenarios and language used in academic situations (Aarts et al., 2011; Hornberger & Link, 2012; Madiba, 2014; Makalela, 2015). They argue that reading a textbook or writing a report makes quite different demands on a person compared to talking to a friend.

In educational contexts, it was observed that although language minority learners were able to converse in peer-appropriate ways (Lemmer, 2010) in face-to-face situations in a second language (Gu, 2015), the learners encountered difficulties in manipulating language in decontextualized academic situations (Baumann & Graves, 2010; Janks & Makalela, 2013). This discrepancy in what has come to be called basic interpersonal communicative skills (BICS) and cognitive academic language proficiency is a useful distinction for today's teachers (Cummins, 2008).

Cummins (2008) suggests that cognitive academic language proficiency (CALP) enables the learner to learn in a context, which relies heavily on oral explanation of abstract or decontextualized ideas, as opposed to basic interpersonal communicative skills (BICS). This is often the context in which high school science is taught (Gibbons 2009), with unfamiliar events or topics being described to learners with little or no opportunity to negotiate shared meaning (Fang, 2006, Miller, 2009).

According to Cummins (2008) learners who have not yet developed their CALP will be at a disadvantage in such settings.

Actually according to Cummins (2008) learners require both BICS and CALP to achieve optimally in the school situation. Where there is language deficit in the area of CALP, learners lack the language proficiency to master academic content and to become proficient in school discourse (Van den Branden, 2010). The lack in the academic dimension of language proficiency on the part of the language minority learner often goes unnoticed by several teachers (Ernst-Slavit & Mason, 2011). It is normally hidden on the playground or in everyday conversation because the learners have already acquired informal, colloquial language or BICS (Cummins, 2008).

The latter consist of the 'visible' aspects of language such as pronunciation, basic vocabulary and grammar which allow learners to converse fluently in undemanding daily scenarios (Melby-Lervag & Lervag, 2014). However, in order for learners to achieve academic success, a more sophisticated command of language or CALP is necessary (Bellens & De Fraine, 2012). Learners must be able to use a language to: grasp concepts, establish relationships between concepts or information sets, analyse, classify, store and retrieve information, and articulate information processed in oral and written form (Cummins, 2008; Rowe, 2013).

Language minority learners are actually able to demonstrate higher order thinking, such as generalising, hypothesising, and arguing in their home language (Garcia, 2011). Yet they lack the CALP required to carry out higher order cognitive operations through the medium of English language which is used as the language of instruction in most South African schools (Makalela, 2014a; Msimanga & Lelliott, 2014). Consequently, teachers in the multicultural classroom report that language minority learners experience difficulty with academic concepts and terminology (Lambert, 2015) because these terms and ideas are more abstract, less easily understood and experienced than ideas and terms used in social interaction (Canagarajah, 2011).

In most cases teachers do not realise that this cognitive difficulty is due to language and may ascribe it to a lack of intellectual ability on the part of the learner (Gu, 2015). In the same vein, BICS and CALP have been linked to visible and quantifiable aspects of language and to less visible and easily measured aspects respectively. Baker (2011) linked the metaphor to Bloom's taxonomy of educational objectives to the BICS and CALP distinction using the image of an iceberg (see Figure 1.1).

Above the surface of the water line are the language skills of pronunciation, vocabulary (BICS).

Considering this argument, according to Cummins (2008), BICS would be sufficient for the surface level of cognitive processing, that is: recall (remembering something previously encountered or learned), comprehension (grasp of basic meaning without necessarily relating it to other material), and application (use of abstractions in particular and concrete situations). Cummins (2008) goes on to suggest that under the surface the deeper levels of cognitive processing are linked to CALP. These deeper levels comprise: analysis (breaking down a whole into its parts so that the organisation is clear), synthesis (putting elements into a coherent whole), and evaluation (judging the adequacy of ideas or material for a given purpose).

Another useful distinction has been made between context-embedded and context-reduced communication. In context-embedded communication learners can actively negotiate meaning and language is supported by a wide range of paralinguistic or situational cues, such as body language (Garcia, 2011). This comprises a cognitive undemanding situation where a person has mastery of language skills sufficient to enable easy communication. On the other hand during context-reduced communication there are very few cues to convey meaning (Cummins, 2008).

The communication largely relies on linguistic cues to meaning and may even involve suspending knowledge of the real world in order to manipulate the logic of the message. This comprises a cognitive demanding situation where information must be processed quickly without accompanying situational clues (Baker, 2011). Classroom communication is characterised by cognitively demanding tasks and the range of contextual support and degree of cognitive involvement in a variety of classroom activities is illustrated in Figure 1.2.

While second language learners may understand and participate in social conversations in everyday life quite well, they are expected to have more problems with academic language (Haag et al., 2013), which makes it difficult for them to fully understand classroom discourse as well as academic readings and tasks. This certainly does not mean that that social language is inherently or generally less sophisticated than academic language (Martin et al., 2012), yet the two language

registers are assumed to differ in certain aspects (Haag et al., 2013), particularly in the relative frequency of complex grammatical structures (Lesaux et al., 2010), specialised vocabulary (Gu, 2014), and uncommon language functions (Haag et al., 2013).

Based on the theoretical assumptions described above, academic language can be conceived as the language that is spoken in the classroom (Van Laere et al., 2014) or other academic contexts in order to impart and acquire knowledge (Cummins 2008; Haag et al., 2013). To capture characteristics of academic language in texts and instructions of test items, they can be rated in terms of various descriptive, lexical, and grammatical criteria (Haag et al., 2013). Descriptive features include the overall number of words and average sentence length (Haag et al., 2013; Lambert 2015). These features are relatively difficult (Wei, 2011), with longer sentences posing greater challenges for readers (Hornberger & Link, 2012).

Lexical features encompass general academic vocabulary, which is used across school subjects and disciplines (Howe & Lisi, 2014), as well as specialised academic vocabulary (Landsberg et al., 2011), which is associated with a specific discipline (Garcia & Wei 2014). These words are usually abstract and semantically opaque (Haag et al., 2013). Grammatical features that tend to appear in academic contexts more often than in everyday language are mainly verb forms in passive voice (Haag et al., 2013), prepositional phrases (Shaw et al., 2010), noun phrases, and participial modifiers (Dehn, 2011).

Other researchers (Bowering, 2005; Dawes 2004; Melby- Lervag & Lervag, 2014; Van Laere et al., 2014) adapted Cummins' model, to explain in part, the academic performance in science of EAL learners (see Figure 1.2). The horizontal continuum deals with the degree of contextual support available for meaning making and ranges from context embedded to context reduced. Context-embedded communication occurs when language is supported by meaningful concrete, visual cues, and when learners and teachers together can negotiate meaning for example, by means of feedback or any other form of communication (Torres & Zeidler, 2010).

At the other end of the continuum is the context-reduced communication, which depends on linguistic cues for meaning (Mji & Makgato, 2006). The vertical

continuum deals with at the top, the tasks or activities in which learners have mastered the language necessary to perform them (Torres & Zeidler, 2010). These tasks or activities are considered to be cognitively undemanding. The bottom of the continuum, on the other end, represents activities that are cognitively demanding (Mji & Makgato, 2006), because they require language skills that have not been mastered (Van Laere et al., 2014).

As a result authentic language proficiency requires proficiency in both BICS and CALP while attention must be given to the kind of contextual support (Lambert, 2015) and the degree of cognitive involvement acquired through execution of learning tasks (Aarts et al., 2011). Furthermore, the determination of a learner's proficiency levels in BICS and CALP is no straightforward matter. Tests assessing language proficiency based on BICS might show learners to be quite fluent (Bake, 2011; Lemmer, 2010), however, tests which require cognitive operations to be carried out show that this surface fluency is not equally reflected in CALP (Cummins, 2008).

In the same vein, tests assessing intelligence, aptitude and interest may not render accurate results as learners not proficient in the language of instruction are often unable to complete many of the activities correctly (Garcia & Wei, 2014).

The distinction between BICS and CALP is that the former refers to conversational fluency in everyday informal speech (Gu, 2015). The latter is a dimension of language strongly related to general cognitive skills and academic performance (Bunch et al., 2010; Martin et al., 2012). Evidence in support of this notion comes from the observation that native speaking children acquire conversational fluency at an early age, while their academic language use develops throughout their schooling and beyond (Gu, 2015). Physics concepts can be highly abstract in that they involve re-naming and re-contextualising every day or familiar words or ideas (Martin et al., 2012; Van den Branden, 2010; Rowe, 2013).

For example, in Physics texts, concepts such as impulse, velocity, displacement, or power (Physical sciences CAPS document, 2011) are re-situated within broader processes or phenomena. Understanding this involves linguistic, conceptual and cognitive shifts that teachers tend to assume will be easy to make (Fang, 2006).

However, for low-literacy learners this is a seismic shift, which needs to be carefully scaffolded if learners are to comprehend the scientific context and content (Huang & Morgan, 2003). In most schools in South Africa, the language used in Physics lessons is often context reduced or decontextualized (Botes & Mji, 2010).

In other words, the concepts or topics being described to the learner are unfamiliar and there is little or no opportunity to negotiate shared meaning (McCallum & Miller, 2013). Presenting a new scientific concept to high school learners, therefore, is an example of context reduced language because the information presented may be abstract (Mji & Makgato, 2006), for example Forces (Physical Sciences CAPS Document, 2011), and unrelated to the learners' everyday activities, for example resolving vectors (Physical Sciences CAPS document, 2011).

Based on my experience as a Physics teacher, in order to make material comprehension to low-literacy English language learners, scaffolding needs to be done in the learner's mother tongue. The only problem with this view is that in mainstream classes, the primary focus is on delivering the Physics curriculum, rather than language-focused Physics content that is accessible to all learners (McCallum & Miller, 2013). Learning Physics is, in many ways, like learning a new language. In some ways it presents more difficulty in that many of the hard, conceptual words of science- such as energy, power, and work- have a precise meaning in Physics and sometimes an exact definition, but a very difficult meaning in everyday life (Taboada, 2012).

Physics education hence involves dealing with familiar words, like work and field, and giving them new meanings in new contexts (McCallum & Miller, 2013). Equally, many of the 'naming' words of our lives have been commandeered by science (Botes & Mji, 2010), consider: element, conductor, cell, field, circuit, compound. This is made worse because many of the terms of Physics are metaphors; for example, a field in science is not really a field. Physics education also involves introducing new words- sometimes in familiar contexts (for example tibia, fibula) but at other times in unfamiliar contexts (for example allele, enzyme, longitudinal), note Lesaux, Kieffer, Kelley and Harris (2014).

Another category of language which Physics teachers use has been christened the 'language of secondary education'. The list includes terms such as modify, compare, evaluate, hypothesise, infer, recapitulate... and so on (Landsberg et al. 2014; Lesaux et al., 2014). These are words used by teachers and also found in examination papers but rarely heard in play grounds. A primary challenge in today's multicultural schools is to meet the needs of learners from linguistically diverse backgrounds who have a limited English proficiency (Baker, 2011). While language minority learners may be labelled by their lack of good English speaking skills (Van Houtte, 2011), they are in fact a very diverse group.

They frequently differ in many aspects such as ethnicity, age, gender, and language background (Garcia, 2011), communicative needs (Rowe, 2013), their levels of proficiency in a second language (Msimanga & Lelliott, 2014), their attitudes towards the second language (Landsberg et al., 2011), and their cognitive styles (Botes & Mji, 2010). As language minority learners enter an English medium institution, they bring with them a wealth of cognitive (Taboada, 2012), social (Goldman, 2012), and linguistic skills (Nagy & Townsend, 2012) which have been developed in their first language (Berninger & Abbott, 2010).

Unfortunately, most schools are of the opinion that if this prior knowledge is not stored in English, it does not exist at all (Morsy et al., 2010). Based on this misconception, most schools may fail to address the needs of these language minority learners (Lesaux et al., 2014). Consequently, these learners' access to academic knowledge might be delayed and they may also be hindered from full participation in school, contributing to a sense of social alienation (Shaw et al., 2010). Research suggests that proficiency in the language of instruction influences learners' performance in science subjects (Taboada, 2012).

Language proficiency refers to the ability of an individual to speak or perform in an acquired language (Gu, 2015). Gottlieb (2004) came up with five English language proficiency standards (also called levels) that reflect the social and academic dimensions of acquiring a second language that are expected of English language learners in grade levels R to 12. Overall, the language proficiency standards (or levels) centre on the language needed and used by English language learners to

succeed in school, and are explained as follows (Gottlieb, 2004; Lambert, 2015; Landsberg et al., 2011):

English Language Proficiency Standard 1:

English language learners communicate in English for social and instructional purposes within the school setting. These are also referred to as *extremely limited users* and can understand only isolated words. They have great difficulty in understanding structures, but may give some correct responses to questions of a simpler kind. Their comprehension level is very low even for simple texts, and their proficiency score is between 0- 19%.

English Language Proficiency Standard 2:

English language learners communicate information, ideas, and concepts necessary for academic success in the content area of Language Arts. These learners are also referred to as *limited users* as their basic competence is limited. They have frequent problems in understanding non- factual information and will not be able to exercise skills needing inference and interpretation.

These learners normally score very low in reading as well as grammar and cloze (will not understand the overall coherence of the passage) and may not be able to answer questions pertaining to text organisation. Their proficiency score ranges from 20- 39%.

English Language Proficiency Standard 3:

English language learners communicate information, ideas, and concepts necessary for academic success in the content area of Mathematics. These learners are also referred to as the *modest users*.

These learners exhibit partial command of the language, coping with overall meaning in most situations, though they are likely to make many mistakes in interpretation and in understanding structures and writing conventions. They are, however, able to handle basic communication reflected in some knowledge of grammar and vocabulary. Their proficiency score is between 40- 59%.

English Language Proficiency Standard 4:

English language learners communicate information, ideas, and concepts necessary for academic success in the content area of Physics and are referred to as competent users. They generally have adequate command of the language despite some misunderstandings and inaccuracies. These language users have a good understanding of some conventions in writing, and can interpret a text, know the structures, and exhibit confidence in using the language. They are found in the performance range of between 60- 79%.

English Language Proficiency Standard 5:

English language learners communicate information, ideas, and concepts necessary for academic success in the content area of Social Studies, and are also referred to as good users.

These language users have operational command of the language and generally handle complex language well and understand detailed reasoning, reflective of a certain degree of analytical and interpretive skills. They have a range of vocabulary and can understand complex structures. They are also aware of the structure of organisation and coherence in texts. Their proficiency score is above 80% (Gottlieb, 2004; Lambert, 2015; Landsberg et al., 2011).

Each of the English language proficiency standards encompasses four domains: listening, speaking, reading, and writing (Lesaux et al., 2014). The language domains reflect the modality of the communication that is further delineated by the language proficiency levels and their model performance indicators (Baumann & Graves, 2010; Beers & Nagy, 2011). The definitions of the language domains in the learning of English language are as follows:

Listening – process, understand, interpret, and evaluate spoken language in a variety of situations.

Speaking – engage in oral communication in a variety of situations for an array of purposes and audiences.

Reading – process, interpret, and evaluate written language, symbols and text with understanding and fluency.

Writing – engage in written communication in a variety of forms for an array of purposes and audiences (Berninger & Abbott, 2010; Gilbert & Graham, 2010; Goldman, 2012).

According to researchers in language learning, there is a set of conditions that shape the acquisition process. Among them is the recognition that individual language learners vary in their productive and receptive skills (Keiffer & Lesaux, 2012a), with receptive language (listening and reading) generally developing prior to and to a higher level than productive language (speaking and writing). Hence English language learners may not be at a uniform level of English language proficiency across the four domains (Keiffer & Lesaux, 2012b).

Unless English language learners have been schooled in the native language, their oral language or literacy may not be fully developed for their age level (Lesaux et al., 2014). Their differential language acquisition in the four domains must be taken into consideration in instructional planning and assessment (Beers & Nagy, 2011; Lyon et al., 2011).

The five language proficiency levels outline the progression of language development implied in the acquisition of English as an additional language, from 1, Entering the process, to 5, Bridging to the attainment of academic content standards (Goldman, 2012; Kieffer & Lesaux, 2012b). The language proficiency levels delineate expected performance and describe what English language learners can do within each domain of standards as represented diagrammatically below:

Table 2.1: English Language Proficiency Standard 4: English language learners communicate information, ideas, and concepts necessary for academic success in the content area of SCIENCE, grade 9 to 12.

Domain	Level 1 Entering	Level 2 Beginning	Level 3 Developing	Level 4 Expanding	Level 5 Bridging
Listening	Locate physical, biological, chemical, or earth/space structures from pictures and oral statement (such as cells, magnetism atoms)	Different types of physical, biological, chemical, or earth/space structures from pictures and oral statements (such as compound, solar systems)	Match the functions of related physical, biological, or chemical structures from oral descriptions (such as atomic/nuclear structures)	Compare/contrast the functions of related physical, biological, or chemical structures from oral descriptions (such as fossils, melting/boiling points)	Match analogies (of the functions) of related biological, chemical, or physical structures from oral description from grade level science text
speaking	Identify parts of systems, chains, or cycles from diagrams or graphic	Give examples of or describe component of systems, chains, or cycles	Describe how systems, chains, or cycles operate from diagrams or graphic	Discuss how systems, chains or cycles are interdependent (such as ecosystems or respiratory systems)	Explain and give examples of the principle of interdependence of systems or the iterative nature of chains and cycles (such

	details (such as taxonomy systems, food chains, or life cycles)	from diagrams, or graphic organisers (such as functions of veins and arteries of the circulatory system)	organisers (such as solar system or water cycle)		as endocrine system or mechanics)
Reading	Identify data from scientific studies from tables, charts, or graphs	Match sources of data depicted in tables, charts, or graphs from scientific studies with research questions	Extract information on the use of data presented in text and tables	Interpret data presented in text and tables in scientific studies	Evaluate scientific data and discuss the implications of the studies presented in grade level text
Writing	Draw pictures and label steps in scientific work	State procedures for scientific experiment in biology, chemistry,	Provide information learned from scientific experiments in a lab report,	Interpret findings gleaned from data from scientific experiments	Justify conclusions reached from examining scientific data

		or physics	including pre- experiment predictions		
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(Gottlieb,2004).

While Physics achievement may seem to have little to do with language skills at first sight, research suggests that literacy plays a significant role in Physics education (Van Laere et al., 2014): all learners must acquire scientific knowledge and skills through gradually mastering a new kind of language, characterised by a specific vocabulary, a high level of abstraction, and limited contextual support (Van den Branden, 2010). Proficiency in the language of instruction therefore plays a pivotal role in Physics education (Gu,2015).

This is highly challenging for learners who are being taught in a language different from their home language: not only do they have to acquire new scientific skills- just like those taught in their home language- but they must do so also in the language of instruction (Lyon et al., 2011), which they have often not yet fully mastered (Goldenberg, 2008; Van Laere et al., 2014). The new literacy that Physics learners must acquire in order to perform well in Physics is known under different but related names: disciplinary literacy, decontextualized language, and cognitive academic language proficiency (Gu, 2015; Lyon et al., 2011; Van Laere et al., 2014).

In terms of disciplinary literacy, two researchers Shanahan and Shanahan (2008) distinguish three consecutive levels. Basic literacy refers to the relatively simple process of decoding words (as in the levels 1 and 2 of the English language proficiency standard 4 in the figure above), intermediate literacy relates to basic fluency, broad word knowledge, and comprehension strategies to deal with texts (Van Laere et al., 2014). Disciplinary literacy concerns the mastery of specific concepts and discourses used in science. Disciplinary literacy is closely related to the concept of decontextualized language, as presented by Cummins (2008) in the theory of language acquisition, which refers to abstract language that is distant from the here and now (Rowe, 2013).

In their early language development stages children highly use contextualised language (for example through pointing, labelling, and facial expressions) and then gradually develop the capacity to produce more decontextualized language (Miller, 2009), particularly once they enter school (Fang, 2006). Learning to master decontextualized language is often very challenging due to the associated skills required, such as abstract thinking, an underlying assumption of causality, and mastering a relatively complex vocabulary and grammar, all of which imply an advanced level of language proficiency (Msimanga & Lelliott, 2014; Van Laere et al., 2014).

Most classroom activities are characterised by context- reduced and cognitively demanding communication (Msimanga & Lelliott, 2014), with Physics education as one of the most obvious examples: Physics is concerned with describing phenomena (Aarts et al., 2011), conceptual reasoning, as well as organising, applying, and evaluating new information (Van den Branden, 2010). The relationship between a learner's proficiency in the language of instruction and their performance in Physics has been found to come to the fore as early as primary school level (Maerten- Rivera et al., 2010), where reading ability is found to play a significant role (Hornberger & Link, 2012).

Reading comprehension entails knowledge of specific vocabulary (Martin et al., 2012), text structures, and strategies (Garcia & Wei, 2014), which have to be applied in learning areas. As these texts are used more frequently from senior primary school onwards, the ability to comprehend language area material is crucial for learners to succeed in school (Shanahan & Shanahan, 2008; Taboada, 2012). Also, Taboada (2012) shows that knowledge of vocabulary significantly contributes to the comprehension of science material with both learners learning in their home language or those whose language of instruction is different from their home language, even after accounting for proficiency in the language of instruction.

Cremer and Schoonen (2013) argue that language minority learners (those whose language of instruction is different from their home language) do not so much fail on the foundation skills of the language of instruction, such as word decoding, but fall behind in comprehension skills, namely vocabulary knowledge and reading comprehension. Furthermore, their word knowledge is more context- specific and

less meaning based than that of learners being taught in their home language (Rowe, 2013). As a result a large gap in performance levels exists between these two groups of learners (Murnane et al., 2012).

Performance assessments play a critical role in science education reform (Lyon et al., 2012). By evaluating learners' ability to perform specific tasks and the products they create in the process, performance assessments more directly measure key inquiry-based skills, such as conducting a scientific investigation, as opposed to traditional paper-and-pencil tests (Lyons et al., 2012). As with assessments in other subject areas, assessing in science also measures a learner's proficiency in the language of assessment/instruction (Bornman & Rose, 2010).

There is a large number of non-native speakers of English in South African schools (Landsberg et al., 2011) whose content area achievement is being assessed in English (Makalela, 2014b). This reality adds further urgency to equity concerns regarding the issue of language and assessment (Lyon et al., 2012).

2.4.2 Use of language in Physics assessment

Research on language in Physics education has focused on a variety of topics, such as the particular functions of language in Physics classrooms (Lesaux et al., 2014; Kieffer & Lesaux, 2012a; Nagy & Townsend, 2012), the relationship between the language practices familiar to non-dominant learners and those found in Physics classrooms (Barton & Tan, 2009), and the ways in which language in Physics may alienate some learners and preclude them from participating in scientific discourse (Gu, 2014; Van Laere et al., 2014; Shaw et al., 2010).

In terms of assessment, numerous studies document significant links between learners' level of proficiency in the language of instruction and their performance in content-based assessments (Lambert, 2015; Makalela, 2015; Shaw et al., 2010). Studies focusing on the reading and vocabulary demands of multiple choice assessments have shown that items with complex syntactic structure, cultural references, unfamiliar vocabulary, and/or multiple meaning words favour native English learners over English language learners (Lyon et al., 2012).

If learners are tested in a language that is not their home (native) language, the scores might reflect not only their competencies in the measured content area (for example Physics), but also their mastery of the language (Haag et al., 2013). Physics problems entailing linguistic demands are expected to impede second language learners (Gu, 2015; Makalela, 2015) from fully understanding the items and, hence, from demonstrating their scientific ability (Haag et al., 2013).

Native speakers, in contrast, are more likely to possess the language skills necessary for understanding linguistically challenging Physics word problems. Thus, items with high linguistic demands (for example long and complex instructions) may measure construct- irrelevant language competencies (Haag et al., 2013). These items could be disproportionately more difficult for second language learners (Lesaux et al., 2014) and, thus, less appropriate for capturing their scientific competencies than native speakers of the respective language (Haag et al., 2013).

Hence given the inextricable link between language and assessment, the assessment of English language learners is one of the thorniest difficulties in educational policy and practice (Shaw et.al 2010). The same authors (Shaw et al., 2010) go on to state that for all test takers, any test that employs language is, in part, a measure of language skills. Such confounding variables may be mitigated by the use of accommodations such as customised dictionaries (Lyons et al., 2012).

2.4.3 Dimensions of Physics assessments

Assessment in Physics consists of three dimensions- participant structures, communicative modes, and written texts/genres.

(a) Participant structures

Physics assessments in modern day classrooms are now designed to resemble authentic scientific processes, which by nature involve a variety of social interactions. Learners may be arranged as a whole class, small group, pair, or as an individual depending on the assessment task, its goal and objectives (Botha & Reddy, 2011).

Within each arrangement, learners can participate in a variety of ways. However, in such a setting, these participation structures influence who can say what and to whom, which also affects the nature of discourse in the assessment activities (Lyon et al., 2012).

(b) Communicative modes

Physics assessments call for learners to use different kinds of productive and receptive language abilities as well irrespective of their proficiency in the language of instruction (Lesaux et al., 2014). In some cases learners might need to listen to the teacher's instructions (the interpretive mode), engage in a two-way dialogue with group or class members while performing the investigatory task (the interpersonal mode), or present information (presentational mode) through a written report (Lyon et al., 2012).

Each of these three communicative modes presents different language demands on the learner (Beers & Nagy, 2011). The mode is realised through a specific participant structure, which influences the challenges and opportunities present for language minority learners (Berninger & Abbott, 2010). For instance if learners engage in the interpersonal mode with the teacher or classmates during a task or discussion, they may receive immediate feedback not afforded to them while just listening to the teacher during chalk-talk (Kieffer & Lesaux, 2012a).

(c) Written texts and genres

Writing is central in the consideration, production, reproduction and dissemination of scientific meaning (Lyon et al., 2012). The expanded interactional and communicative context of science assessments often require learners to read and write (Garcia & Kleifgen, 2010) a number of written texts that may vary not only in their content but also in how they are structured (Osborne, 2010) and the purpose they serve in the assessment activity (Rijmen, 2010). These texts presented in performance assessment can serve as opportunities for learners to engage with scientific content (Bunch et al., 2010) and practices in more productive ways that are often available on traditional paper-and-pencil tests (Brijlall, 2008).

At the same time, depending on the particular texts and how they are used in the assessment, they also may present challenges (Martin et al., 2012), especially for English language learners (McCallumm & Miller, 2013). Several performance assessments, therefore, may be in part assessments of learners' ability to engage with and produce particular kinds of texts (Lyon et al., 2012; Maerten-Rivera et al., 2010).

2.5 Characteristics of a language- friendly school

In many schools that have linguistically diverse populations faulty practices abound in the education of second language learners. Some of these practices include the fact that learners are: considered to have little or no language nor cognitive abilities because they are not able to demonstrate these abilities in English, expected to achieve proficiency in English through English language classes which are taught using the methods of first language instruction with no second language reinforcement in the regular classroom, expected to function in all subject areas as if they are native English speakers with no adjustment to instructional methods (Garcia & Kleifgen, 2010; Osborne, 2010; Shaw et al., 2010).

The learners are also tested and assessed using tests which are not culturally sensitive and which are not presented in English, actively discouraged from speaking their first language in class, on the playground or at home, taught by teachers who have no knowledge of the home language of learners hence are notable to translate concepts into the learners' home language (Lemmer, 2010; Martin et al., 2012; Msimanga & Lelliott, 2014). These faulty practices make it obvious that the provision of equal educational opportunities is not automatically guaranteed by desegregating schools.

Multicultural education, therefore, is not achieved by the mere enrolment and presence of culturally and linguistically diverse learners in a particular school (Baker, 2011). In actual fact cross- cultural respect and understanding among learners, the celebration of diversity and the support of multilingualism is an outcome of schooling that requires careful and deliberate planning and implementation by all stakeholders in education (Bellens & De Fraine, 2012).

The needs of all language minority learners in our schools will only be addressed by a school environment which supports the language development of both first and second languages in a rich variety of contexts and not only in the formal classes (Clark et al., 2012). Below are some suggestions to accommodate language minority learners in formal schools.

(a) Supportive school leadership

All stakeholders in education should be involved in compiling a policy supportive of culturally and linguistically diverse learners. The school leadership should hold high expectations for language minority learners (Sierens & Van Avermaet, 2010), be knowledgeable of effective instructional methods to teaching language minority learners (Msimanga & Lelliott, 2014), and communicate this knowledge to teachers and members of the school governing body.

The stakeholders must take a strong leadership role in instituting strong programmes for language minority learners as well as being committed to recruiting teachers who are bilingual and trained in methods for teaching language minority learners (Landsberg et al., 2011). The first step in the process of such policy making should be to carry out a needs assessment in the school.

Information should be collected on the profile of linguistically diverse learners within the whole school, a comparison of English language learners to native speakers (O'Reilly & McNamara, 2007), school attendance (Bunch et al., 2010), and the existence as well as effectiveness of all language programmes within the school (Lambert, 2014). Thereafter, the school can now develop a mission statement which will give direction to the school and create a framework for the school's goals (Van Houtte, 2011).

Strategic planning will then follow in which goals, aims, and objectives of the school are determined (Makalela, 2014a; 2014b), responsibilities are delegated and an action plan and a budget are drawn up (Gu, 2014).

(b) Teacher development

All members of staff within the school should be committed to the support of language minority learners. All schools, as far as possible, should offer staff

development programmes or sponsor staff to attend such programmes. From staff development programmes, members of staff will learn effective instructional approaches to teaching language minority learners (Aarts et al., 2011), principles of second language acquisition (Garcia, 2011), working with parents of language minority learners (Bunch et al., 2010), and the language of their learners (Martin et al., 2012).

There also needs to be close collaboration between school policy planners, English language teachers (Landsberg et al., 2011), as well as subject teachers in the school (Rowe, 2013). In this way effective instructional strategies can be developed to meet the needs of language minority learners.

(c) Parental involvement

The benefits of parent involvement in education are well documented: higher academic achievement (Landsberg et al., 2011), reduced school dropout (Murnane et al., 2010), and reduced absenteeism (Sierens & Van Avermaet, 2010). There are several strategies that schools can implement in trying to bridge the gap between parents of language minority learners and the school. The first could be short visits by teachers to homes of language minority learners.

Even in cases where teachers do not understand the language spoken by the parents at home, the visit enables them to understand the parents' attitude towards schooling (Bornman & Rose, 2010), their traditions and beliefs, as well as suggestions on how these parents can be involved in the school programmes (Friend, 2008).

The school can also offer English language learning classes to parents during or after hours. Such programmes provide language skills to parents which will enable them to assist their children with school work at home (DoE, 2008). Where possible school communications to parents (such as newsletters and reports) should be translated into the home language of language minority learners within the school (Friend, 2008).

(d) Recognising learners' first language

Upon attainment of political independence in 1994 apartheid education was desegregated and the new South African Constitution (RSA, 1996a art 29, cited in De Wet, 2002:119) and the South African Schools Act (RSA, 1996b art 6, cited in De Wet, 2002:119) re-affirmed the right of all learners to receive education in the language of their choice (De Wet, 2002).

This is not the case, however considering the use of the English language at institutions of higher learning, and in the work place. As a result most schools teach their learners the home language until Grade 4 before switching over to English. The suggestion, according to the Education Policy (Department of Education, 2012) is that curriculum will be offered in English and support will be given in the learners' home language. The Language-in-Education Policy (LiEP) makes room for mother tongue education or "an additive approach to multilingualism" (Department of Education, 2002).

When learners are placed in bilingual classes where teachers are able to give support in the learners' first language, learners are bound to develop both academic concepts and English language proficiency more effectively (Garcia & Wei, 2014). In many schools in South Africa teachers are not able to use the language of these minority learners (Makalela, 2015).

However, the following suggestions might help: creating a bilingual print environment, supplying school and class libraries with books (Botes & Mji, 2010), magazines, newspapers and other resources in the language of language minority learners (Gu, 2014), and encouraging bilingualism in all class activities (Van Laere et al., 2014). In sum, research shows that learners' proficiency in the language of instruction (Garcia & Wei, 2014; Lambert, 2014; Msimanga & Lelliott, 2014) and particularly their reading abilities are related to Physics achievement (Van Laere et al., 2014).

What should Physics teachers do about their specialist language? The researcher came up with an English- Southern Sesotho dictionary for use by Grade 11 Physics learners. This dictionary only contained key words and concepts found in the topic *Mechanics* (Physical Sciences CAPS Document, 2011) and were translated into

Southern Sesotho, since that is the home language of the majority of Physics learners in Fezile- Dabi district.

2.6 English – Southern Sesotho Physics dictionary

In this knowledge-based and information- driven global economy, academic success is essential to an individual's life outcomes (Duncan & Murnane, 2011). Yet many learners experience academic failure because of underdeveloped literacy skills (Murnane et al., 2012).

The growing number of language minority learners, who come from homes where the primary language spoken is not the language of schooling, is at particular risk of school failure (Lesaux et al., 2014). This population is charged with simultaneously developing English language proficiency while also learning academic content (Duncan & Murnane, 2011), and therefore needs to learn with tremendous efficiency to keep pace with the demands of the curriculum (Lesaux et al., 2014).

Studies of traditional, multiple- choice assessments have shown that for an assessment given in English, learners' levels of proficiency in that language impact their performance (Shaw et al., 2010). Be it filling in a bubble or writing an essay, English second language learners in particular may struggle with comprehending an item or prompt as well as producing a suitable response (Shaw et al., 2010).

Literacy research and instructional initiatives have historically focused on young children (Gu, 2015), yet there is a growing concern about developing evidence-based approaches to promoting adolescents' literacy skills (Goldman, 2012), ensuring their abilities keep pace with what it means to be literate. For example, the vocabulary and language of the young reader's storybook, filled with concrete ideas and objects, is much more straightforward and basic than the abstract language and concepts read by the adolescent studying for a science exam (Duke&Carlisle, 2011).

It has long been understood that early reading difficulties are often exacerbated with increasing grade levels (Kieffer & Lesaux, 2012a). Now it is becoming clear that young learners who fare well in the early grades may struggle later due to the greater complexity of language and content (Taylor & Bishop, 2010).

This is especially true for language minority learners (Goldman, 2012), often they decode and comprehend the conversational language that conveys ideas and topics in beginner books (Lesaux et al., 2014), but lack the sophisticated, abstract vocabulary (Goldenberg, 2011) necessary to support later text comprehension and production (Mancilla-Martinez & Lesaux, 2011). Yet, few studies have evaluated specific approaches to advance at-risk adolescents' literacy skills and come up with instructional strategies to assist the language minority learners in performing better in academic subjects (Lesaux et al., 2014), hence need for this research.

Understanding language minority learners and meeting their academic needs presents an enormous challenge to most teachers and schools (Lesaux et al., 2014). Educational policies and practices should be developed that tap the knowledge (Makalela, 2015) and skills (Rowe, 2013) that learners possess in their home language while providing them with appropriate tuition in English language (Kieffer & Lesaux, 2012a). In a way educational environments should be created that enable the learners to develop (Garcia & Wei, 2014) and maintain both their first and second languages in the most effective way possible (Hornberger & Link, 2012) while acquiring and developing their academic language (Haag et al., 2013).

Given the superficial resemblance between everyday vocabulary and general academic vocabulary (Wei, 2011), teachers are likely to assume that learners understand the terms used in the classroom and do not deliberately and systematically explain those (Haag et al., 2013). Therefore, learners' mastery of academic language strongly depends on their opportunities to acquire academic vocabulary outside school (Haag et al., 2013; Howe & Lisi, 2014; Van Laere et al., 2014), which specifically disadvantages language minority learners (Makalela, 2014a), as they usually have a smaller second language knowledge base on which they can draw to infer the meaning of general academic words (Makalela, 2015).

This then results in the minority learners lagging behind the native speakers in their command of academic language (Madiba, 2014; Makalela, 2014b). It is advisable, therefore, that every teacher should know something about language acquisition (Cummins, 2008), the acquisition of second language (Beers & Nagy, 2011) and the impact of linguistic diversity on the teaching/learning situation (Van Houtte, 2011). Subject teachers are also encouraged to understand how a learner's academic

performance is related to different levels of language skills (Duke& Carlisle, 2011; Goldman, 2012).

With respect to addressing such issues, Siegle (2007) documented the effectiveness of linguistic modifications (such as dividing prompts into smaller units and adding visual supports) to high school Physics assessment items in significantly raising the scores of English language learners. The researcher came up, with the aid of highly qualified multilinguists, with an English- Southern Sesotho Physics dictionary which was used in Physics classes for the topic *Mechanics* to Grade 11 Physics learners who were in the experimental group (see Appendix A). These were learners whose home language is Southern Sesotho and are learning Physics using the English language.

Home language is the language used at home as the primary means of communication (Evans et al., 2010). When listing the eleven official languages of South Africa (Mji & Makgato, 2006) people generally tend to make the distinction between English and Afrikaans as 'European' languages and the other nine languages, popularly called 'African' languages (Evans et al., 2010). More than 98% of all South Africans use one of these 'African' languages as a home language (Evans et. al, 2010). Southern Sesotho belongs to the Bantu languages and uses a distinctive writing system and makes use of some words that have been borrowed from English and Afrikaans (Evans et al., 2010), for example *sekolo* (English: school), or *tafolo* (Afrikaans: *tafel*).

A dictionary is a reference book that not only offers the meaning of words in systematic order but provides information about their spelling, pronunciation, origin, use, and other grammatical details (Evans et al., 2010). Brijlall (2008) suggests that every teacher should include the use of a dictionary in any given subject, especially where English is the learner's language of instruction and not their mother tongue.

Dictionaries date back many centuries, from the earliest ones compiled on clay tablets by the Assyrians and the ancient Egyptian dictionaries written on papyrus leaves to the present day (Evans et al., 2010), where dictionaries are printed on paper, burned onto CDs or designed electronically on the internet (Van Laere et al., 2014). There are many kinds of dictionaries and many different ways of categorising

them. The two most basic kinds of dictionaries are bilingual dictionaries and monolingual dictionaries (Evans et al., 2010).

Bilingual dictionaries consist of headwords in language A, followed by their translation equivalents in language B (Evans et. al 2010), for example *motho* (Southern Sesotho) human being, person (English), *motsotso* (Southern Sesotho) minute (English). The dictionary developed for this research focused on English-Southern Sesotho translations and explanations of core Physics terms found in the topic *Mechanics*, Grade 11.

This was necessitated by the fact that most teachers in South Africa, especially in former Model C English medium schools struggle to respond adequately to the increased linguistic diversity found in their classrooms (Botes & Mji, 2010), where the majority of English as an Additional Language (EAL) learners fare badly in Physics education. Most, if not all, of the explanations given in these classes are only in English which may be to the detriment of the learners whose home language is different, as I observed during my teaching stint at one of such schools.

Building academic vocabulary- words that appear frequently in texts across academic disciplines, but rarely occur in oral conversation (Baumann & Graves, 2010) is one promising route for improving struggling learners' academic outcomes (Nagy & Townsend, 2012) especially when presented in the learners' first language (Makalela, 2014b). The target group for this dictionary was Grade 11 Physics learners whose home language is Southern Sesotho and had low English language proficiency.

The dictionary did not, however, provide translations for the entire topic but selected terms and expressions most often used in the topic and contained in the Grade 11 Examinable Content guidelines for Physical sciences for the year 2015. The intervention design was theoretically grounded in principles of effective vocabulary instruction, principles written about extensively (Berninger & Abbott, 2010; Lesaux & Kieffer, 2010; Nagy & Hiebert, 2010; Nagy & Townsend, 2012).

The first design principle that guided this research was that such instruction must be text-based, so that academic vocabulary words are studied in the authentic contexts in which they are used (Gu, 2015; Lesaux et al., 2014). Second in light of the

heterogeneous nature of words (Nagy & Hiebert, 2010), the dictionary focused on a particularly high-utility and abstract population of words- academic words found in the topic *Mechanics*, Grade 11.

Focus was on building the learners' morphological awareness, defined as the understanding of complex words as combinations of meaningful smaller units or morphemes (that is prefixes, suffixes, and roots) that contribute to the words' meanings and functions (Lesaux et al., 2014). The past decade has seen a relative surge in evaluation studies focused on vocabulary instruction for language minority learners, while using their home language as an intervention (Proctor, Dalton, Uccelli, Biancarosa, Mo, Snow and Neugebauer, 2011).

Seven interventions were implemented as part of the instructional core for a single subject area (science, social studies or English language; Duke & Carlisle, 2011; Duncan & Murnane, 2011). One was designed as a school wide initiative to provide a daily vocabulary lesson as part of each content area class as well as English language learning (Proctor et al., 2011), and one tested the effects of supplementary vocabulary instruction delivered in learners' home language in an after- school setting (Goldman, 2012).

All these studies reported significant treatment effects on curriculum- based measures of words taught. Additionally, findings also suggested effects on curriculum- based measures of content taught (Lesaux et al., 2014), researcher-developed measures of morphological awareness (Lesaux et al., 2010), metacognitive skills (Duke & Carlisle, 2011), and reading comprehension (Goldman, 2012), as well as significant effects on a norm-referenced measure of reading comprehension (Lesaux et al., 2010) as well as improved academic performance in tested subject areas (Botes & Mji, 2010; Madiba, 2014; Makalela, 2015).

In order to achieve in-depth scientific understanding, it has been suggested that effective communication of scientific ideas is the key because language forms an integral part of this communication (Makalela, 2014a). In a similar vein, it has been pointed out that many of the learners' problems in science education originate from an inadequate knowledge of the basic vocabulary (Janks & Makalela, 2013; Lambert ,2015; Madiba, 2014).

It has also been argued that language is the medium by which teachers introduce and convey concepts and procedures, through which texts are read and problems are solved (Wei, 2011). The English- Southern Sesotho Physics dictionary developed for this study was not intended to replace transformative pedagogy in science, including experiments, modelling, demonstrations, visuals and hands-on activities but to reinforce the language learners need to engage with these activities.

2.7 Chapter Summary

Different learner characteristics are significantly related to Physics achievement. Research consulted and cited in this chapter largely demonstrates that speaking a home language that is different from the school's language of instruction has a negative correlation with academic achievement in Physics. Language undoubtedly plays a pivotal role in academic achievement. Modern day Physics educators should therefore take cognisance of the diversity of their classes by making an effort to accommodate all cultures and languages of their learners.

The literature reviewed indicates the ineffectiveness of monolingual ideologies and practices in modern day diverse schooling communities. This is because monolingual setups do not provide positive educational experiences that are essential for high academic achievement of multilingual learners. The 21st century problems call for a scientifically informed citizenry, hence the importance of maximum comprehension of scientific concepts by all Physics learners in the class. A lack of maximum exposure to and acquisition of the language of instruction is one of the main causes of lower academic performance in Physics. Physics educators are therefore encouraged to come up with activities, pedagogies and resources that depict multilingualism.

2.8 Conclusion

The use of two or more languages, usually English and other indigenous languages, has become a frequent observation in multilingual classes in South Africa. Translanguaging needs to be promoted on a larger scale in an informal or structured manner. Research cited earlier shows a significantly greater success rate of translanguaging than individual language engagement. The role of language for

conceptualisation and for scientific problem solving skills cannot be over emphasised.

Bilingual and multilingual classrooms are now a common sight in the world, South Africa included. There are millions of learners around the world who are receiving tuition in a language that is not their home language. Such learning scenarios, termed immersion contexts, can be further categorised into late immersion, shallow immersion, total immersion, deep immersion and submersion contexts (Cummins, 2008).

A review of 30 years of research on second language immersion indicates that the term “immersion education” came into use in Canada in the 1960s to refer to programs where the French language was used as a medium of instruction for students whose home language was English (Cummins, 2008).

In this context learners are taught content subjects in the language of instruction hence being exposed to authentic input in the second language. Cummins further differentiates three types of immersion programmes namely: early immersion which starts in kindergarten or Grade 1, middle immersion which starts in Grade 4 or 5 and late immersion which starts in Grade 7. All these programs are characterized by at least 50% instruction in the target language, and in this case it was French (Cummins, 2008).

The learners’ home language is thus supported and encouraged in an academic situation. The core tenets of immersion programs include the following:

- i. The second language is the medium of instruction.
- ii. The immersion curriculum parallels the local mother tongue curriculum.
- iii. Overt support exists for the mother tongue.
- iv. The program aims for additive bilingualism.
- v. Exposure to the second language is largely confined to the classroom.
- vi. Students enter with similar (and limited) levels of second language proficiency.

vii. The teachers are bilingual.

viii. The classroom culture is that of the local mother tongue community.

(Cummins, 2008)

The present study intended to contribute to the existing research by examining the relationship between the language of instruction and learners' academic achievement in Physics. The demonstrated importance of language in general and speaking a different home language than the language of instruction in particular contains a number of implications.

First, the finding that home language plays a significant role in Physics achievement confirms the theoretical assumption that language minority learners experience a greater challenge in reaching a high level for Physics achievement (Van Laere et al., 2014). Future research has been called to focus on developing new ways to support such learners in their learning process (Msimanga & Lelliott, 2014; Van Laere et al., 2014).

Although the most obvious option would be to invest in initiatives focusing on the language of instruction, the home language can also be brought into the learning process as a scaffold (Msimanga & Lelliott, 2014). Content areas such as Physics can serve as a content vehicle, providing a rich source of input for learning (Cummins, 2008).

As existing achievement gaps are often related to ignoring the knowledge and skills a child has already acquired in his home language (Baker, 2011), this alternative route may provide the opportunity to incorporate learners' linguistic repertoire as didactic capital into the learning process (Sierens & Van Avermaet, 2010). This would be particularly valuable in light of school population's growing linguistic diversity.

Second, proficiency in the language of instruction especially reading achievement contributes considerably to Physics achievement. Initiatives focusing on rich vocabulary instruction and comprehension skills (Melby-Lervag & Lervag, 2014) can serve language minority learners to become more proficient in Physics literacy.

Conclusively, from literature reviewed, teachers should seek to enhance academic achievement in the linguistically diverse classroom by creating an environment which addresses the learners' desire to communicate effectively and learn. The environments created must be structured around the multidimensional process of language development and each learner's diverse cultural background- one way being to incorporate the learners' home language in science education.

The next chapter outlines the research methodology and design used in this research. This includes sampling techniques to be used, data collection and analysis methods, and statement on research ethics.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

Presented below is the research methodology and design used during the study. It should be noted that this study made use of a mixed method approach in which both qualitative and quantitative methods were used to collect data by embracing the triangulation design.

3.1 Introduction

In this chapter the researcher discusses the research methodologies employed to explore the effects of language in Physics. The research design and the data collection methods are discussed as well as the sampling methods and the development of the data collection instruments. The chapter also discusses ethical considerations and the data analysis methods used in the study.

Research methodology outlined herein focuses on the process and the kind of tools and procedures used by the researcher in this study. The research methodology presented here, focuses on the individual steps followed during the research process and the most “objective” procedures employed (McMillan & Schumacher, 2010).

In order to answer the research questions as widely and exhaustively as possible both qualitative and quantitative approaches were used in this study.

3.2 Research design

The design of the study is sequential explanatory design.

3.2.1 Introduction

As alluded to in Chapter one, research design refers to a plan for selecting participants (Cohen et al., 2011), research sites, and data collection procedures (McMillan & Schumacher, 2010), answer the research question(s). The research design used in this study shows exactly who was studied and when, where, and under which circumstances (McMillan & Schumacher, 2010).

The goal of this research was to provide results that would be judged to be accurate, trustworthy, and reasonable (McMillan & Schumacher, 2010). The researcher, in order to get such credible results, carefully planned the research design. This way

the researcher got to eliminate or at least reduce sources of error (McMillan & Schumacher, 2010; Setati, 2011).

In this research triangulation was employed. For the purpose of triangulation, the study made use of both qualitative and quantitative methodologies. This was an advantage in that the results from each method converged and indicated the same results (McMillan & Schumacher, 2010). Furthermore, its use was necessitated by the fact that the strategy enabled the use of different kinds of data-collection instruments such as the 3 tests written, and the interviews conducted to explore the problem at hand (McMillan & Schumacher, 2010).

Since the researcher wanted to explore all aspects related to incorporating language teaching and Physics content teaching triangulation was most ideal. As stated earlier the data collected during the study was both quantitative (from the 3 tests) and qualitative (through holding interviews). Such data were suitable because the interviews provided research opportunities which extended the type of information that could be collected. The use of both methods allowed the researcher to understand how participants perceived their situation and their role within this context (Cohen et al., 2011).

3.2.2 Qualitative research

The qualitative design used in this study was just as systematic as the quantitative design used, though it emphasised on gathering data on naturally occurring phenomena, the schools (Tuckman, 2011). The qualitative data collected during the study was in the form of words, rather than numbers as the researcher searched and explored, using a variety of methods to find answers to the research questions (Cohen et al., 2011).

The qualitative part of this research began with assumptions about the problem being investigated. To study this problem, the researcher collected the data in a natural setting sensitive to the participants (Punch, 2011). The design used in this research assumed an unstructured approach to inquiry which was flexible with regards to the objectives, sample, and questions asked as the researcher sought to extensively explore the nature of the role of language in Physics (Van Staden, 2010).

Even though there are many different ways of analysing qualitative study results such as content analysis, grounded theory analysis (Van Staden, 2010), discourse analysis, narrative analysis, global analysis (Punch, 2011), conversation and ethno methodological analysis, and computer-aided qualitative data analysis (McMillan & Schumacher, 2010), in this study Gläser & Laudel's model was used to analyse the qualitative data (Gläser & Laudel, 2013).

Gläser and Laudel (2010) Model for qualitative content analysis

The model starts from a theoretically derived set of categories that can be assigned to a dimension. This reduces the openness of the first step but introduces openness to the second step.

All versions of qualitative content analysis include at least the possibility of deriving categories from prior theory. In theory-guided qualitative research, it is important to prepare for the data analysis by deriving categories from the same theoretical framework that already has guided data collection (Gläser & Laudel, 2013). This model is ideal for applying qualitative content analysis to transcripts of semi-structured interviews (Schreier, 2012).

The researcher started from a theoretically derived set of categories that remained modifiable in the number of categories, structure of categories, and the possible nominal values that could be assigned to a dimension of a category. This process reduced the openness of the first step- creating the categories- but introduced openness to the second step- applying the categories to the empirical material.

Information was extracted from a text for further use independently of the text. The extracted "values" of categories represented the data contained in the text as precisely and completely as possible (Gläser & Laudel, 2013).

Extraction essentially meant identifying relevant information, the category to which the information belonged, rephrasing the information contained in the text as short concise statements about the value of each dimension, assigning these statements to the relevant dimensions of the category and collecting them separately from the text (Gläser & Laudel, 2013).

This model was appropriate as it applies qualitative content analysis to transcripts of semi-structured interviews in which the unit of analysis ranges from a sentence to a paragraph (Schreier, 2012). In analysing the qualitative data, the researcher read the sentences and decided whether it contained relevant information, and if so, to which category the information belonged. The relevant information was then extracted by formulating short descriptive statements about the values in the dimensions. Each dimension contained either a single word or a phrase (Gläser & Laudel, 2013).

The extracted raw data was then processed in order to further consolidate the research's information base. The aim of this step was to improve the quality of the data by summarising scattered information, remove redundancies and correct errors.

Both Leedy and Ormrod (2010) and de Vos et al. (2011) advise that the process of moving from data to conceptualisation and theorisation is the most distinguishable aspect of qualitative data analysis. This study employed the steps provided by Gläser & Laudel (2010) to analyse the data systematically, by segmenting it into words or categories that subsequently formed the basis of the emerging story of the phenomenon under scrutiny.

The use of such a model presented the researcher, with many options on how to convert the "raw" data into final patterns of meaning (Setati, 2011). The choice of options depended on the methodological structure of the inquiry and the corresponding aims of the analysis procedures (Punch, 2011). The qualitative data for this study was analysed using the interpretative method. This method entailed close examination of data in order to find constructs, themes and patterns that helped answer the research questions (Cohen et al., 2011).

In other words this process reduced the volume of information collected, identified significant patterns, and constructed a framework for communicating the essence of what the data revealed. The researcher analysed the learners' responses to interview questions closely, finding links and similarities in the responses. This final written report includes the voices of participants (Gray, 2011), the reflectivity of the researcher (Leedy & Ormrod, 2010), and a complex description and interpretation of the problem which was being studied (Killen, 2010).

3.2.3 Quantitative research

A quantitative design which sought to establish the relationship between the measured variable and the sequential steps which were followed in the study, were established before the study began (McMillan & Schumacher 2010: 12). These were developed so that the data would have a fair opportunity to show hypothesised relationships between the different variables identified in the research (McMillan & Schumacher, 2010).

An important consideration with quantitative research, however, is to operationalise and use variables that can show and prove the existence of such relationships (Gray, 2011; McMillan & Schumacher, 2010). One common way to ponder about this important feature is for the researcher to examine the sensitivity of the variables as measured to show relationships. Sensitivity refers to the ability to detect differences or correlations between the variables (McMillan & Schumacher, 2010).

In this research an experimental design which enabled the researcher to intervene with a procedure that determined what the participants would experience (Killen, 2010) was used. In other words the researcher had control over what happened to the participants by systematically imposing (to the experimental group) and withholding (from the control group) the intervention (McMillan & Schumacher, 2010).

The researcher then made comparisons between participants who had (experimental group) and those who had not (control group) received the intervention (Tuckman, 2011) by comparing their performance in the post- test. The experimental group received intervention in the form of Physics lessons in their home language (Southern Sesotho) and the use of the English- Southern Sesotho Physics dictionary while the other group (the control) did not receive any intervention.

The experimental design used in this research was the true experimental design. This design was used as it had a unique characteristic of accommodating random assignment of participants to either of the two groups (McMillan & Schumacher, 2010). The researcher settled for the randomised pre- test- post- test control group design which made it possible for the random assigning of learners to either of the groups (Rubin & Babbie, 2010).

This design can be summed up in Figure 3 below:

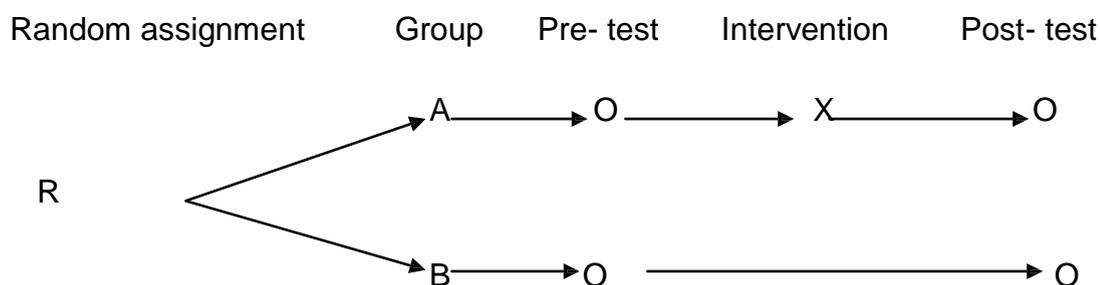


Figure 3.1: Summary of research design

(McMillan & Schumacher, 2010)

The first step was to have all the Grade 11 Physics learners at the two schools involved in the study write the English language proficiency test, as English is the language of instruction at their respective schools.

The researcher then identified the best 40 learners and invited them to participate in the study. Since the study was on the effects of language on academic achievement in Physics, selecting learners with high proficiency in English was done to ensure that learners with high proficiency in the language of instruction participated in the study. The second step taken during this study was to pre-test the learners on the dependent variable.

The next step was the random assignment of the participants to the experimental and control group (Tuckman, 2011). The purpose of random assignment was to enable the researcher to reasonably rule out any differences between the two groups that could influence the results.

Generally, educational researchers like to have at least 15 participants in each group in order to assume statistical equivalence, and they have more confidence in the results if there are 20 to 30 participants in each group (McMillan & Schumacher, 2010). In this research each group had 20 learners.

After random assignment of learners the intervention was then administered to the experimental group only; keeping all other conditions the same for both groups to ensure the only difference was the manipulation of the independent variable. The

control group was taught in English language. The experimental group was taught using English language and their home language (Southern Sesotho).

The experimental group was also given English- Southern Sesotho Physics dictionaries to use as intervention. These were dictionaries that had Sesotho translations of key Physics words and concepts found in the Grade 11 topic *Mechanics*. The dictionary was developed by experienced multilinguals that have an understanding of Physics. After the administration of the intervention to the experimental group, the two groups were then post- tested and their performance compared (Gay, 2010; Gray, 2011).

The pre- test- post- test control group design used in this study controlled four sources of threats to internal validity. Threats related to history were generally controlled in so far as events that are external to the study affected both groups equally. Selection and maturation were controlled because of the random assignment of participants (McMillan & Schumacher, 2010).

Statistical regression and pre- testing were controlled, because any effect of these factors was equal for both groups. Instrumentation was also not a problem as the same standardised self- report procedures were used. Attrition was absent because the treatment given to the experimental group did not cause any systematic participant dropout (McMillan & Schumacher, 2010).

After the post- test the experimental group was then interviewed to determine their evaluation of the intervention they had received.

3.2.4 Mixed method design

This study made use of both qualitative and quantitative designs as these two represent different ends of the continuum and should not be viewed as polar opposites (Killen, 2010). The use of both designs in this research ensued they complemented each other's shortcomings (Denzin, 2012).

Mixed method designs can differ to a great extent from data collection and analysis methods used for quantitative and qualitative designs, depending on the purpose of the research, the sequence in which quantitative and qualitative methods are used, and the emphasis given to each method.

The following notation system is used to represent different mixed method data collection and analysis designs:

- (a) Uppercase letters (QUAL or QUANT) indicate a priority given to the method;
- (b) Lower case letters (qual or quant) show a lower priority given to the method;
- (c) An arrow (→) indicates the sequence of the collection and analysis of data;
- (d) A + indicates the simultaneous collection and analysis of both quantitative and qualitative data.

This research gave prominence to quantitative research hence assumed the following notation:

QUANT→ qual (McMillan & Schumacher, 2010).

In this research sequential explanatory design was used by the researcher. This design made it possible for both quantitative and qualitative data to be collected and analysed in two phases (Tuckma, 2011), with primary emphasis on quantitative methods. Initially quantitative data was collected and analysed followed by qualitative data collection and analysis.

This research adopted a triangulation approach in which data was presented through numbers and analysed through words and statistics (McMillan & Schumacher, 2010). The notion of triangulation involved viewing issues from more than a single perspective (Leedy, 2010) through the methods used in data collection (Babbie 2010), the variegated participants involved (Denzin, 2012), and the theoretical triangulation (Gay, 2010).

Triangulation was used because the strengths of one method offset the weaknesses of the other, so that together, they provided a more comprehensive set of data (Cohen et al., 2011). The triangulation design was used because the strengths of each approach were applied to provide not only a more complete result but also one that was more valid (McMillan & Schumacher, 2010).

Triangulation enabled the researcher to get a better understanding of the problem being investigated (Gray, 2011) through the use of different theories (Cohen et al.,

2011), methods of research and methods of data collection (de Vos, Strydom, Fouche, Delpont, Bartley, Greif, Pate, Rosenburg, Schulze and Schurink, 2011).

De Vos et al. (2011: 434) go on to state that;

“...triangulation commonly uses a multi-method approach to data collection to avoid errors and biases inherent in any single methodology...and thus is more multi-method in nature...whilst a mixed method refers to a separate methodology in which both qualitative and quantitative approaches, methods and procedures are combined or mixed to come up with a more complete picture of the research problem”.

Triangulation in this study was used because the researcher wanted to explore all aspects related to the extent to which language can be a contributing factor to the academic performance of Grade 11 Southern Sesotho Physics learners. In this research data was collected from learners' performance in the English Proficiency test, the pre- test, the post- test (Mechanics Baseline test) and responses from interviews that were held with participants who were in the experimental group.

The interviews were on participants' views and feelings on the use of their home language (Southern Sesotho) in the teaching/learning of Physics, as well as the effectiveness and relevance of the English- Southern Sesotho Physics dictionary which they used in class during the study. This assisted the researcher to compare responses of learners (during the interview) against their performance in the three tests they had written.

As stated earlier, in this research one group (the experimental) received intervention in the form of lessons in their home language (Southern Sesotho) and made use of the English- Southern- Sesotho Physics dictionary (cause). The researcher evaluated the effectiveness of the intervention basing on the experimental group's performance in the post- test (Bell, 2011) compared to that of the control group (effect), since the experimental group had received the intervention.

With mixed method design, the researcher was not limited to using techniques associated with traditional designs, either quantitative or qualitative (de Vos et al., 2011) but made use of the strengths of each to complement the weaknesses of the other design (McMillan & Schumacher, 2010). This was the ideal design since this

research involved collecting data from written tests as well as from interviews (Leedy & Ormrod, 2010; McMillan & Schumacher, 2010).

Empirical data was collected through giving all the Grade 11 Physical Sciences learners an English language proficiency test. The essence of this test was to determine the learners' proficiency in the language of instruction (English) used by their respective schools. Those with a high proficiency in English language (the top 40) were invited to participate in the other four phases of the study (writing a pre-test, intervention, writing a post- test, and interviews). They started by writing a Physics pre- test. This was done so as to compare their language proficiency against their performance in Physics.

The pre- test was written first before learners were assigned equally into one of the two groups, experimental or control. After the learners wrote the pre- test the researcher then identified key Physics terms and concepts found in the topic *Mechanics* at Grade 11 level and developed an English- Southern Sesotho Physics dictionary with the assistance of qualified and experienced multilinguals.

Both groups were then taught the same topic (Mechanics) during afternoons and on Saturdays so that the smooth running of the two schools would not be affected. The only difference was that those in the experimental group were taught in Southern Sesotho (their home language) and were given Sesotho translations to key Physics concepts through the provision of an English- Southern Sesotho Physics dictionary which was compiled by qualified and experienced multi- linguists.

In order not to disadvantage learners in the control group, these learners were also accorded lessons in Southern Sesotho and had access to the English- Southern Sesotho Physics dictionary as soon as the research had been completed.

Once the researcher had decided to use an interview to collect data in this study, an interview schedule was constructed. The interview schedule listed all the questions that would be asked and these were related directly to the aims, and research questions of the study (Cohen et al., 2011). Learners from the experimental group, after writing the post- test, were interviewed by the researcher on their experiences with the Physics dictionary as well as the Physics lessons delivered to them in their home language (see Appendix J).

In this research, the researcher used the phenomenological interview. The technique used is a specific type of in-depth interview used to study the meanings or essence of a lived experience among selected participants, how it was experienced, and, lastly, the meanings that the participants (interviewees) attach to the experience (McMillan & Schumacher (2010: 356). Phenomenological interviews are a form of qualitative interviews that are standardised open-ended (Cohen et al., 2011). The researcher determined the exact wording and sequence of questions that were asked during the interviews (McMillan & Schumacher, 2010) and the questions were completely open-ended (Creswell, 2014).

By maintaining the same wording and sequence of interview questions, the researcher ensured responses from interviewees were based on the same content, and this also made it easy to analyse the responses. The interviews were held with participants from the experimental group only as they are the ones who had been given intervention. The researcher conducted a single but comprehensive interview with each of the learners in the experimental group. Each interview lasted approximately 20 minutes.

The responses were tape-recorded by the researcher with the learners' permission. Tape-recording the responses ensured completeness of the verbal interaction and provided material for reliability checks; suggest McMillan and Schumacher (2010: 360). The researcher then transcribed the tape recordings immediately after the interview. This ensured that data was captured accurately for analysis (Gay 2010). Once data had been collected from the tests and interviews, it was then presented, analysed and interpreted.

The learners were asked the same questions in the same order so as to avoid any bias or researcher influence (Babbie, 2010; Gray, 2011). The questions followed a given sequence that was adhered to during the interview (McMillan & Schumacher, 2010). Interview questions are usually in one of three forms: structured, semi-structured, or unstructured (McMillan & Schumacher, 2010). In this research, the researcher used semi-structured questions as these enabled respondents to give individual, independent responses. The researcher tape-recorded the interviews with the learners' permission and transcribed them as soon as the interviews were over.

The interview transcriptions were then analysed and reported on before they got lost or distorted (Gray, 2011). In collecting and analysing data qualitatively, the researcher made use of the following strategies: planning, beginning data collection, basic data collection, closing data collection, and completion (Punch, 2011). Completion of active data collecting blended into formal data analysis (Cohen et al., 2011).

3.3 Site, Population and Sampling

Presented below is the site used in the study, the population as well as the sampling techniques used.

3.3.1 Site

The two schools in the study are situated in a farming area and are referred to as “farm schools”. The schools attract learners from the farming community as well as the surrounding “black townships”. The home language for most of the learners at the two schools, according to information provided by the respective principals, is Southern Sesotho whereas the language of learning and teaching at the two schools is English. The distance between the two schools is less than a kilometre.

3.3.2 Population

A population can be described as a specific group of people to which participants or characteristics of participants are being referred (Bell, 2011), compared (McMillan & Schumacher, 2010) and generalised (Tuckman, 2011). The population for this research was the target group from which the researcher wanted to get information about the problem of interest (Gray, 2011) and before drawing conclusions (Leedy & Ormrod, 2010). McMillan and Schumacher (2010) define a population as a group of elements or cases, whether individuals, objects, or events, that conform to specific criteria and to which we intend to generalise the results of the research.

The population is then subdivided into target population and survey population. The target population is often different from the list of elements from which the sample is actually selected, which is termed the survey population or sampling frame (McMillan & Schumacher, 2010).

In this study the target population was all Grade 11 Physics learners whose home language is different from the language of learning and teaching, whereas the sampling frame was the Grade 11 Physics learners whose home language was Southern- Sesotho and attended school at the two schools under study. The participants were aged between 15 and 17, and out of the 40 learners who took part in the study 24 of them were girls while 16 were boys.

By defining the population, the researcher was in a position to establish boundary conditions that specified who should be included in the study (Gay, 2010). This had an advantage in that the researcher chose a suitable sample (de Vos et al., 2011).

3.3.3 Sampling

A sample frame can be regarded as an objective list of the population from which the researcher can make his/her selections (Cohen et al., 2011). The sampling frame for this research was Grade 11 Physical Sciences learners in Fezile- Dabi district. From this sampling frame, the researcher chose a sizeable representation (Cohen et al., 2011) and came up with an accessible population (Denzin, 2012) from the two high schools used in the study.

The two schools are situated in a farming area and are referred to as “farm schools”. The schools attract learners from the farming community as well as the surrounding “black townships”. The home language for most of the learners at the two schools, according to information provided by the respective principals, is Southern Sesotho whereas the language of learning and teaching at the two schools is English.

The researcher used simple random sampling in this research. After the learners had written the language proficiency test, those classified as having the highest proficiency were invited to participate in the study. Before writing the English Language proficiency test the learners were assigned numbers from 01 to 98, since there were 98 Grade 11 Physical Sciences learners at the two schools involved in the study.

The numbers of the top 40 learners in the proficiency test were then drawn into one of the two groups (experimental or control), having an equal number of participants in each group after writing the pre- test. This technique had the advantage that all participants had an equal opportunity to be in either of the two groups. Since the

population used in the study was small, this also justified the use of simple random sampling. The use of this sampling technique in this research also eradicated sampling bias (Babbie, 2010; Gay, 2010; Punch, 2011).

Table 3.1: Biographic details: Experimental group

Learner	Age	Gender
1	16	F
5	15	M
11	15	F
16	16	F
17	17	F
29	16	M
34	15	F
43	15	M
48	16	M
55	15	M
59	15	F
65	15	F
68	17	F
72	15	M
76	16	M
85	16	F
86	15	M
91	15	F
93	15	F
98	16	F

KEY

F = Female

M = Male

The learners' ages are in years, rounded off to the nearest whole number.

It can be noted that 12 of the learners who were in the experimental group were girls while 8 were boys. Of the 20 learners, 10 were aged 15; 8 were aged 16 and 2 were 17 years old during time of the study. The 20 learners were in Grade 11 in the

schools in the Fezile- Dabi district. All 20 were also taking Physical Sciences as a subject.

Table 3.2: Biographic details: Control group

Learner	Age	Gender
4	15	M
8	16	F
14	15	F
21	15	M
26	16	F
37	17	F
40	16	F
49	16	M
52	15	F
56	17	F
62	17	M
69	16	M
70	16	F
74	15	M
80	16	M
82	16	F
87	15	F
88	16	F
95	16	F
97	16	F

KEY

F = Female

M = Male

6 of the learners were aged 15, eleven aged 16 and 3 aged 17.

3.4 Data collection and analysis

Presented below is the data collection and analysis processes adopted in the study.

3.4.1 Data collection

The data was collected through writing tests (the English proficiency test, Physics pre-test as well as a post-test). Interviews were carried out with the learners who

had lessons in their home language and had access to the English – Southern Sesotho Physics dictionary compiled and supplied by the researcher. Questions for the interviews were centred on trying to find out the learners' experiences and views on the treatment given to them (lessons in their home language as well as the English- Southern Sesotho Physics dictionary).

After writing the post- test learners who were in the experimental group were then interviewed by the researcher. In this research, the researcher used the phenomenological interview. This type of in- depth interview enabled the researcher to establish meanings or essence of a lived experience among the selected 20 participants, how it was experienced, and, lastly, the meanings that they (interviewees) attached to the experience (McMillan & Schumacher 2010: 356).

The interviews, in this study, were held with participants from the experimental group only as they are the ones who were given intervention. The responses were tape-recorded by the researcher ensuring data was captured accurately for analysis (Gray, 2011). Transcribing the interview responses helped the researcher to eventually come up with an end product that was easier to analyse than the original audio recorded detail (Cohen et al., 2011). Once data had been collected from the tests and interviews, it was presented, analysed, interpreted, and described. All the data, whether quantitative or qualitative, was collected by the researcher.

3.4.2 Quantitative data analysis

There are several ways to describe quantitative research data and one way to classify the methods is by determining whether they are univariate or bivariate. Univariate analysis summarises the data on a single variable, usually the dependant variable whereas bivariate analysis is used when there is a correlation among variables or when different groups are being compared (Gray, 2011; McMillan & Schumacher, 2010; Punch, 2011). Two variables are therefore used for correlation.

The following table (Table 6) presents a comparison between univariate and bivariate analysis techniques:

Table 3.3: Univariate versus Bivariate analysis

Univariate	Bivariate
Frequency polygon	Correlation
Histogram	Comparing frequencies
Frequency polygon	Comparing percentages
Stem-and-leaf display	Comparing means
Percentage	Comparing medians
Mean	
Median	
Mode	
Range	
Standard deviation	
Box-and-whisker plot	

(McMillan & Schumacher 2010: 152)

After collecting the data, I organised it so that it could easily and correctly be interpreted and understood (Cohen et al., 2011). Group data can be represented using five methods: frequency distributions, stem-and-leaf displays, histograms, bar charts, and frequency polygons (McMillan & Schumacher, 2010).

In this research bivariate analysis was used and the researcher compared the frequencies, percentages, learning gains, p-values, standard deviations, effect size indices, and means obtained in the different tests by the learners in the two groups (control and experimental) participating in the research. These were then presented on a bar graph for easy comparison. On the graphs, the horizontal axis represents participants while the x- axis represents marks obtained by the learners.

The means, standard deviations, effect size indices, p- values, and learning gain for all tests written in this study were calculated for each group using R- computing and compared.

The mean is the arithmetic average of all scores (Woolfolk, 2010) and is calculated by summing up all the scores obtained in the respective variable and then dividing the total by the number of scores (Tuckman, 2011).

The mean is the most frequently used measure of central tendency because every score is used in computing it. The calculations for the mean were done using the R-computing.

The mean is very frequently reported in studies that have quantitative data and is essential to the interpretation of results in which groups are compared with each other (McMillan & Schumacher, 2010).

In this study, the means, standard deviations, p-values, effect size indices, and learning gain for the three tests (English Language proficiency, pre-test and post-test) were calculated and compared for the two groups, the control and experimental using R-computing. The Cronbach's alpha for the post-test was also calculated using R-computing.

3.4.3.1 Qualitative data analysis

Qualitative research aimed at mechanistic explanations poses specific challenges to qualitative data analysis because it must integrate existing theory with patterns identified in the data (Gläser & Laudel, 2013). Qualitative data can be analysed using one of the two methods- coding or qualitative data analysis. Both methods produce an information base that is structured by categories and can be used in the subsequent search for patterns in the data and integration of these patterns into a systematic, theoretically embedded explanation (Gläser & Laudel, 2013).

Used as a stand alone method in qualitative research outside the grounded theory approach, coding leads to an indexed text, that is, both the original text and the index are kept and subjected to further analysis by the researcher (Schreier, 2012). Qualitative content analysis extracts the relevant information and processes only this information.

Qualitative content analysis has advantages compared to coding whenever the research question is embedded in prior theory and can be answered without processing knowledge about the form of statements and their position in the text, which usually is the case in the search for mechanistic explanations (Gläser & Laudel, 2013).

3.4.3.2 Qualitative content analysis

Regardless of its popularity, coding procedures often lead to two problems that are not easily solved; these are an overload of codes as well as an overload of texts from the responses (Bernard & Ryan, 2010). Since these negative aspects appear to be “hardwired” (Boeije, 2010) in the coding procedure, the researcher came up with an alternative in analysing the data. The alternative identified and used was the extraction of information from the original text and its separate processing.

Since the core idea of this method was to consciously leave the original text behind and analyse the information extracted from it, it is best termed qualitative content analysis (Gläser & Laudel, 2013). In analysing qualitative data in this research the researcher used Gläser and Laudel’s (2010) model explained earlier on page 88.

During the data collection process it was essential to use codes that disguised the learners’ real names mainly for ethical reasons. Learners were assigned numbers from 01 to 98. The researcher reduced and placed the findings into four main themes. In this research the process of categorising and theme formulation followed a combination of themes embedded in the reviewed literature (see Chapter 2), research questions (see Chapter 1) and interview questions (see Appendix J) that were used to collect data (Punch, 2011).

3.5 Description of the development of data collection tools

The English- Southern Sesotho Physics dictionary was developed by the researcher with assistance from qualified English- Southern Sesotho multilinguals at the Wits University Language School and North- West University (Vaal Triangle Campus), see Appendix A.

The dictionary was designed in such a way that it correlated with the content prescribed in the Curriculum and Assessment Policy Statement (CAPS) for Grade 11. Its purpose was to enhance the Grade 11 Physics learners’ comprehension of Physical Sciences. In a way the dictionary had a two-fold function: to enhance comprehension of Physical Sciences concepts and language teaching.

The dictionary, which focused on the translation of key Physics concepts from English to Southern Sesotho, was based on the topic *Mechanics*, a topic prescribed

in the CAPS document for Physical sciences. The CAPS document (DoE, 2011) for Physical Sciences in Grade 11 indicates that the following concepts should be covered under *Mechanics*:

- Vectors and scalars
- Newton's Laws of motion
- Resultant and resolution of vectors
- Different kinds of forces
- Acceleration and instantaneous speed and velocity

The English- Southern Sesotho Physics dictionary covered most of the key words found under the above-mentioned topic. The Physics words were taken from the Grade 11 Physical Sciences CAPS document (DoE, 2011, Physical Sciences) as well as the pre- test written by the learners.

The English language Proficiency test used in this research was the Sample Proficiency Test developed by the Yeditepe University (see Appendix L). The test had 80 multiple choice questions, with 4 possible answers per question and was written in 90 minutes.

The pre- test and post-test was the Mechanics Baseline Test (MBT) developed by David Hestenes and Malcolm Wells (see Appendix K). The test comprised 26 multiple choice questions, with 5 possible answers for each question and was written in 45 minutes. The experimental group was also interviewed by the researcher after writing the post- test. The following is the interview schedule:

Question 1

How do you feel about your performance in the three tests?

Question 2

If your performance differed in the three tests, what could have caused the difference?

Question 3

Comment on the lessons you received during the study.

Question 4

Did you find the English-Southern Sesotho Physics dictionary useful?

Question 5

Which language do you think is the best for you to learn Physics in?

Question 6

Do you think being taught Physics in your home language makes any academic difference? Provide reasons for your answer.

The interview questions were asked to the learners in the same order and using the same wording.

3.6 Validity and reliability

Validity concerns the accuracy with which a researcher actually gathers the information that s/he thinks they are gathering. SAQA (2005: 15) describes validity as "...concerned with the appropriateness, usefulness, and meaningfulness of inferences made from the assessment results". Validity, therefore to some extent, is the degree to which reality of a situation being investigated is captured.

The common conception or conventional interpretation of validity is that an assessment tool is valid to the extent that it measures what it purports to measure. Validity in this research, defined whether the three research tools used measured what they were supposed to measure (Meyer, Lombard, Warnich and Wolhuter 2010: 40). It could therefore be said that validity in this research was concerned with the quality of the assessment tools in terms of congruence with the intended outcomes or hypothesis.

In order to obtain high validity for this research, the researcher chose a design that controlled as many extraneous and confounding variables as possible (de Vos et al., 2011; Tuckman, 2011). Identifying extraneous and confounding variables was key to an appropriate evaluation of the worth of conclusions from this study. A list of the variables used in this research is presented in Figure 3.2 below:

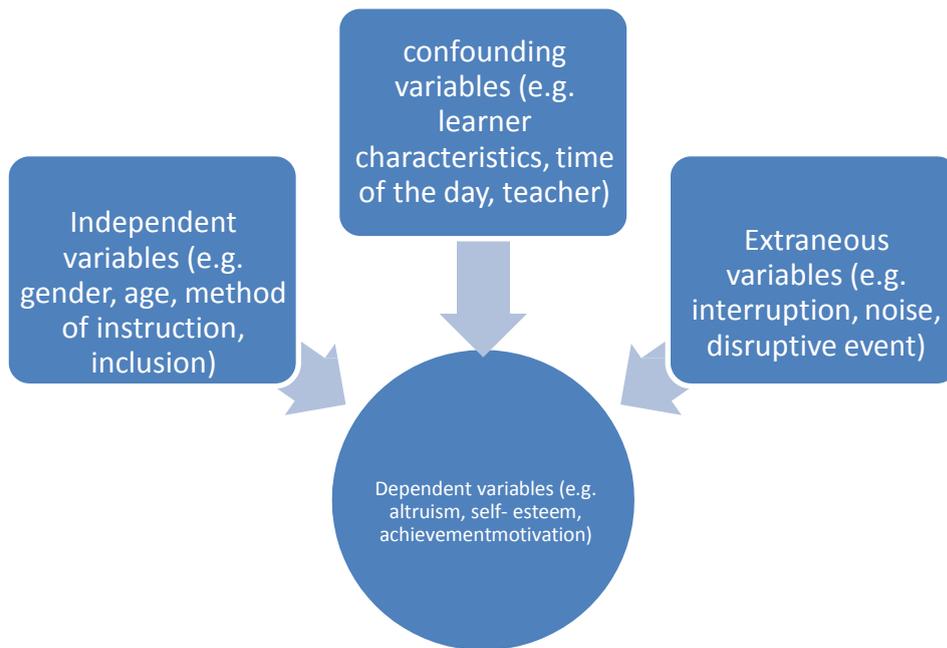


Figure 3.2: Variables controlled in this research

(Tuckman, 2011)

In order to control extraneous and confounding variables, participants in this study were chosen randomly while attrition was countered by ensuring that data was collected over a maximum of twelve weeks.

Together with validity, reliability is the most often cited principle of assessing a situation under investigation. Killen (2010: 351) views reliability as the degree to which an assessment tool is free from errors of assessment. Some of the words used to mean the same as reliability are: dependability, consistency, predictability, trustworthiness, stability, and certainty, adds Killen (2010).

In this research, reliability was taken as the extent to which measures were free from error. To achieve this the researcher ensured that questions asked were not ambiguous, and assessment was done when participants were of sound health, in a good mood, highly motivated, and using error-free tools (Wyss, Tai and Sadler, 2007: 49).

In this research the English proficiency test developed by Yeditepe University, as well as the Mechanics Baseline Test (MBT) developed by Hestenes and Wells (2013) were used. The advantage of using these tests was that they have high

validity and reliability as they are internationally validated instruments set and moderated by highly qualified and competent examiners and moderators. The Proficiency test was text independent, which is not based on a set text or syllabus and was out of 80 marks. As a Proficiency Test, it tested both skills and knowledge (Gottlieb, 2006).

In this Proficiency Test, reading was given 20 marks as it is the basis for grammar and writing and because it is important in further studies which learners have to undertake in their later academic work. One passage of reading was of narrative type and tested learners' understanding of events, characters, descriptions and also the perception of meanings which were implicit in the details of the story.

One passage was a non-fictional text containing information, argument, opinion, facts and ideas. Reading of this kind is focused on ability to arrive at the gist of an idea or argument, to correctly separate opinions from facts (which implies some ability to analyse), to be able to distinguish main ideas from subordinate ones, to understand the tone or viewpoint, for example humorous, ironic, serious (Cummins, 2008).

The third passage was a short poem, 20 lines long. This was to test if learners could understand language which was composed differently- it was not linear, had hidden meanings, unusual expressions and used sound effects (for example rhyme), simile and metaphor which conveyed meaning indirectly rather than directly (Gottlieb, 2006).

The Mechanics Baseline Test (MBT) instrument is an advanced companion to the Force Concept Inventory (FCI). FCI questions are designed to be meaningful to learners without formal teaching in *Mechanics*, and to elicit their preconceptions about the subject in a qualitative way, see Appendix K.

In contrast, the MBT questions were designed to probe concepts and principles that could not be grasped without formal knowledge about *Mechanics*, and required a quantitative approach to answer them that is more involved than plugging in numbers and formulae (Hestenes & Wells, 2013). The MBT is a multiple choice test which has 26 questions.

The test assessed learner conceptual understanding of basic Newtonian mechanics that are generally covered as an introductory course in grade 11. Permission to use the test was granted by Dr David Koch of Arizona State University (fcimbt@verizon.net) on the 11th of June 2015, who emphasised that the tests should be used purely for educational and research purposes only and the password for accessing the tests should be safe guarded. The Cronbach's alpha was also calculated for the post test to determine the test's reliability.

The post- test was in line with the requirements for assessment tasks for Physical Sciences which stipulate that a task should encompass 4 cognitive levels (DoE Physical Sciences CAPS document, 2011). This is to afford opportunities for all learners to achieve at various levels.

A table on the cognitive levels is presented below:

Table 3.4: Physical Sciences cognitive levels

	Cognitive levels	1	2	3	4
Weighting across questions		15%	35%	40%	10%

The Mechanics Baseline Test constitutes questions covering the four cognitive levels. The following table provides an explanation of the four cognitive levels. The verbs given in the fourth column below could be useful when formulating questions associated with the cognitive levels given in the first column.

Table 3.5: Description of Physics cognitive levels

Description of cognitive levels	Level	Explanation	Skills demonstrated	Action verbs
Evaluation/Synthesis	4	At the extended abstract level, the learner makes connections not only within the given subject area but also beyond it and generalises and transfers the principles and ideas underlying the specific instance.	<ul style="list-style-type: none"> • Compares and discriminates between ideas • Assesses value of theories, presentations • Makes choices based on reasoned arguments • Verifies value of evidence • Uses old ideas to create new ones • Predicts and draws conclusions 	Assess, decide, rank, grade, level, measure, recommend, judge, compare, conclude, summarise, interpret, combine, interpret, formulate, justify, design, substitute, what if?
Analysis/ Application	3	The learner appreciates the significance of the parts in relation to the whole. Various aspects of the	<ul style="list-style-type: none"> • Sees patterns and the organisation of parts • Recognises hidden meanings • Uses information, methods, 	Analyse, separate, order, explain, connect, classify, arrange, infer, break down, distinguish,

		<p>knowledge become integrated, the learner acquires deeper understanding and ability to break down a whole into its component parts.</p>	<p>concepts and theories in new situations</p> <ul style="list-style-type: none"> • Solves problems using required skills or knowledge 	<p>diagram, outline, point out, identify, illustrate, apply, demonstrate, calculate, relate, experiment, discover, prepare, construct, manipulate, examine, solve.</p>
Comprehension	2	<p>A number of connections may be made but the meta-connections are missed, as is their significance for the whole. The learner has first level understanding, recalls and understands information and describes meaning</p>	<ul style="list-style-type: none"> • Understands information and grasps meaning • Translates knowledge into new contexts and interprets facts • Compares, contrasts, orders, groups, and infers causes and predicts consequences • Observes and recalls 	<p>Summarise, describe, interpret, contrast, predict, associate, estimate, differentiate, extend, discuss, explain, generalise, give, example, rewrite, infer</p>

			information	
Recall	1	Simple and obvious connections are made. The learner recalls and remembers facts	<ul style="list-style-type: none"> Observes and recalls information 	List, define, tell, describe, identify, show, know, label, collect, select, reproduce, match, recognise, examine, quote, tabulate, name

(Physical Sciences CAPS document Grade 10-12; 2011).

The researcher analysed the cognitive levels of questions that were in the Mechanics Baseline Test and the results were as follows :

Table 3.6: Analysis of the cognitive levels of the Pre- test and Post- test

Grids	Cognitive Level 1	Cognitive Level 2	Cognitive Level 3	Cognitive Level 4
Questions 1 to 4	1 mark each			
Questions 5 to 13		1 mark each		1 (Question 7)
Questions 14 to 24			1 mark each	
Questions 25 to 26				1 mark each
Total mark	4	8	11	3
Percentage	15.4	30.8	42.3	11.5

Almost half of the test (46.2% of the paper) comprised Level 1 and 2 questions. This was from Question 1 to 13, excluding Question 7. These are the levels that require simple recall and comprehension. The data collection process can be summed up as follows

Step 1

- All Grade 11 Physics learners write the English Language Proficiency test

Step 2

- The learners are ranked according to their performance in the proficiency test

Step 3

- The best 40 learners in the proficiency test are selected to participate in the study

Step 4

- The 40 learners write the pre- test
- Learners are assigned to either experimental or control group

Step 5

- Experimental group is given intervention

Step 6

- The 40 learners write the post- test followed by interviews for experimental group.

Figure 3.3: Summary of data collection process

3.7 Statement on research ethics

Research ethics observed in this study were concerned with beliefs about what was right or wrong from a moral perspective (Booyse et al., 2011: 34). Participants had a right to refuse to participate, or withdraw from the study at any point regardless of the consequences this might have to the study (Gay, 2010). Ethical rights of participants observed in this study were; informed consent, confidentiality, voluntary participation, and full disclosure (Gray, 2011).

Permission to conduct the study was sought from the Provincial Director of Education, Free State province. Permission was granted by the Director for Research and Innovation (Free State province), the District Director of Education (Fezile- Dabi district), as well as from the respective principals, and the learners' parents (see Appendices C to I).

This was after the researcher had applied for and was granted permission to carry out the research by Unisa's College of Education (CEDU) Research Ethics Review Committee (Ref: 2016/04/13/48166413/08/MC).

3.7.1 Voluntary participation

Voluntary participation meant that participants in this research could not be compelled, coerced, or required to participate (McMillan & Schumacher 2010). Participating in this research was purely on voluntary basis, where the participants had the choice whether or not to participate (Tuckman, 2011).

The learners also had the opportunity to decide whether they wanted to partake till the end of the research or pull out along the way (de Vos et al., 2011). McMillan and Schumacher (2010: 118) state that participants cannot be compelled, coerced, or required to participate.

3.7.2 Confidentiality

Like in all social science research, the researcher was mandated to protect the privacy of all participants (Babbie, 2010). This entailed that access to participants'

information such as their characteristics, responses, behaviour, and any other information that could make them be identified was not to be made public (Cohen et al., 2011). Booyse et al. (2011: 35) propound that confidentiality in research means that those studying or reading the research results will not be able to establish the identity of those who participated on the basis of their responses.

In this research numbers were used to represent participants. Learners were allocated numbers 01 to 98. These numbers were drawn from a hat when the researcher was allocating the learners to either of the two groups (experimental and control).

The learners were identified by these numbers throughout the research. This is supported by McMillan and Schumacher (2010: 122) who say confidentiality can be attained through collecting the data anonymously using a system to link names to data can be destroyed, asking the participants to use aliases or numbers, and reporting only group, not individual results.

3.7.3 Informed consent

Informed consent was achieved by providing participants with an explanation of the research, an opportunity to terminate their participation at any time with no penalty, and full disclosure of any risks associated with the study (McMillan & Schumacher, 2010). Consent was obtained by asking participants' parents to sign a form that indicated understanding of the research and consent to participate (McMillan & Schumacher, 2010).

Informed consent implied that the participants had a choice about whether or not to participate (McMillan & Schumacher, 2010) in the study. The aim of the research was explained to all participants before they participated in the research. The participants were also informed of their right to withdraw from the research at any stage without fear of reprisal (Bell, 2011).

Participants agreed in writing after being informed of and understanding the risks that could be involved (Booyse et al., 2011: 34). Since the learners who were taking part in this research were minors, their parents were therefore required to co-sign the consent forms (Leedy & Ormrod, 2010), see Appendix F.

3.7.4 Full disclosure

The researcher was open and honest with participants about all aspects of the study. This involved a full disclosure of the purpose of the research, without deceiving or misleading the participants (McMillan & Schumacher, 2010). The researcher was open upfront with all participants as to how the research was going to be conducted.

The participants were also informed of any likely risks that could occur while taking part in the research (de Vos et al., 2011; Punch, 2011). In this study the only foreseeable risk was discomfort. The purpose of the research was communicated to all participants (Woolfolk 2011: 498). During this research, therefore, no information regarding the research was withheld from the participants.

3.8 Pilot Study

A pilot study was carried out with 40 Grade 11 Physical Sciences learners from a school that was not part of the research. The aim of the pilot study was to determine the usefulness and appropriateness of the English- Southern Sesotho Physics dictionary as well as the tests to be administered during the main study and the clarity of the interview questions.

This helped the researcher determine how much time the learners would need to complete the tests. The study was carried out during Saturdays and questions focused on Grade 11 *Mechanics*. From the pilot study, the researcher was able to conclude that the data collection tools were appropriate though Questions 7; 8 and 18 proved quite challenging for the learners. The interview schedule also proved feasible.

3.9 Chapter Summary

The study adopted a mixed method approach (simple experimental design) to elicit from a sample of 40 Physics learners (20 experimental; 20 control) the effect of language on their academic performance in the subject as well as their reflections on the use of their home language as a language of instruction in the Physics class. The data collection instruments used are internationally validated. The pre- and post- test was developed by Arizona State University while the English Language Proficiency test was developed by Yeditepe University. The participants were

informed of the aim of the research, the risks involved, matters of confidentiality, full disclosure and informed consent.

3.10 Conclusion

The research assumed a simple experimental design where learners were allocated into one of the two groups, either the experimental or control through simple random sampling. The learners were referred to using numbers for confidentiality and anonymity. The data was collected using the English language proficiency test, a pre- test and a post- test. Learners in the experimental group were also interviewed.

In order not to disadvantage those in the control group, the learners were taught the same topic in Southern- Sesotho by the same teacher and had access to the English- Southern- Sesotho Physics dictionary as soon as the study had been completed.

Once data had been collected, it was then presented, analysed and interpreted in the next chapter. The next chapter will therefore detail data collection, interpretation, analysis as well as conclusions arising from the data collected and analysed.

CHAPTER 4: DATA PRESENTATION, INTERPRETATION AND ANALYSIS

This chapter details the data collected during the study, how it was analysed by the researcher as well as the results that emanated from the analysis.

4.1 Introduction

The present study aimed to investigate whether language is a contributing factor to the academic performance of Southern Sesotho Physics learners. Societies world-wide have become more linguistically diverse, thus many learners enter the Physics class with a home language that is completely different from the language of instruction used in the Physics class.

The study took into account the learners' home language (Southern Sesotho) and their proficiency in the language of instruction (English) in relation to their academic performance in Physics. Three achievement tests were administered to the learners, namely an English Language Proficiency test, a pre- test, and a post- test. The learners' marks in the three tests were recorded on performance tables and presented on bar graphs.

The mean, pass rate, standard deviations, learning gain, effect size indices, standard deviations, and p value for each test were calculated. In analysing quantitative data the researcher used R- computing and recorded the findings in tables and bar graphs. After writing the three tests, learners in the experimental group were then interviewed in order for the researcher to gather information on the learners' evaluation of the intervention given to them during the study.

The responses to the interview questions were written down by the researcher as well as being tape- recorded with the learners' permission. The responses were then transcribed and analysed by the researcher.

In carrying out the study the researcher wanted to answer the following research question and subquestions:

1. What is the role of language in the teaching/learning of Physics?

2. How does language affect the academic performance of Grade 11 Physics learners?
3. To what extent can Southern Sesotho be used as a medium of instruction in the teaching/learning of Physics to Grade 11 learners?

The research also had hypotheses that had to be either accepted or rejected:

Research hypothesis: *There is no relationship between language and academic performance in Physics.*

Null hypothesis: *There is no significant difference between the academic performance of the control and experimental groups in Physics.*

4.2. Data presentation and analysis

Analysis of data was done quantitatively as well as qualitatively. Quantitative data was collected from the three tests written by the participants while qualitative data was from the interviews held with the experimental group.

4.2.1 Quantitative analysis

One of the most commonly used statistical procedures for analysing quantitative research data is the t -test. There are three types of t -test that are commonly used in research: single sample, two- sample with different groups, two- sample with same group. In each case there is a comparison between two values to see if the values are the same or different (McMillan & Schumacher, 2010).

In this research the two- sample t -test was used. The two- sample t -test is considered to be the most common use of the t -test and is also referred to as an independent samples t -test (Leedy & Ormrod, 2010). The purpose of using this statistical procedure was to determine if there was a statistically significant difference in the dependent variable between the two groups in this research (McMillan & Schumacher, 2010).

The researcher calculated the mean and standard deviation of each sample using the R- computing (Rubin & Babbie, 2010), used them to determine the t -statistic, which is considered as the difference between the sample means divided by the standard error of the mean

The calculated t values were either a three- or four- digit number with two decimal places. To determine the level of significance, the researcher compared this calculated number with theoretical t values in the distribution of t table (McMillan & Schumacher, 2010). The researcher used the table by locating two numbers: the degrees of freedom (df) and the level of significance desired (McMillan & Schumacher, 2010).

In analysing quantitative data in this study the researcher used the two- sample t -test with independent (different) groups described above. The means, standard deviation, effect size index, learning gain, and degrees of freedom were calculated for all tests written by the two groups in the study and then compared. The researcher used R- computing for the calculations. An independent statistician assisted with the quantitative analysis of the test results.

After writing the pre- test learners were randomly assigned to either the experimental treatment group receiving lessons in their home language or control group. Separate t - tests were calculated to determine if there were significant differences between the two groups with respect to their performance in the three tests (English Language proficiency test, pre- test, and post- test).

The probabilities (whether their performance is the same or different) were formalised by statements that were tested, and these statements are referred to as hypotheses (Rubin & Babbie, 2010). The research hypothesis for this research was considered as the research prediction being tested. The researcher made reference to probability in terms of sampling and measurement error, and used a statement called the statistical hypothesis. Statistical hypotheses are stated in either null or alternative form (McMillan & Schumacher, 2010).

4.2.2 Null hypothesis

The null hypothesis stated that there was no difference between the population means of the two groups that were being compared in the study (Tuckman, 2011). In other words the population means were considered the same. The researcher made use of inferential statistical test to determine the probability that the null hypothesis was false (Gray, 2011). If the null hypothesis was false, then there was a high probability that there existed a difference between the two groups (McMillan & Schumacher, 2010).

The reason why null hypotheses were used with inferential statistics in this study was that the researcher was not trying to prove something to be true, but only trying to disprove it (McMillan & Schumacher, 2010).

4.2.3 Alternative hypothesis

The alternative hypothesis is the opposite of the null hypothesis (Punch, 2011) and represents the research or experimental hypothesis in statistical terms. The alternative hypothesis can either be directional or nondirectional. A directional hypothesis states that one population mean is either greater or less than the other population mean (McMillan & Schumacher, 2010),

Since the directional alternative hypothesis postulates one outcome, it is often referred to as one-tailed or one-sided while the nondirectional alternative hypothesis is referred to as a two-tailed or two-sided alternative hypothesis (McMillan & Schumacher, 2010). The alternative hypothesis, whether directional or nondirectional, is used in deciding whether or not the null hypothesis can be rejected (Cohen et al., 2011).

In this study the research hypothesis was that *there is no relationship between language and academic performance in Physics* while the null hypothesis was that *there is no significant difference between the academic performance of the control and experimental groups in Physics*.

The researcher, in determining whether to accept or reject the null hypothesis, calculated the means for the two groups for all tests they wrote using R-computing software using the two-sample t -test with independent groups formula.

After determining the t value the researcher established the degrees of freedom. The term degrees of freedom (df) is a mathematical concept that denotes the number of independent observations that are free to vary (McMillan & Schumacher, 2010). The calculated value was then compared with corresponding values on the distribution of a t -table.

In determining whether or not to reject the null hypothesis the researcher then went on to calculate the p value. This is also called level of probability and is expressed

as a decimal and indicates how many times out of 100 or 1,000 the researcher would be wrong in rejecting the null hypothesis, assuming the null hypothesis is true.

If the p value was the same or less than 0.05 ($p \leq 0.05$) then the researcher rejected the null hypothesis since there would be statistically significant difference. The researcher determined the p value for both groups for the three tests written during the study. Where the null hypothesis was rejected the researcher made the statement that *there is a statistically significant difference*.

A p value between 0.05 and 0.10 is usually thought of as marginally significant, and anything greater than 0.10 is labelled a non significant difference (McMillan & Schumacher, 2010). In cases where the p value was greater than 0.10 ($p > 0.10$) the researcher accepted the null hypothesis.

In analysing qualitative data the researcher used Gläser and Laudel's (2010) model. The researcher started to reduce data by generating categories and codes from the interview responses. The transcribed text data were divided into segments or codes. The codes were then reduced until the researcher managed to collapse them into the four themes. The process of data reduction yielded four main themes that led to further sub-themes as the thematic discussion of findings unfolded.

4.3 English Language Proficiency test

The English Language Proficiency test had eighty (80) items. These were broken down into seven (7) sections. The first section had eighteen items and required the participants to fill in blank spaces using one or two words that were provided. There were four possible answers and the participants had to choose the most appropriate one, see Appendix L.

Section two comprised long sentences with explanations. The participants were then asked to give the correct response, for example:

Question (19)

A friend of yours complains that apart from her, all her other colleagues in her office have received a pay raise. She feels hurt so she wants to quit immediately. You think she is behaving unreasonably. Since she cannot afford to remain unemployed, you advise her to be more careful. You say:

- (a) Your colleagues are not better than you. Why does your boss refuse to give you a pay raise?
- (b) How can you survive on such a low salary? I would suggest that you start looking for another job.
- (c) I understand how you feel, but why don't you find another job before you quit?
- (d) I feel sorry for you. I think your boss simply does not trust you. It is better to be unemployed than work for him.

This section comprised two questions which were rather too abstract and demanded good reasoning.

The third section had ten (10) questions in which the participants were given sentences and they had to choose responses that had closest meaning to the given long sentences, for example:

Question (21):

It was not until they watched the evening news that people realised how much damage the storm had caused.

- (a) People did not know how much damage the storm had caused until they watched the evening news.
- (b) People watched the evening news because they realised that the storm had caused a lot of damage.
- (c) Before watching the evening news, people knew the storm had caused a lot of damage.
- (d) After they realised that the storm had caused a lot of damage, people watched the news until late in the evening.

The fourth section had ten (10) questions that required the participants to fill in blank spaces using sentences and not one word answers as was the case in section one. For example:

Question (37)

Since his family is the most important part of his life, _____.

- (a) whenever he thinks about his children and wife

- (b) he makes sure he is always present in his children's lives.
- (c) so that he does not have any regrets in the future.
- (d) that's the reason why he tries to satisfy all his children's desires.

In the fifth section of the proficiency test participants were instructed to give a word that had the closest meaning to the underlined one. For example:

Question (48):

The school is required to notify parents if their children fail to come to school.

- (a) Notice
- (b) Annoy
- (c) Confirm
- (d) Inform

The section had ten (10) questions. The sixth section had ten (10) questions and required the participants to fill in given sentences with one word answers. The questions were relatively short and in simpler English.

The last section had four passages which the participants had to read before answering questions. This section had twenty (20) questions with four possible answers per question.

All ninety-eight (98) grade ten Physics learners wrote the English Language Proficiency test. However before they wrote the test they were given numbers by which they would be referred to during the course of the study. The numbers ranged from 1 to 98. Their performance in the English Language proficiency test was as follows:

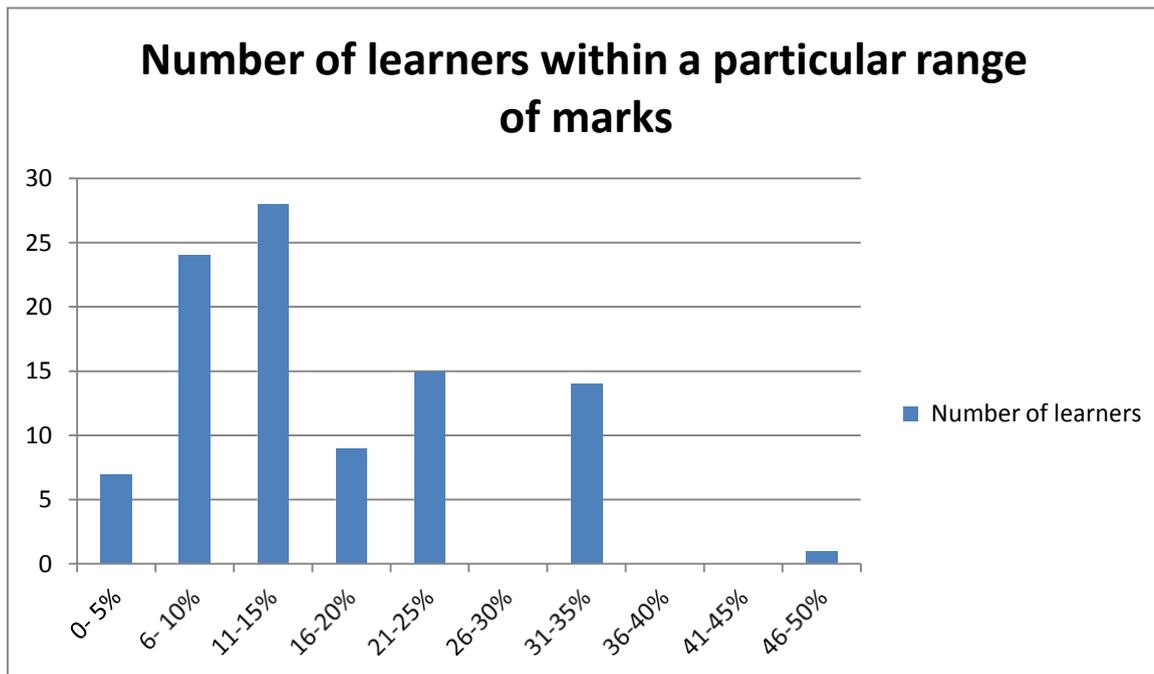


Figure 4.1: Number of learners within a particular range of marks

The mean for the 98 learners in the English Language proficiency test was 12.95% while the pass rate stood at 15.3%

A meagre 15.3% of the 98 participants managed to achieve a mark of 30% or better in the English Language Proficiency test. This is proof of a low proficiency in the language. Their marks as a percentage, for the 15 learners who passed the proficiency test are represented in the following bar graph:

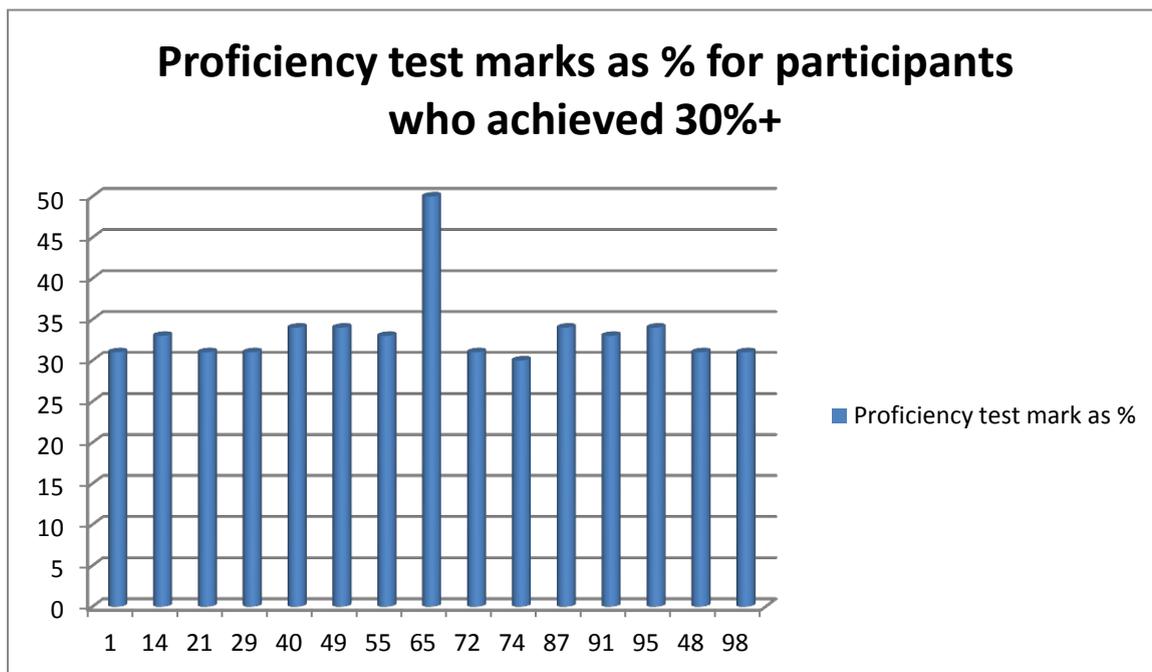


Figure 4.2: English Language proficiency marks for learners who achieved a score of 30%+

15 of the 98 learners who wrote the proficiency test attained a mark of 30% or higher. This actually meant that only 1 in every 6.5 learners passed the test according to Department of Education standards where 30% is regarded a pass (Department of Education, 2011) for additional languages.

The 98 learners were then ranked according to their performance in the English Language proficiency test and the top forty (40) were invited to participate in the research. Since the research was on the effect of language on the academic performance of Physics learners this justifies why the top forty were chosen to participate in the research.

These were the learners who exhibited a better understanding of the English language, which happens to be their language of instruction, than the rest of the group. The researcher went on to carry out an error analysis for the performance of the top forty learners in the English Language proficiency test. The essence of the

analysis was to determine which aspects of the test were incorrectly answered by the learners.

Their individual performance per section was as follows:

The researcher then plotted a bar graph basing on the information in the table above to have a clear analysis of the learners' performance per section. The vertical axis of the graph represents the number of incorrect responses per section while the horizontal component of the graph represents the learners.

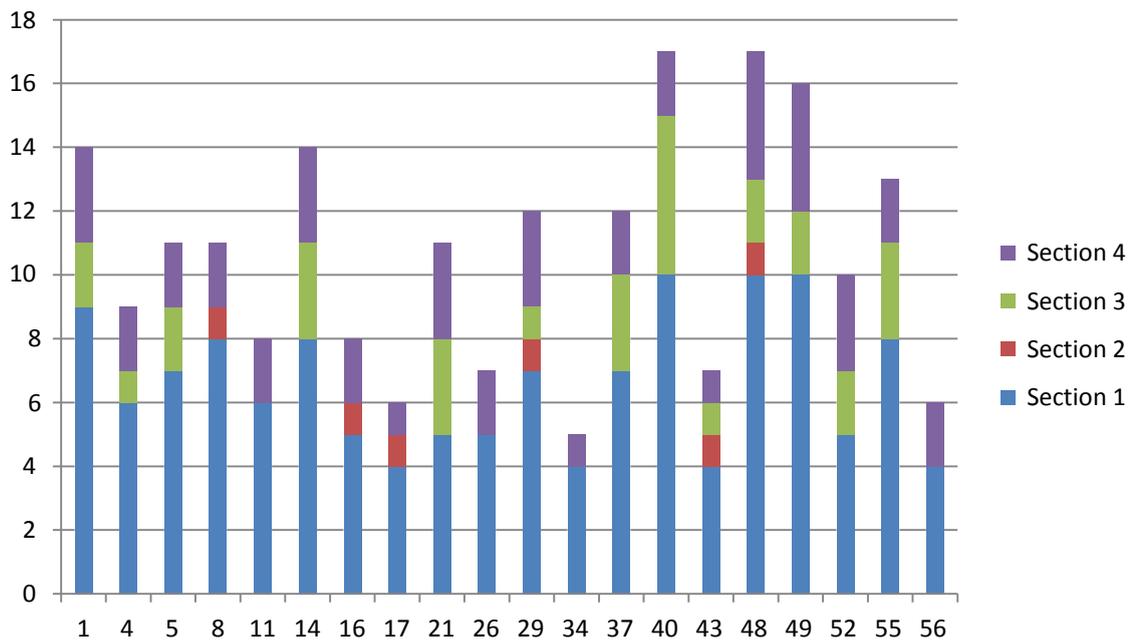


Figure 4.3: Section 1 to 4 analysis of incorrect responses for first twenty participants in the top 40

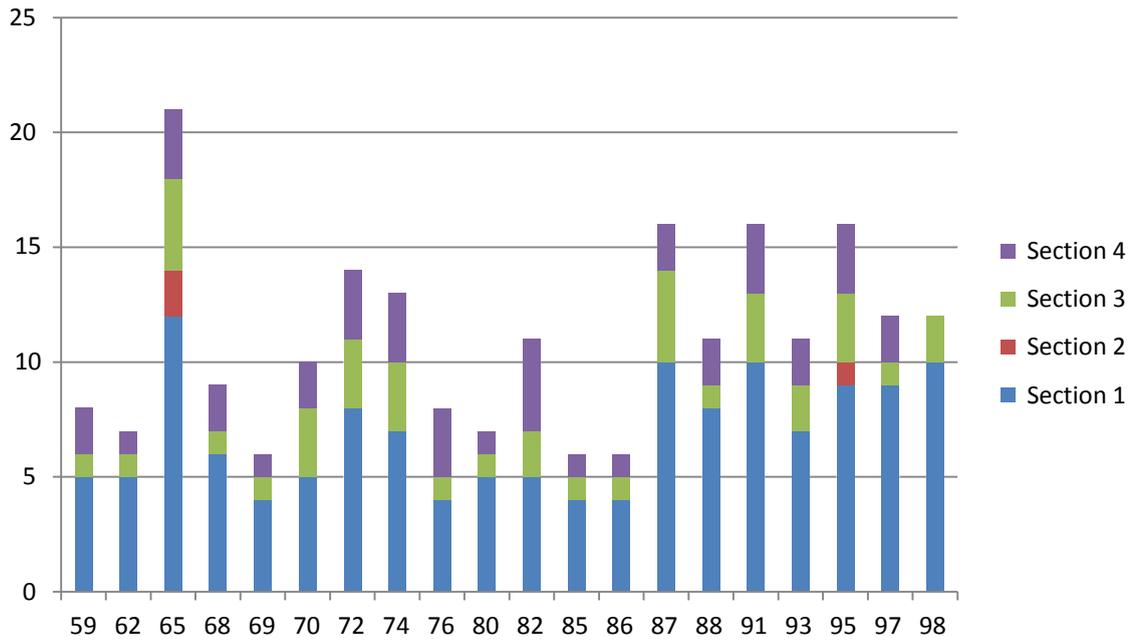


Figure 4.4: Section 1 to 4 analysis of incorrect responses for the other twenty participants in the top 40

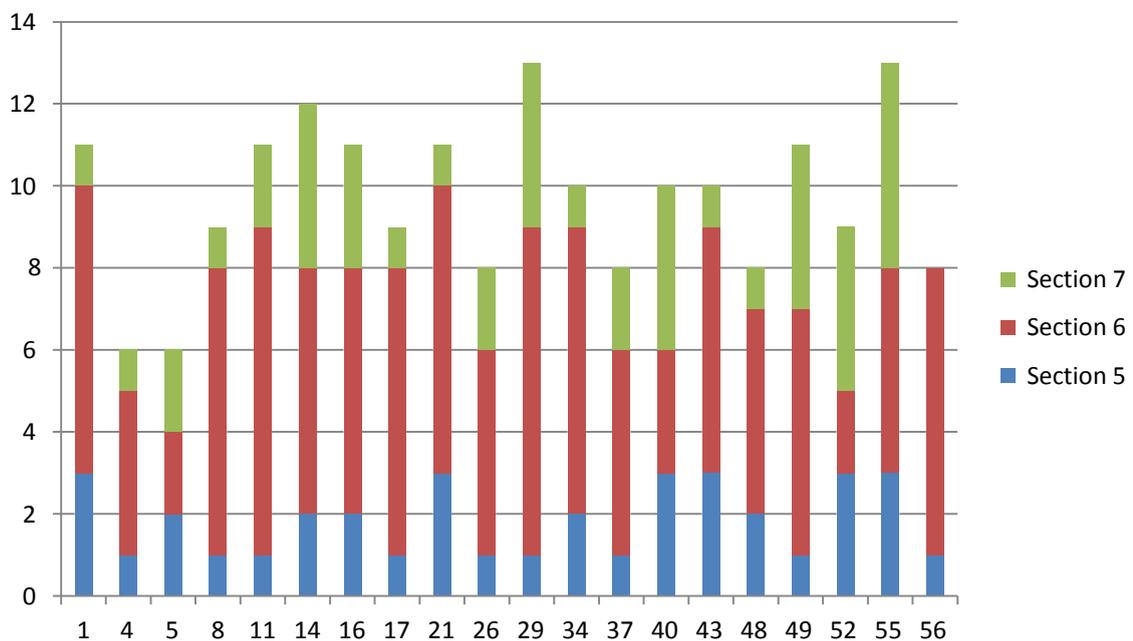


Figure 4.5: Section 5 to 7 analysis of incorrect responses for first twenty participants in the top 40

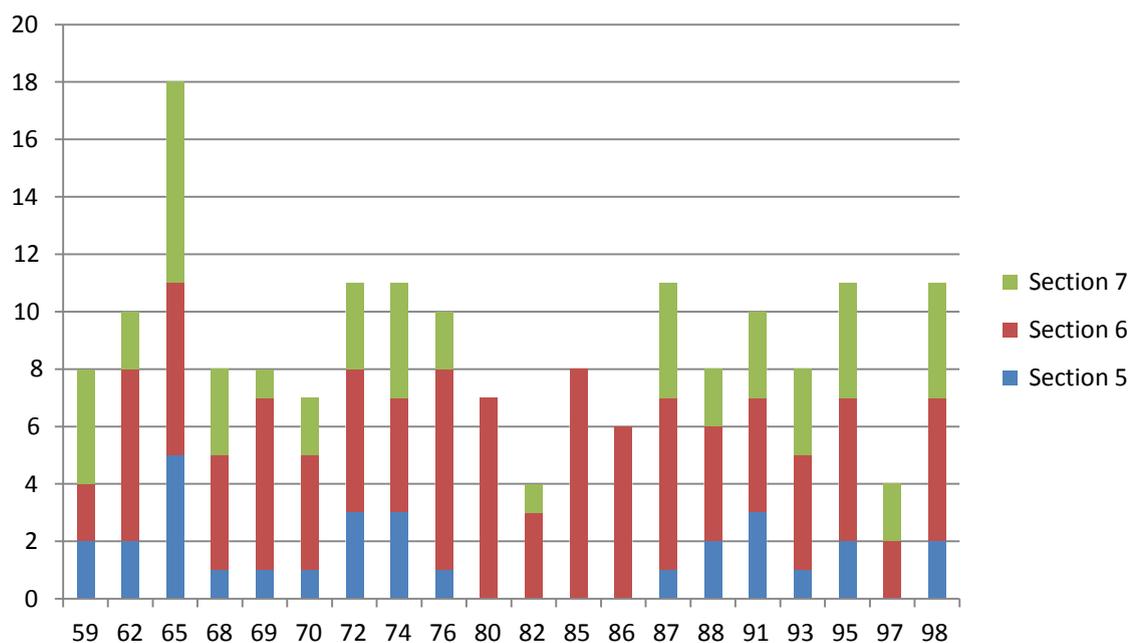


Figure 4.6: Section 5 to 7 analysis of incorrect responses for the other twenty participants in the top 40

From the graphs, it is evident that Sections 2; 3; 4; 5 and 7 were badly done by the learners. The highest mark in all the sections, except section 2, was less than 50%. For sections 2; 5; and 7 the lowest mark was 0%.

The researcher then went on to analyse the number of learners, from the top forty, who scored at least 30% per section. This score (30%) was chosen as it is the Department of Education’s pass mark and the results were as follows:

TABLE 4.1: Analysis of learners’ performance in the English Language Proficiency test

Section	30%+	Pass rate	Highest %	Lowest %
1	23	58	67	22
2	8	20	100	0
3	11	28	50	10
4	15	20	40	10
5	10	25	50	0
6	36	90	80	20
7	1	3	35	0

The information in the table above was then plotted onto a graph. On the vertical axis are the 7 sections while the horizontal axis represents the marks as a percentage.

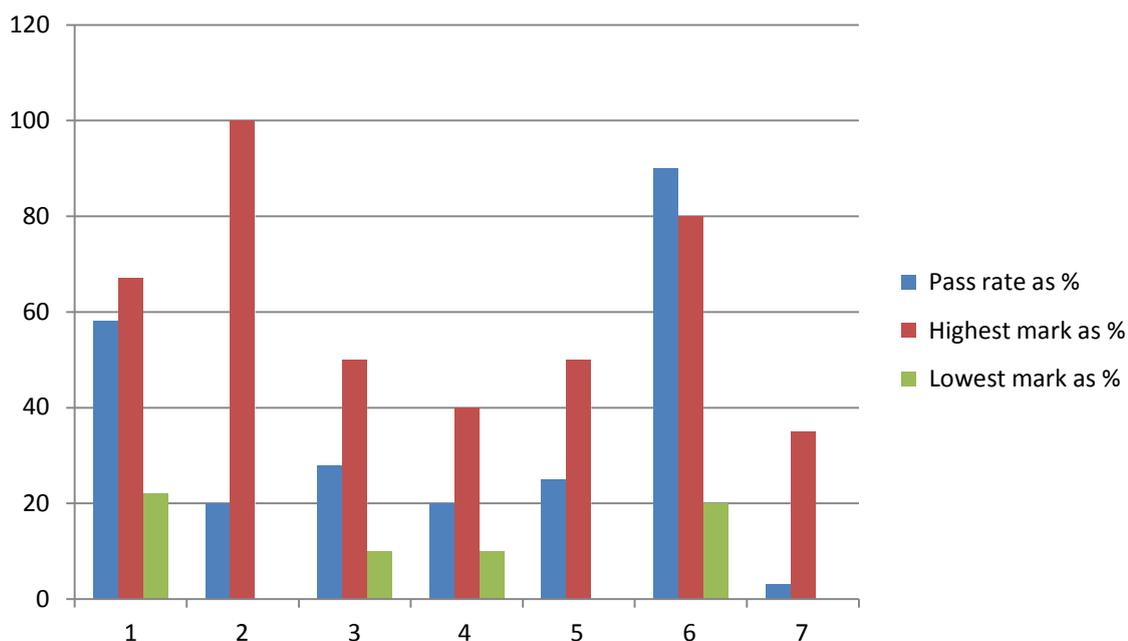


Figure 4.7: Comparison of participants' performance section by section in the proficiency test

The worst sections, according to the statistics on the table above, were sections 2; 3; 4; 5 and 7. The first three sections are those in which learners were given long sentences and/or instructions and then required to choose the most appropriate answer from a possible four answers that were equally long.

A mere 20% of the learners got a pass mark (at least 30%) in section 2; 28% in section 3; another 20% passed section 4; 25% of the 40 learners passed section 5; with a meagre 3% passing section 7.

Their poor performance is evidence that they do not understand long sentences or tend to be confused by them and would just choose any answer from the given

choices. Some of the sentences contained vocabulary the participants did not understand.

For example:

Question (20):

You get stuck in heavy traffic on your way to an important job interview. You arrive there thirty minutes late and when you finally meet your interviewer, you offer your apologies and try to explain why you were late. You say:

- (a) I apologise for being late. I knew that there would be a lot of traffic on the roads today.*
- (b) I am terribly sorry that you had to wait for me. I have no excuse for being so late.*
- (c) Please forgive me for keeping you waiting. I apologise for all the inconveniences that I might have caused.*
- (d) I apologise for being so late. If there had not been a lot of traffic on the roads, I would have arrived here on time.*

Question (23):

The new sports centre will provide more opportunities for students and teachers alike.

The sentence closest in meaning to the given sentence is;

- (a) The new sports centre will provide more opportunities for students than for teachers.*
- (b) The opportunities that the new sports centre will offer are similar for both teachers and students.*
- (c) Both teachers and students will be provided with more opportunities by the new sports centre.*
- (d) Teachers like the fact that the new sports centre will provide more opportunities for their students.*

Such sentences contain a lot of words which the learners had to know and understand their meaning in order for them to correctly answer the questions. Since the marks were very low that proves that the learners' understanding was limited. However sentences of similar lengths are a common sight in Physics, for example:

If 30g of reactant A reacts partially with 25g of reactant B, which ONE of the following statements is CORRECT?

- A. The total mass of products plus any unreacted reactants will be less than 55g.*
- B. The total mass of products plus any unreacted reactants will be greater than 55g.*
- C. The total mass of the products plus any unreacted reactants will be 55g.*
- D. The total mass of the products will equal to 55g.*

(Adapted from Free State DoE grade 10 June 2014 Formal Assessment Task)

Section five (5) was on vocabulary. The learners were given sentences that had one word underlined. They were supposed to give a word that meant the same as the underlined one. For example:

Question (45):

Many businesswomen find it difficult to cope with the pressure of working with male superiors and quit their jobs.

The word closest in meaning to the underlined one is;

- (a) create*
- (b) deal*
- (c) try*
- (d) leave*

Only 25% of the respondents managed to achieve a score of at least 30% in this section. This shows that 75% of them were not able to give synonyms of the underlined words. This is due to the fact that the learners did not know the meanings of the underlined words in order for them to supply the synonyms.

In section seven (7) the learners were given four comprehension passages of lengths 25; 14; 23; and 22 lines respectively. They were then asked questions

based on the passages read. From the table above it can be seen that only one participant managed to reach the 30% pass mark, representing a 3% pass rate.

This therefore means that the participants did not understand the passages they had read to enable them to answer the comprehension questions correctly.

The best answered were sections 1 and 6 where 58% and 90% of the participants got 30% or above, respectively. In both sections they were given short sentences and had to fill in blank spaces with one word answers. The participants, basing on the results from the two sections perform better when they are given short sentences, a scenario rarely found in Physics.

The language used in the sentences was also light and straight forward, for example:

Question (3):

The old man managed to tell his son _____ he kept all his money only a few minutes before he died.

- (a) Whether*
- (b) Which*
- (c) When*
- (d) Where*

Question (14):

The more he thought about the problem, _____ the solution seemed to be.

- (a) easier*
- (b) the easiest*
- (c) easiest*
- (d) the easier*

These two sections were less demanding in terms of understanding the sentences, and analysing them before answering the questions. The given possible answers were also one word answers which were relatively easy to comprehend. Considering the error analysis above, it is evident the learners fared badly in questions that were long and required thorough reading and analysis.

Considering the above, the most common marks were those below 30%. This in itself shows how badly the learners performed in the proficiency test. Only 15 of the top 40 learners managed to attain 30% or higher in the test. This represents a mere 37.5% pass rate, lest we forget this is their language of instruction at their respective schools and it is the language in which their examinations are set and answered.

The researcher then went on to compare the performance of learners assigned to the two groups (Experimental and control).

Null hypothesis: *There is no statistical difference in the academic performance between the two groups.*

TABLE 4.2: Statistical Analysis of Experimental group and Control group English proficiency test

		Dependent t- test statistics					
		Mean	Sd	p- value	Effect size	Gain	
Test							
English	Experimental	24.9%	6.17%	0.7102	0.04	0.00	
Language	Control	25.15%	6.09%				

The p- value, effect size, and gain indicated in the table above is for both groups. Considering the means and standard deviations of the two groups, it is evident that the groups' performance was almost the same. There was a difference of 0.25% in their means and 0.08% in the standard deviations. There was a 0.00 learning gain as no intervention was given for English Language proficiency.

Learners assigned to the experimental group had a mean of 24.9% while the control group had a mean of 25.15%. There was a difference of 0.08% in their respective standard deviations, with the experimental group having a higher standard deviation. These statistical values were calculated using R- computing. The null hypothesis is not rejected.

4.4 Pre- test

Null hypothesis: *There is no statistical difference in the academic performance between the two groups.*

The forty learners were then given a pre-test to write. The test used in this study is popularly known as the Mechanics Baseline Test (MBT). The MBT was developed by David Hestenes and Malcolm Wells of Arizona State University and it has 26 multiple choice questions. The test assessed learners' quantitative problem solving skills focusing on the topic *Mechanics*.

Their performance is represented in the following graph:

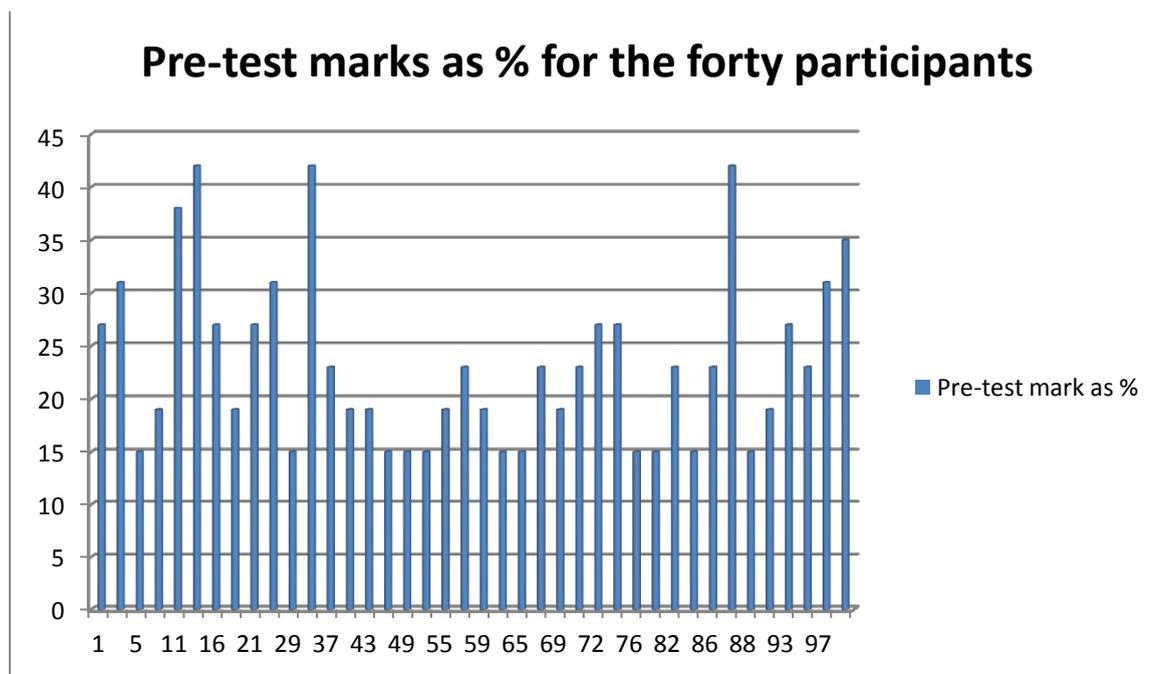


Figure 4.8: Pre- test marks (N = 40)

From the table above 8 participants of the 40 that wrote the pre-test achieved a score of 30% or higher. This represents a pass rate of 20%. The highest participant got 11 out of 26 which translates to 42% while the lowest had 15%.

The average mark for the 40 participants was 24.3%. This shows how badly participants performed in the pre-test. With a pass rate of 20% this means 80% of the group (or 4 in every 5) failed the test.

After writing the pre- test the forty learners were then randomly assigned to either the control or experimental group. The following graphs present the learners' marks in the pre- test per group, that is control and experimental.

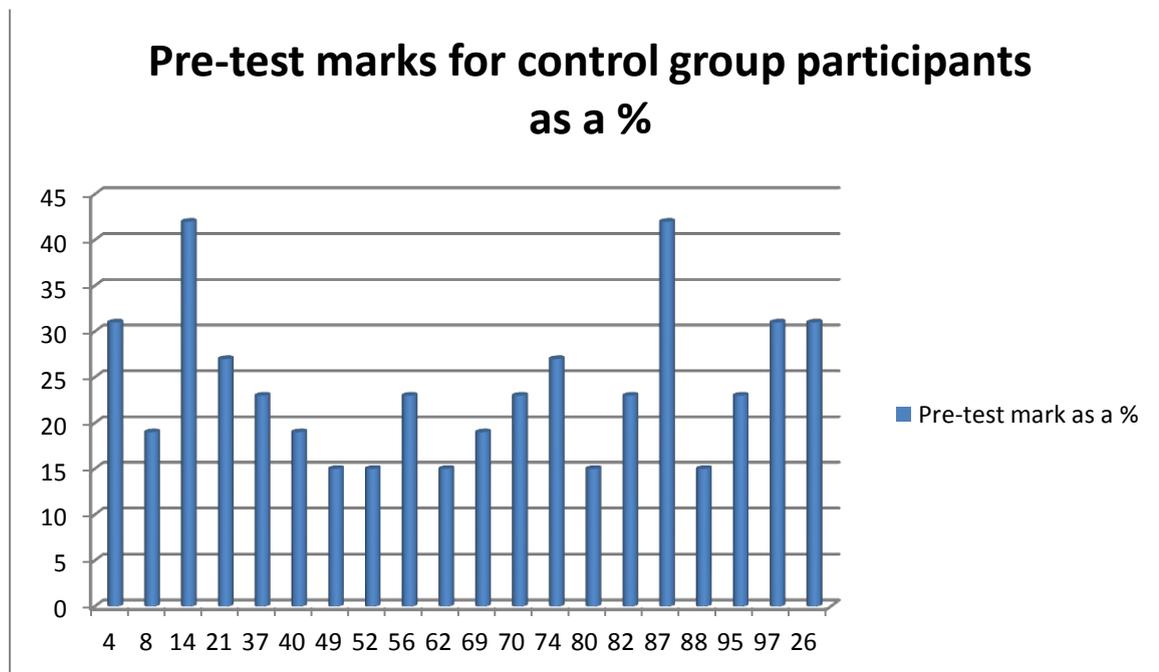


Figure 4.9: Pre- test marks: Control group (N = 20)

The mean for the 20 learners assigned to the control group was 23.9% with a standard deviation of 8.26%. 5 of the 20 learners assigned to this group attained a mark above 30%. The calculated p- value was 0.6461. Since the p- value falls between 0.05 and 0.10, this shows a marginally significant difference (McMillan & Schumacher, 2010).

Figure 4.10 below shows the pre- test marks attained by learners assigned to the experimental group.

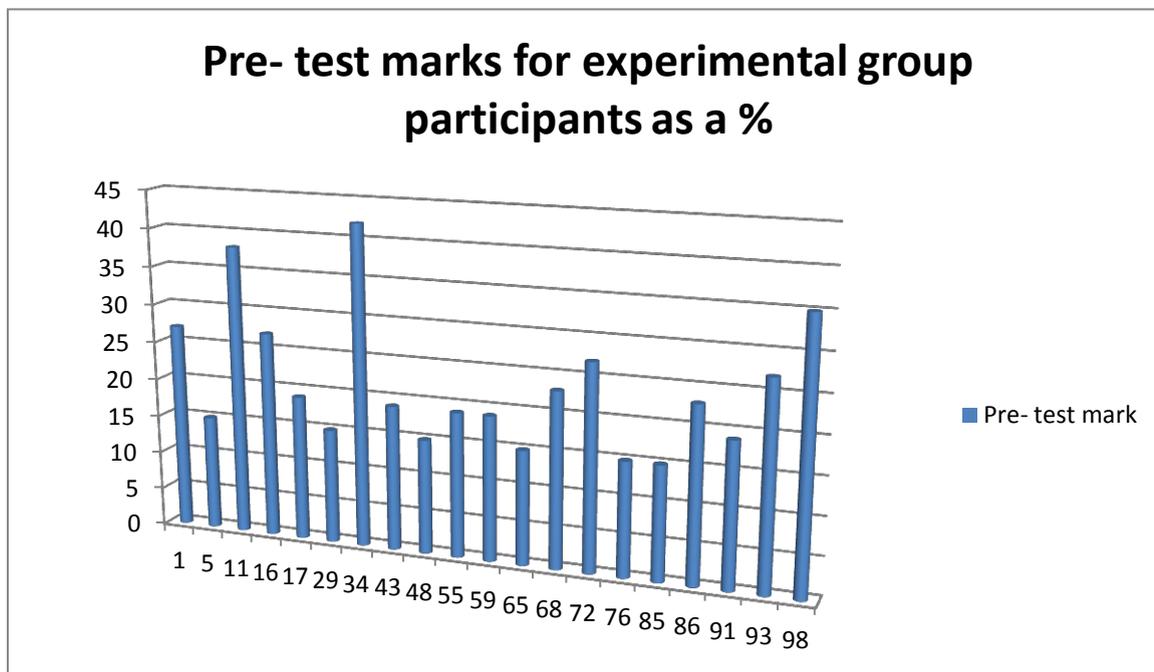


Figure 4.10: Pre- test marks: Experimental group (N = 20)

Only 3 of the 20 learners assigned to the experimental group passed the pre- test. The mean for this group was 22.7% within a standard deviation of 8.13%. Considering the DoE's pass mark of 30%, the group's pass rate was 15%.

A statistical comparison of the two groups' performance (control and experimental) in the pre- test yielded the following results:

Table 4.3: Statistical Analysis of Experimental group and Control group Pre- test results

		Dependent t- test statistics				
		Mean	sd	p- value	Effect size	Gain
Pre- test						
Experimental		22.7%	8.13%	0.6461	0.14	0.02
Control		23.9%	8.26%			

The p- value, effect size index, and gain indicated in the table above is for both groups, control and experimental.

From the statistical analysis above we cannot reject the null hypothesis considering the negligible difference in the means of the two groups as well as the p- value obtained (McMillan & Schumacher 2010). *There is insufficient evidence to indicate a difference in the academic performance in the pre-test results for the experimental and control group.* The poor performance in the pre- test indicates that learners who have a low proficiency in the LoLT face more difficulty in attaining a proficient level in Physics (Van Laere et al., 2014). This finding was in line with previous research (O'Reilly & McNamara, 2007; Taboada, 2012; Van Laere et al., 2014) which suggests that being proficient in the LoLT is positively related to Physics achievement.

4.5 Intervention

The researcher then identified key words and concepts found under the topic *Mechanics* and developed an English- Southern Sesotho Physics dictionary. The dictionary had translations of these words from English to Southern Sesotho (the learners' home language) as well as Sesotho explanations for some of the words.

Learners who had been drawn to the experimental group had lessons on the topic *Mechanics* in both English and Southern Sesotho. Translanguaging (the switching over between English and Sesotho languages) was used during the experimental group's lessons to emphasise important concepts as well as explaining meanings of difficult words to the learners.

In addition to the multilingual Physics lessons the experimental group had, these learners were also given an English- Southern Sesotho Physics dictionary to use during class. During the lessons learners in the experimental group were allowed to converse in their mother tongue (Southern Sesotho). Questions and answers were translated from English to Southern Sesotho or vice versa for clarity and full comprehension by all learners in the group.

These dictionaries were kept by the researcher to prevent the control group from having access to them. Those in the control group were taught the same concepts by the same teacher but only in the school's language of teaching/learning (English).

The learners from both groups were then given a post- test to write. They wrote the same test under the same conditions in the same room.

4.6.Post - test

The test comprised most of the words incorporated into the English- Southern Sesotho Physics dictionary the experimental group had been given together with some that had been translated orally during the experimental group's multilingual Physics lessons. The test had 26 multiple choice questions and was written in 45 minutes. This was the same test used as the pre-test.

To try and curb some obvious threats to validity, the questions were jumbled up, for example Question 1 in the pre- test became Question 15 in the post test. However when the tests (pre- and post-test) were being analysed the same numbering as that on the pre-test was adhered to. The learners were given their scripts at the end of the study to prevent them from memorising the answers.

4.6.1 Test reliability

To test for the reliability of the post-test, Cronbach's alpha was determined for the two groups (control and experimental). Cronbach's alpha is a lower band estimate of the reliability of psychometric tests. The deduction on the test's reliability rests in the comparison between the calculated values against the tabulated one. The following are guidelines for interpreting test reliability basing on Cronbach's alpha:

$\alpha \geq 0.9$ excellent test

$0.8 \leq \alpha < 0.9$ Good test

$0.7 \leq \alpha < 0.8$ Acceptable

$0.6 \leq \alpha < 0.7$ Questionable

$0.5 \leq \alpha < 0.6$ Poor

$\alpha < 0.5$ Unacceptable (Creswell, 2014; McMillan & Schumacher, 2010).

The researcher calculated Cronbach's alpha for the two groups after disregarding Questions 7; 18 and 20. These were the three questions that were badly done by the learners due to their advanced content. Before the three questions were

disregarded the alpha estimate stood at 0.53, thus falling in the “poor” level (Creswell 2014).

Cronbach’s alpha estimate of the Mechanics Baseline Test: Post test (Experimental group):

$$\alpha = \frac{26}{25} \left(1 - \frac{3.1586}{11.3475} \right)$$

$$\alpha = 0.75$$

According to tabulated international standard values, the above alpha estimate (0.75) is indicative of an acceptable test given to the learners.

Cronbach’s alpha estimate of the Mechanics Baseline Test: Post test (Control group):

$$\alpha = \frac{26}{25} \left(1 - \frac{1.5652}{5.3275} \right)$$

$$\alpha = 0.73$$

The Cronbach alpha estimate for both groups highlighted the high level of reliability of the test given to the learners. Though the reliability did not fall in the “good” bracket, but according to Creswell (2014) the calculated value showed that the test was acceptable. A possible reason could be that the test was designed for learners of a higher level than the grade used in the study.

To achieve high reliability and consistency in psychometric tests, the tests must be within the learners’ reading level and be of appropriate language (McMillan & Schumacher, 2010). To determine the applicability of McMillan and Schumacher’s assertions to this study, the questions in the test will be discussed individually.

The test was divided into two subtopics: Motion, and Force for the purposes of thorough analysis.

4.7 Question by question analysis of learners’ responses

Learners’ responses to respective questions are presented below.

4.7.1 Motion questions analysis

Learners’ responses to questions on motion were analysed first by the researcher.

4.7.1.1 Questions 1 to 4: Experimental group

The table below takes a microscopic view at how individual questions were answered by learners in the experimental group in the two tests.

Table 4.4: 1 Questions 1 to 4: Experimental group

Pre-test and Post-test results of Motion questions per question(Experimental)																							
Question 1 Pre-test			Question 1 Post-test			Question 2 Pre-test			Question 2 Post-test			Question 3 Pre-test			Question 3 Post-test			Question 4 Pre-test			Question 4 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %
A	3	15	A	1	5	A	3	15	A	4	20	A	3	15	A	2	10	A	4	20	A	2	10
B	12	60	B	11	55	B	4	20	B	2	10	B	3	15	B	3	15	B	3	15	B	4	20
C	3	15	C	1	5	C	3	15	C	2	10	C	2	10	C	4	20	C	6	30	C	11	55
D	1	5	D	4	20	D	9	45	D	11	55	D	5	25	D	0	0	D	3	15	D	2	10
E	1	5	E	3	15	E	1	5	E	1	5	E	7	35	E	11	55	E	4	20	E	1	5
Total		100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100

Considering Question 1 to 3, in both the pre- and post-test the majority of learners in the experimental group chose options which happened to be the correct answer. This was proof that the learners understood the basic concepts of Motion. Question 4 presented challenges for the learners in the pre- test. 30% of the learners got the answer correctly.

Question 1 options A and C were chosen by 15% of the learners in the pre- test and by 5% in the post test. This showed that 15% of the learners had a misconception of velocity as a function of time. The question also contained words such as multi, flash, interval, and occurred. These words could have been out of the learners' vocabulary reach. After such words were included in the Physics- Southern Sesotho Physics dictionary given to the learners as intervention, only 5% got the question wrong in the post test.

25% of the learners got Question 3 incorrect in the pre- test. The question, again, was about the velocity of an object as a function of time and contained words such

as graph, represents, net force, relationship, and below. These words were then included in the dictionary and explained to the learners in their home language. In the post-test not a single learner chose the incorrect option they had chosen in the pre-test (option D). The learning gain (g) and effect sizes for the four questions were calculated to determine the effectiveness of the intervention, and presented below are the results:

Table 4.5: Dependent t-test statistics: Questions 1 to 4: Experimental group

Dependent t-test statistics Motion(experimental)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
1	Pre	60	49.24	0.375	0.20	-0.125
	Post	55	50			
2	Pre	45	50	0.63	0.20	0.182
	Post	55	50			
3	Pre	35	47.94	0.097	0.42	0.308
	Post	55	50			
4	Pre	30	46.06	0.054	0.54	0.357
	Post	55	50			

The group's conceptual knowledge learning gain can be represented graphically as follows:

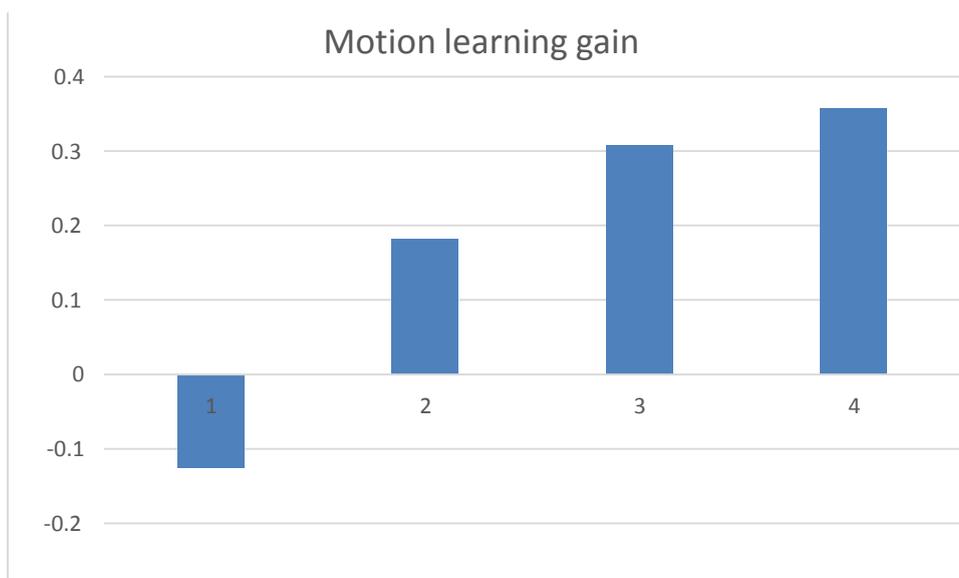


Figure 4.11: Learning gain: Question 1 to 4: Experimental group

For all graphs on learning gain in this report, the vertical component of the graph shows the learning gain. A high learning gain (g) is one that is ≥ 0.7 . An average learning gain is considered to be $0.3 < g < 0.7$ and a low g score is one < 0.3 (Creswell 2014). According to the above calculations, there was a negative learning gain for Question 1. Questions 2 to 4 had a positive g . Question 2 had a low learning gain (0.182) whereas Questions 3 and 4 had a g of 0.308 and 0.357 respectively.

According to Creswell (2014) and McMillan and Schumacher (2010) the last two questions presented an average learning gain. The rise in g for the two questions could have been due to the effect size. The effect size (ES) is the difference between two means in standard deviation units (Creswell, 2014). ES is a statistical index of the practical or meaningful differences between groups (McMillan & Schumacher, 2010).

Effect size indexes of about 0.20 are typically regarded as small effects, those of about 0.5 as medium effects and those above 0.80 are regarded as large effects (McMillan & Schumacher, 2010). The effect size indices for Questions 3 and 4 represent medium effects suggesting a positive effect in the use of learners' home language in Physics lessons.

4.7.1.2 Questions 1 to 4: Control group

The control group's performance in the first four questions is presented below:

Table 4.6: Questions 1 to 4: Control group

Frequency	Valid %														

70% of learners in the control group got Question 1 correct in the pre- test. However, this number dropped to 45% in the post test. There was a 5% increase in the number of learners who got Question 2 correct in the post-test and a 10% rise for Question 3. Statistics for Question 4 did not change in the two tests (40%).

Question 1 presented a shock. 70% of the learners in the control group got the answer correct in the pre- test. This number however dropped to 45% for the same question in the post test. McMillan and Schumacher (2010) warn that inconsistencies might occur if there is threat to internal validity.

The two means for the group (pre- and post-test) for these questions were calculated and the results were as follows:

Table 4.7: Dependent t-test statistics: Questions 1 to 4: Control group

Dependent t-test statistics Motion(control)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
1	Pre	70	46.06	0.054	0.54	-0.83
	Post	45	50.00			
2	Pre	50	50.25	0.375	0.10	0.10
	Post	55	50.00			
3	Pre	40	49.24	0.263	0.20	0.17
	Post	50	50.25			
4	Pre	40	49.24	0.50	0.00	0.00
	Post	40	49.24			

For a clearer analysis of the group’s learning gain emanating from lessons delivered to them, a graph was drawn and presented the following picture:

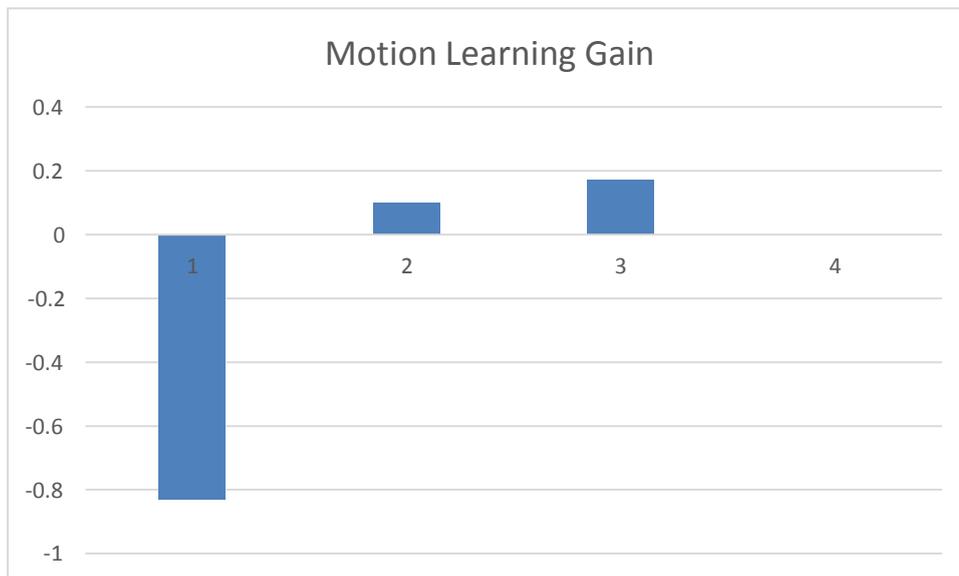


Figure 4.12: Learning gain: Questions 1 to 4: Control group

Question 1 had a negative learning gain and an Effect Size (ES) of 0.54. This (the ES) indicates a significant difference, though it is in the negative considering g. The learning gain for Questions 2 and 3 were 0.10 and 0.17 respectively. According to

Creswell (2014), the two gains (for Questions 2 and 3) indicate a very low gain, one which can be considered insignificant (McMillan & Schumacher, 2010).

Considering the four questions, the experimental group had a higher average learning gain.

4.7.1.3 Questions 5; 6; 11; 12: Experimental group

The following is a continual presentation of findings on Motion (Questions 5; 6; 11 and 12) for the two groups: Experimental and control.

Table 4.8: Questions 5; 6; 11; 12: Experimental group

Pre-test and Post-test results of Motion questions per question(Experimental)																							
Question 5 Pre-test			Question 5 Post-test			Question 6 Pre-test			Question 6 Post-test			Question 11 Pre-test			Question 11 Post-test			Question 12 Pre-test			Question 12 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %			
A	6	30	A	15	75	A	4	20	A	0	0	A	5	25	A	1	5	A	4	20	A	2	10
B	2	10	B	3	15	B	3	15	B	6	30	B	3	15	B	4	20	B	5	25	B	2	10
C	7	35	C	0	0	C	7	35	C	11	55	C	2	10	C	2	10	C	7	35	C	10	50
D	3	15	D	1	5	D	4	20	D	0	0	D	4	20	D	3	15	D	3	15	D	3	15
E	2	10	E	1	5	E	2	10	E	3	15	E	6	30	E	10	50	E	1	5	E	3	15
	20	100	total	20	100	total	20	100	total	20	100	total	20	100	total	20	100	total	20	100	total	20	100

The following table details the group's mean, and standard deviation for respective questions as well as the p- value, effect size index, and learning gain for the four questions.

Table 4.9: Dependent t-test statistics: Questions 5; 6; 11; 12: Experimental group

Dependent t-test statistics Motion(experimental)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
5	Pre	30	46.06	0.001	0.98	0.643
	Post	75	43.52			
6	Pre	35	47.94	0.097	0.42	0.31
	Post	55	50.00			
11	Pre	30	46.06	0.096	0.43	0.29
	Post	50	50.25			
12	Pre	35	47.94	0.097	0.31	0.23
	Post	50	50.25			

The experimental group's learning gain for the four questions can be presented graphically as thus:

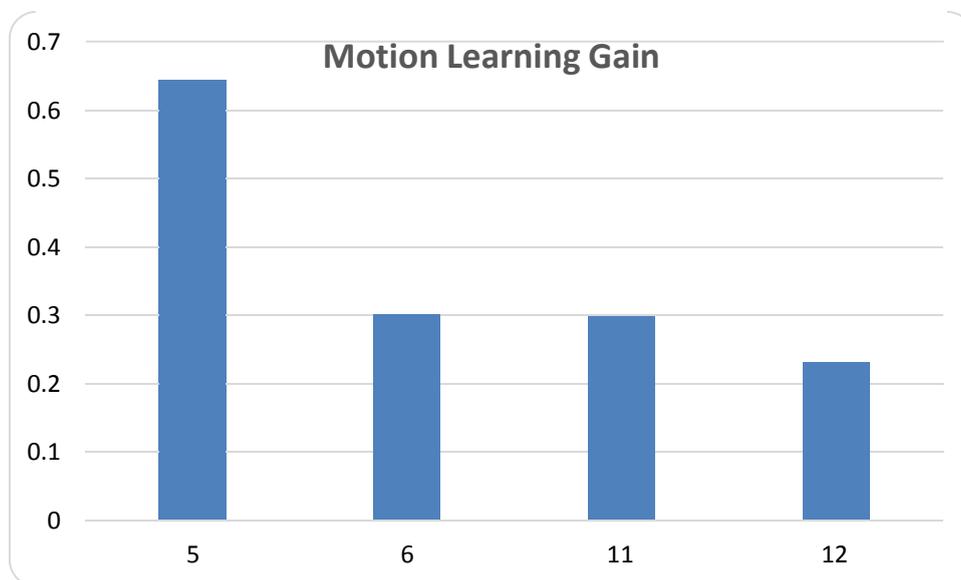


Figure 4.13: Learning gain: Questions 5; 6; 11; 12: Experimental group

The learning gain for the group, considering the four questions, can be presented graphically as follows:

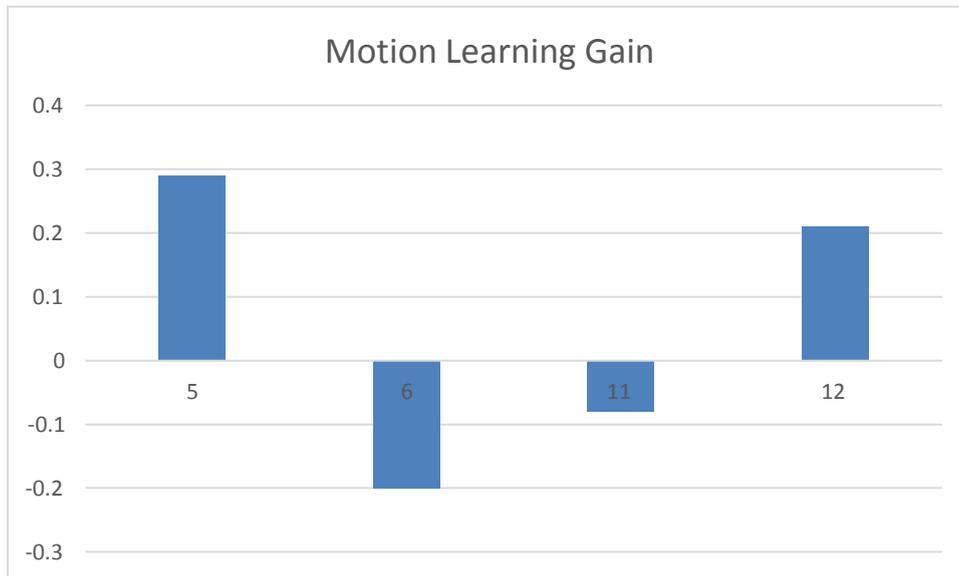


Figure 4.14: Learning gain: Questions 5, 6; 11; 12: Control group

The correct options for Questions 5; 6; 11; and 12 were A; C; E; and C respectively. For Question 5, 30% of the learners in both groups got the answer correct in the pre-test. When they answered the same question in the post test, 75% of learners in the experimental group got it right compared to 50% in the control group. The experimental group had an ES of 0.98 compared to 0.43 for the control group. The experimental group had a g of 0.643 while the control group had a g of 0.29 for the same question. The question had words like acceleration, position, represented, and arrows which were later incorporated in the English- Southern Sesotho Physics dictionary which was given to the experimental group. This could be the reason for the difference in the two groups' performance in the post test for the same question.

Question 6 presented a different picture in the pre- test. 35% of learners in the experimental group answered the question correctly in the pre-test compared to 50% for the control group. Words such as acceleration, block, ramp, and arrows found in the question were included in the dictionary which was later used as part of the intervention package. In the post test, 55% of learners in the experimental group answered Question 6 correctly compared to 40% from the control group. The

experimental group had an ES of 0.42 while that of the control group was 0.20 for Question 6. The g for the experimental group was 0.31 and that for the control group was -0.20. The ES for the experimental group showed a significant difference while that of the control group lay in the insignificant difference range (Creswell, 2014). The experimental group had a g of 0.31, which according to McMillan and Schumacher (2010) is average. The control group had a negative g . Indexes below 0.3 show very low or insignificant learning gain (Creswell, 2014; McMillan & Schumacher, 2010).

In Question 11, 30% of learners in the experimental group got the answer correct, which was option E. 40% of learners in the control group got the answer correct in the pre- test. After intervention was given to the experimental group, 50% of learners in the experimental group got the answer right compared to 35% of the control group. The experimental group had an effect size index of 0.43 and a learning gain of 0.29. The control group, on the other hand, had an effect size index of 0.10 and a learning gain of -0.08.

Even though according to Creswell (2014) g below 0.3 is considered low, that of the experimental group could be said to be average if rounded off because for great accuracy it might be advisable to round off the indexes to one decimal place (McMillan & Schumacher, 2010). This g (for the experimental group) was way higher than that of the control group which was in the negative (-0.08).

In Question 12, 35% of learners in the experimental group got the answer correct in the pre- test compared to 45% for the control group in the same question. In the post-test 50% of the experimental group got the answer correct representing an ES of 0.31 and a g of 0.23. The ES represented a significant difference though a g below 0.3 shows that very little conceptual knowledge learning took place. The control group had an ES of 0.33 and a g of 0.21. The question was on tension in a rope when a particular net force was applied. The question had a few words and needed learners with a strong analysis of diagrams.

4.7.1.5. Questions 17; 23; 24; 25: Experimental group

The next section presents an analysis of Questions 17; 23; 24; and 25, the last group of questions on Motion.

Table 4.12: Questions 17; 23; 24; 25: Experimental group

Pre-test and Post-test results of Motion questions per question(Experimental)																							
Question 17 Pre-test		Question 17 Post-test		Question 23 Pre-test		Question 23 Post-test		Question 24 Pre-test		Question 24 Post-test		Question 25 Pre-test		Question 25 Post-test									
Frequency	Valid %	Frequency	Valid %	Frequency	Valid %	Frequency	Valid %	Frequency	Valid %	Frequency	Valid %	Frequency	Valid %	Frequency	Valid %								
A	3	15	A	1	5	A	2	10	A	3	15	A	2	10	A	10	50	A	6	30	A	10	50
B	7	35	B	4	20	B	5	25	B	3	15	B	5	25	B	4	20	B	3	15	B	3	15
C	5	25	C	3	15	C	3	15	C	4	20	C	2	10	C	3	15	C	3	15	C	4	20
D	3	15	D	10	50	D	3	15	D	10	50	D	7	35	D	2	10	D	5	25	D	1	5
E	2	10	E	2	10	E	7	35	E	0	0	E	4	20	E	1	5	E	3	15	E	2	10
total	0	00	total	0	00	total	0	00	total	0	00	total	0	00	total	0	00	total	0	00	total	0	00

Considering the performance of the experimental group highlighted in the table above, the calculated means, standard deviation, p- value, effect size and learning gain for the group paints the following picture:

Table 4.13: Dependent t-test statistics: Questions 17; 23; 24; 25: Experimental group

Dependent t-test statistics Motion(experimental)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
17	Pre	15	35.89	0.006	0.98	0.41
	Post	50	50.25			
23	Pre	15	35.89	0.006	0.98	0.41
	Post	50	50.25			
24	Pre	10	30.15	0.002	1.33	0.44
	Post	50	50.25			
25	Pre	30	46.06	0.097	0.43	0.29
	Post	50	50.25			

The conceptual knowledge learning gain indices for the experimental group can also be presented graphically as:

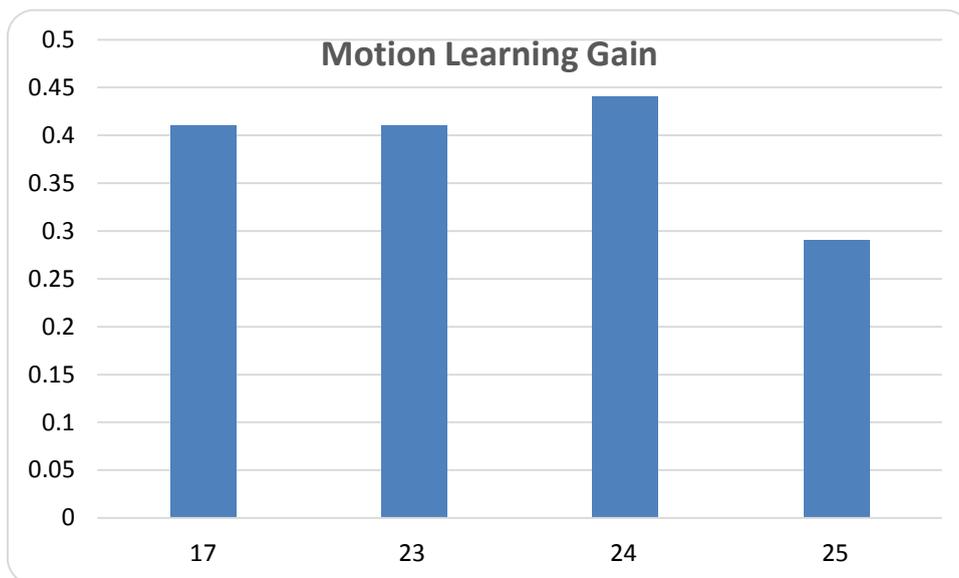


Figure 4.15: Learning gain: Questions 17; 23; 24; 25: Experimental group

4.7.1.6 Questions 17; 23; 24; 25: Control group

The next analysis is on the performance of the control group in Questions 17; 23; 24; and 25. This is presented in the next table:

Table 4.14: Questions 17; 23; 24; 25: Control group

Pre-test and Post-test results of Motion questions per question(Control)																							
Question 17 Pre-test			Question 17 Post-test			Question 23 Pre-test			Question 23 Post-test			Question 24 Pre-test			Question 24 Post-test			Question 25 Pre-test			Question 25 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %			
A	5	25	A	3	15	A	4	20	A	5	25	A	4	20	A	3	15	A	0	0	A	6	30
B	3	15	B	5	25	B	4	20	B	5	25	B	4	20	B	3	15	B	4	20	B	6	30
C	4	20	C	3	15	C	6	30	C	3	15	C	2	10	C	7	35	C	5	25	C	2	10
D	1	5	D	7	35	D	0	0	D	6	30	D	4	20	D	4	20	D	8	40	D	0	0
E	7	35	E	2	10	E	6	30	E	1	5	E	6	30	E	3	15	E	3	15	E	6	30
al	20	100	al	20	100	Tot al	20	100	Tota	20	100	Tota	20	100	al	0		al	20		al		100

The dependent t- test statistics for the control group (Questions 17; 23; 24; and 25) were calculated and the results are presented in the following table:

Table 4.15: Dependent t-test statistics: Questions 17; 23; 24; 25: Control group

Dependent t-test statistics Motion(control)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
17	Pre	5	21.90	0.006	1.37	0.32
	Post	35	47.94			
23	Pre	0	0	<0.001	0.00	0.30
	Post	30	46.06			
24	Pre	20	40.20	0.335	0.12	-0.06
	Post	15	35.89			
25	Pre	0	0	<0.001	0.00	0.30
	Post	30	46.06			

The group's learning gain for the four questions that resulted from the lessons received is presented in the following graph:

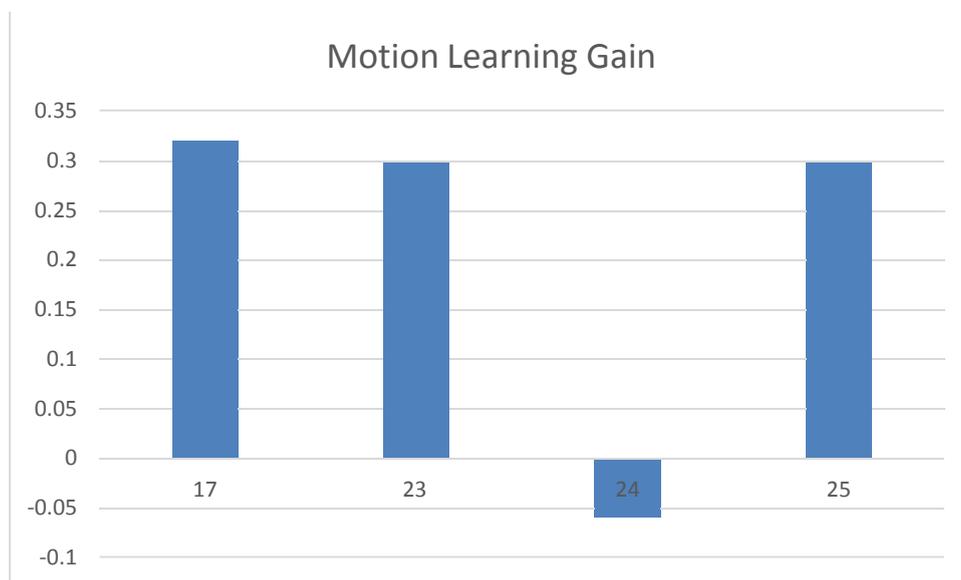


Figure 4.16: Learning gain: Questions 17; 23; 24; 25: Control group

Considering Question 17, 15% of learners in the experimental group wrote the correct answer compared to 5% for the control group. The question had words such

as maximum, acceleration, towing, mass, and twice. After the intervention 50% of learners in the experimental group were able to answer the question correctly in the post-test representing a g of 0.41 and an effect size index of 0.98. An effect size index above 0.7 signifies a very high difference and a g between 0.3 and 0.7 signifies an average conceptual knowledge learning gain.

The control group had a pass rate of 35% in the post test for the same question, representing a g of 0.32 and an ES of 1.37. The learning gain index shows average conceptual knowledge learning for the control group. In Question 23, 15% of learners in the experimental group wrote the correct response, which was D in the pre- test. Not a single learner in the control group got the answer right in the pre- test. The question had words like object, average, and acceleration.

In the post-test 50% of learners in the experimental group got it right compared to 30% in the control group. The experimental group had a g of 0.41 while that for the control group stood at 0.3. This represented an average learning gain for both groups though the experimental group had a very high ES (0.98).

The control group did better in the pre- test (Question 24) than the experimental group. The control group's pass rate stood at 20%, being twice that of the experimental group. When answering the same question in the post test, half of the learners in the experimental group got it right compared to 15% in the control group. This led the control group to have a learning gain of -0.06. The experimental group had a learning gain of 0.44.

Questions 23 to 25 were straight forward calculation ones with a few words in them. The shuffling around of questions in the post-test might have affected the performance of learners in the control group who, maybe, did not understand the meanings of the few words in the questions.

In Question 25 the experimental group's pass rate stood at 30% for the pre- test while that of the control group stood at 0. This was a straight forward calculation that required the calculation process to be explained in detail during the lessons. In the post-test 50% of the experimental group got the answer correct (option A).

The effect size index for the experimental group stood at 0.43 and the learning gain was 0.29. 30% of learners in the control group got the correct answer for the same

question in the post test, representing a learning gain of 0.3. Both groups had an average learning gain.

Considering the 12 questions reviewed so far, the experimental group had a higher average when looking at the effective size as well as the learning gain than the control group. Questions 3; 4; 5; 6; 12; and 17 had a number of unfamiliar words to most of the learners in the two groups.

Most of these words were, later, included in the English- Southern Sesotho Physics dictionary which was then given to the experimental group during the intervention stage. Some of the words were also explained to these learners (in the experimental group) in their home language during the Physics lessons which were delivered in the learners' home language.

4.7.1.7 Questions 7 to 10: Experimental group

The rest of the questions not found in the sections above (4.7.1.1 to 4.7.1.6) were centred on the concept *Force*. These are Questions 7; 8; 9; 10; 13; 14; 15; 16; 18; 19; 20; 21; 22; and 26. Their analysis is presented in the next section.

Table 4.16: Questions 7 to 10: Experimental group

Pre-test and Post-test results of Force questions per question(Experimental)																							
Question 7 Pre-test			Question 7 Post-test			Question 8 Pre-test			Question 8 Post-test			Question 9 Pre-test			Question 9 Post-test			Question 10 Pre-test			Question 10 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %
A	5	25	A	3	15	A	2	10	A	6	30	A	2	10	A	4	20	A	3	15	A	2	10
B	5	25	B	6	30	B	5	25	B	5	25	B	6	30	B	4	20	B	7	35	B	2	10
C	0	0	C	1	5	C	5	25	C	4	20	C	4	20	C	6	30	C	2	10	C	5	25
D	4	20	D	7	35	D	2	10	D	4	20	D	4	20	D	3	15	D	3	15	D	2	10
E	6	30	E	3	15	E	6	30	E	1	5	E	4	20	E	3	15	E	5	25	E	9	45
al	0	00	ot	0	00	ot	0	00	ot	0	00	otal	0	00	otal	0	00	otal	0	00	otal	0	00

Based on information in the table above, the researcher went on to calculate the mean, standard deviation, p- value, effect size indices, and learning gain for the group and got the following results.

Table 4.17: Dependent t-test statistics: Questions 7 to 10: Experimental group

Dependent t-test statistics Force(experimental)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
7	Pre	0	0	0.076	0.00	0.05
	Post	5	21.9			
8	Pre	10	30.15	0.187	0.33	0.11
	Post	20	40.20			
9	Pre	10	30.15	0.187	0.33	0.11
	Post	20	40.20			
10	Pre	25	43.52	0.091	0.46	0.27
	Post	45	50.00			

The following graph presents the learning gain for the experimental group for Questions 7 to 10.

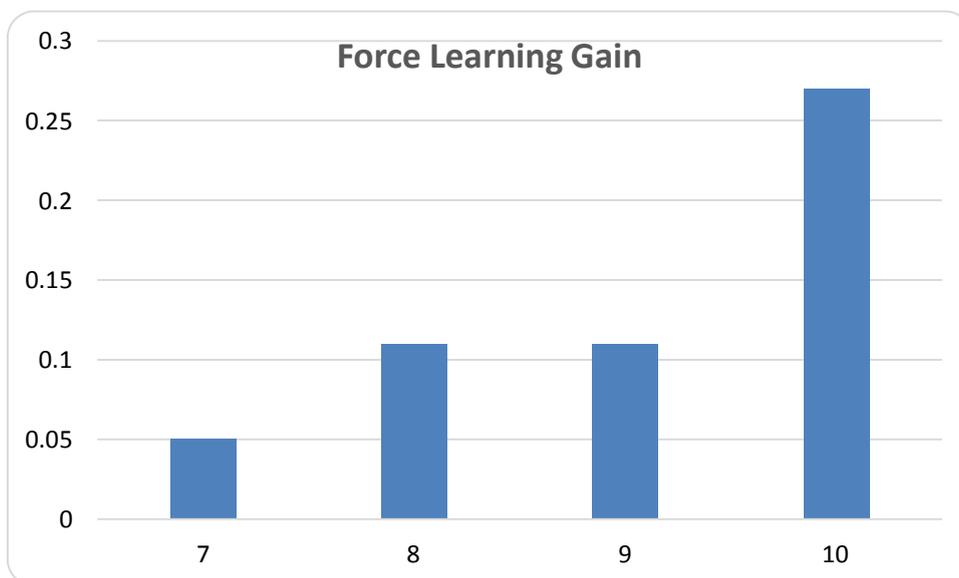


Figure 4.17: Learning gain: Questions 7 to 10: Experimental group

4.7.1.8 Questions 7 to 10: Control group

The following table is a comparison of the control group's performance in the same questions discussed above for the experimental group:

Table 4.18: Questions 7 to 10: Control group

Pre-test and Post-test results of Force questions per question(Control)																							
Question 7 Pre-test			Question 7 Post-test			Question 8 Pre-test			Question 8 Post-test			Question 9 Pre-test			Question 9 Post-test			Question 10 Pre-test			Question 10 Post-test		
Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %				
A	6	30	A	6	30	A	4	20	A	2	10	A	7	35	A	7	35	A	5	25	A	2	10
B	5	25	B	6	30	B	5	25	B	2	10	B	3	15	B	4	20	B	4	20	B	3	15
C	0	0	C	0	0	C	4	20	C	5	25	C	4	20	C	3	15	C	2	10	C	4	20
D	5	25	D	5	25	D	2	10	D	7	35	D	3	15	D	5	25	D	5	25	D	2	10
E	4	20	E	3	15	E	5	25	E	4	20	E	3	15	E	1	5	E	4	20	E	9	45
al	20	100	al	20	100	Tot al	20	100	Tota	20	100	Tota	20	100	al	0		al	20		al		100

The dependent t- test statistics were calculated first before a discussion on the group's performance.

Table 4.19: Dependent t-test statistics: Questions 7 to 10: Control group

Dependent t-test statistics Force(control)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
7	Pre	0	0	0.50	0.00	0.00
	Post	0	0			
8	Pre	10	30.15	0.025	0.83	0.28
	Post	35	47.94			
9	Pre	35	47.94	0.50	0.00	0.00
	Post	35	47.94			
10	Pre	20	40.20	0.043	0.62	0.31
	Post	45	50.00			

For a closer and clearer analysis of the respective learning gain, the researcher presented the data on the following graph:

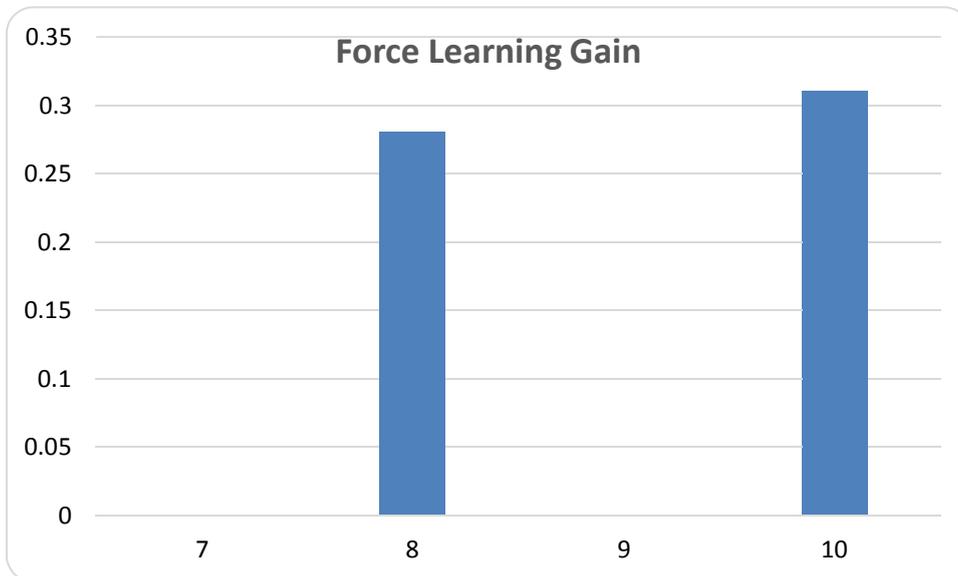


Figure 4.18: Learning gain: Questions 7 to 10: Control group

Question 7 presented an interesting scenario for both groups. The question read:

A person pulls a *block* across a *rough horizontal surface* at a constant speed by applying a force F . The arrows in the diagram *correctly indicate* the directions, but not *necessarily* the *magnitudes* of various forces on the block. Which of the following *relations* among the *magnitudes* W , k , N and F must be true?

The words written in italics were not included in the English- Southern Sesotho Physics dictionary used during the intervention period. In the pre- test not a single learner from either group got the correct answer. 30 % of learners in the experimental group opted for choice A. In the post-test 30% from the same group still went with option A while another 30% chose option B.

The correct response was choice C. Only one learner from the experimental group wrote the correct answer in the post test. The absence of key words in the dictionary could have had a negative effect on the learners. Those words were also not

translated into Southern Sesotho during the Physics lessons held during the intervention phase.

For Question 8 the correct response was option D. 10% of learners in both groups got the correct answer in the pre- test. In the post-test 20% from the experimental group got the answer correct. This was lower than the 35% for the control group.

The experimental group had a learning gain of 0.11 whereas that for the control group stood at 0.28. This shows that the conceptual knowledge gain for the experimental group was lower than that of the control group. The control group also had an ES of 0.83 which is considered to be very high (McMillan & Schumacher 2010).

35% of the control group got Question 9 correct in the pre- test compared to 10% from the experimental group. The number of correct responses for the experimental group rose to 20% for the same question while that for the control group remained at 35%. This culminated in an ES of 0.33 and a g of 0.11 for the experimental group. Though the ES falls within the significant difference level, the learning gain shows low conceptual knowledge gain. The ES and g for the control group stood at 0 since there was an equal number of correct answers in both tests.

Considering Question 10, 25% of learners in the experimental group wrote the correct response in the pre- test, which was E. The number rose to 45% in the post test. This translated to a learning gain of 0.27 and an effect size index of 0.46. The control group presented a brighter picture. Even though only 20 % had got the correct answer in the pre- test, the figure rose to 45% in the post test.

The learning gain for the control group stood at 0.31 (average according to Creswell, 2014; McMillan & Schumacher, 2010) and the effect size index was 0.62 (showing significant difference according to Creswell, 2014; McMillan & Schumacher, 2010).

4.7.1.9 Questions 13 to 16: Experimental group

The next section looks at Questions 13 to 16 for the experimental group.

Table 4.20: Questions 13 to 16: Experimental group

Pre-test and Post-test results of Force questions per question(Experimental)																							
Question 13 Pre-test			Question 13 Post-test			Question 14 Pre-test			Question 14 Post-test			Question 15 Pre-test			Question 15 Post-test			Question 16 Pre-test			Question 16 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %
A	5	25	A	2	10	A	4	20	A	1	5	A	5	25	A	1	5	A	12	60	A	12	60
B	2	10	B	13	65	B	6	30	B	9	45	B	5	25	B	2	10	B	2	10	B	2	10
C	5	25	C	2	10	C	4	20	C	3	15	C	2	10	C	2	10	C	3	15	C	3	15
D	4	20	D	3	15	D	3	15	D	5	25	D	3	15	D	4	20	D	2	10	D	2	10
E	4	20	E	0	0	E	3	15	E	2	10	E	5	25	E	11	55	E	1	5	E	1	5
Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100	Total	20	100

The following table summarises the experimental group's performance in the four questions under scrutiny:

Table 4.21: Dependent t-test statistics: Questions 13 to 16: Experimental group

Dependent t-test statistics Force(experimental)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
13	Pre	10	30.15	<0.001	1.82	0.61
	Post	65	47.94			
14	Pre	30	46.06	0.164	0.33	0.21
	Post	45	50.00			
15	Pre	25	43.52	0.011	0.69	0.40
	Post	55	50.00			
16	Pre	60	49.24	0.50	0.00	0.00
	Post	60	49.24			

Question 16 had a learning gain of zero following an equal number of correct responses in both tests. The group's learning gain is summed up in the next graph:

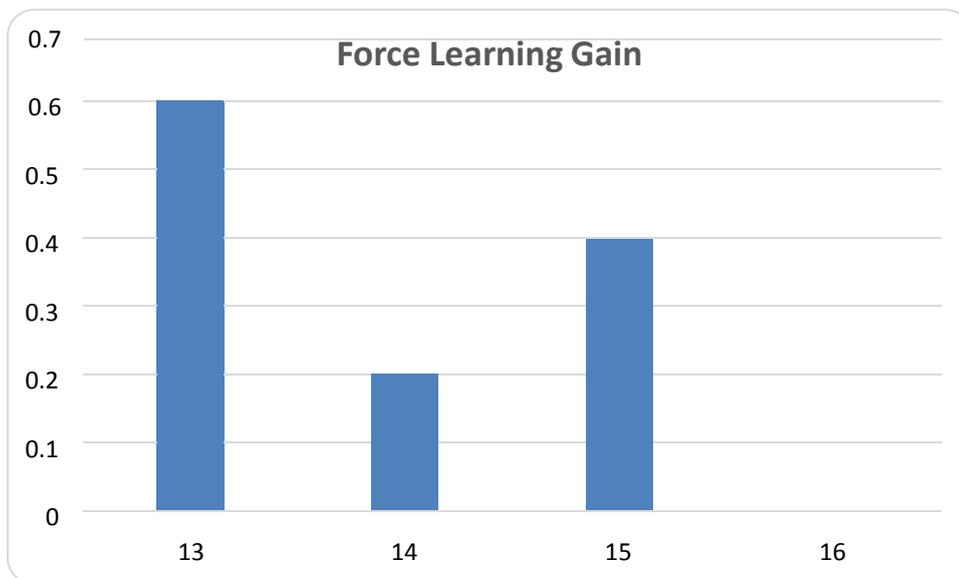


Figure 4.19: Learning gain: Questions 13 to 16: Experimental group

The performance of the control group in the same questions was significantly different from the experimental group especially in Questions 14 and 16.

4.7.1.10 Questions 13 to 16: Control group

Questions on net force and force applied presented great challenge to learners in both groups. The same applied to scenarios were there had to be a resultant force to move an object in a particular direction.

Table 4.22: Questions 13 to 16: Control group

Pre-test and Post-test results of Force questions per question(Control)																							
Question 13 Pre-test			Question 13 Post-test			Question 14 Pre-test			Question 14 Post-test			Question 15 Pre-test			Question 15 Post-test			Question 16 Pre-test			Question 16 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %
A	4	20	A	1	5	A	2	10	A	5	25	A	3	15	A	3	15	A	7	35	A	6	30
B	4	20	B	8	40	B	7	35	B	6	30	B	2	10	B	6	30	B	5	25	B	2	10
C	3	15	C	3	15	C	5	25	C	3	15	C	5	25	C	2	10	C	4	20	C	4	20
D	5	25	D	4	20	D	6	30	D	3	15	D	6	30	D	2	10	D	1	5	D	4	20
E	4	20	E	4	20	E	0	0	E	3	15	E	4	20	E	7	35	E	3	15	E	4	20
al	20	100	al	20	100	Tot al	20	100	Tota	20	100	Tota	20	100	al	0		al	20		al		100

Results from calculations on the dependent t- test statistics revealed negative learning gain for Questions 14 and 16. A summary of the group’s learning gain in the four questions is presented in the following table:

Table 4.23: Dependent t-test statistics: Questions 13 to 16: Control group

Dependent t-test statistics Force(control)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
13	Pre	20	40.20	0.079	0.50	0.25
	Post	40	49.24			
14	Pre	35	47.94	0.016	0.10	-0.08
	Post	30	46.06			
15	Pre	20	40.20	0.141	0.37	0.19
	Post	35	47.94			
16	Pre	35	47.94	0.016	0.10	-0.08
	Post	30	46.06			

The following graph is on the group’s learning gain for the four questions discussed above.

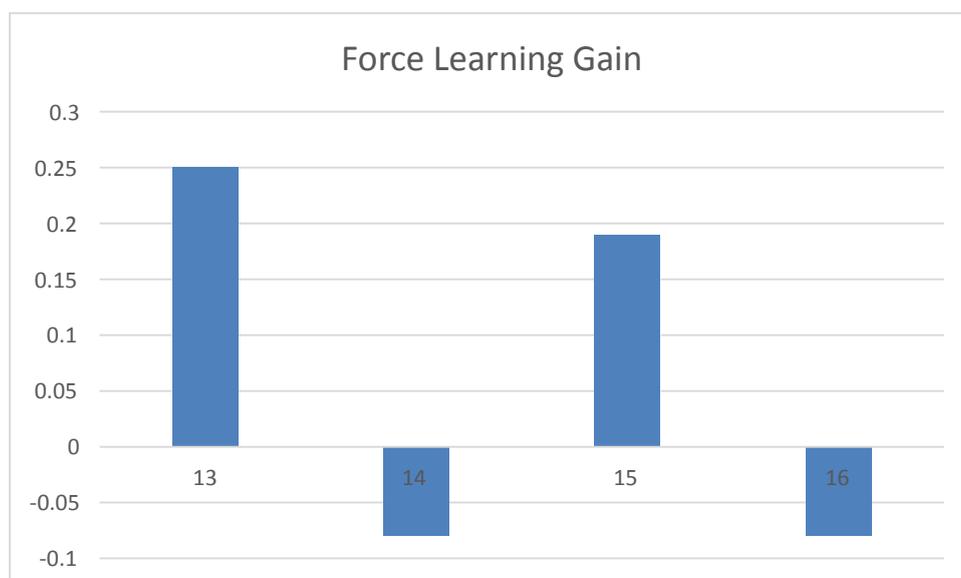


Figure 4.20: Learning gain: Questions 13 to 16: Control group

This section presented results that are way different from the previous section (Questions 7 to 10). The questions had unfamiliar words such as ceiling, elevator, exerted force, constant speed, stationary, depicts, momentum, colliding, and collision. These words were later translated into the learners' (experimental group only) home language during the intervention phase.

The correct response for Question 13 was letter B. 10% of learners in the experimental group got it right compared to 20% from the control group. After the intervention 65% of learners in the experimental group got the answer correct in the post-test in comparison to 40% from the control group. The experimental group had an effect size index of 1.82 and a learning gain of 0.61.

Such an effect size index confirms a very high effect (Creswell, 2014) with a learning gain of 0.61 signifying an average conceptual knowledge learning gain (McMillan & Schumacher, 2010). The control group had an effect size index of 0.50 and a learning gain standing at 0.25. While the ES confirms a significant difference in performance, the learning gain falls within the low level (McMillan & Schumacher, 2010).

30% of learners in the experimental group got Question 14 correct (Choice B). This was 5% lower than the number of correct responses from the control group. In the post-test 45% of the experimental group now got the correct answer compared to 30% from the control group representing a learning gain of 0.21 for the experimental group and -0.08 for the control group.

The number of learners from the control group who got the correct answers in the post test was lower than that in the pre- test. A possible reason could be uncertainty over their answers as the learners only got their scripts back at the end of the study hence did not know which answers were correct until after the study.

For Question 15, the pass rate for the experimental group rose from 25% (pre- test) to 55% in the post test. This culminated in an ES of 0.69 and a conceptual knowledge learning gain of 0.40. If the ES is rounded off for better accuracy (McMillan & Schumacher 2010) then it depicts a very high effect of the intervention even though the learning gain falls in the "average" range (Creswell, 2014; McMillan

& Schumacher, 2010). The control group on the other hand had an ES of 0.37 (significant difference) and a learning gain of 0.19 (low).

For the experimental group, Question 16 had a zero ES and zero learning gain because 60% of the learners got the correct answer in both tests. The control group had an ES of 0.10 (insignificant difference) and a very low learning gain of -0.08 (McMillan & Schumacher, 2010).

This section painted a brighter picture than the previous one as the conceptual knowledge learning gain and effect size rose as high as 0.61 and 1.82 respectively (Question 13, experimental group).

4.7.1.11 Questions 18 to 21: Experimental group

The last section of this analysis presents four questions based on the concept of *Force*. These are Questions 18 to 21 and will be analysed individually for both groups (control and experimental).

Table 4.24: Questions 18 to 21: Experimental group

Pre-test and Post-test results of Force questions per question(Experimental)																							
Question 18 Pre-test			Question 18 Post-test			Question 19 Pre-test			Question 19 Post-test			Question 20 Pre-test			Question 20 Post-test			Question 21 Pre-test			Question 21 Post-test		
	Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %
A	2	10	A	4	20	A	2	10	A	6	30	A	6	30	A	3	15	A	6	30	A	5	25
B	5	25	B	5	25	B	5	25	B	4	20	B	6	30	B	3	15	B	3	15	B	6	30
C	5	25	C	2	10	C	1	5	C	3	15	C	0	0	C	3	15	C	3	15	C	2	10
D	5	25	D	5	25	D	8	40	D	3	15	D	4	20	D	6	30	D	7	35	D	1	5
E	3	15	E	4	20	E	4	20	E	4	20	E	4	20	E	5	15	E	1	5	E	6	30
al	20	100	al	20	100	Tot al	20	100	Tota	20	100	Tota	20	100	Tota	0	0	al	20	100	al		100

This section was poorly done by learners in the experimental group. There was no learning gain for Question 18 and a negative learning gain for Question 21.

Table 4.25: Dependent t-test statistics: Questions 18 to 21: Experimental group

Dependent t-test statistics Force(experimental)						
Question		Mean	Std deviation	p-value	Effect sizes	Gain
18	Pre	25	43.52	0.50	0.00	0.00
	Post	25	43.52			
19	Pre	5	21.9	0.133	0.46	0.11
	Post	15	35.89			
20	Pre	0	0	0.004	0.00	0.17
	Post	16.67	37.48			
21	Pre	30	46.06	0.360	0.11	-0.07
	Post	25	43.52			

The negative learning gain was a result of a decrease in the number of correct responses in the post-test compared to the pre- test. A summary of the experimental group’s learning gain in this section is presented on the following graph:

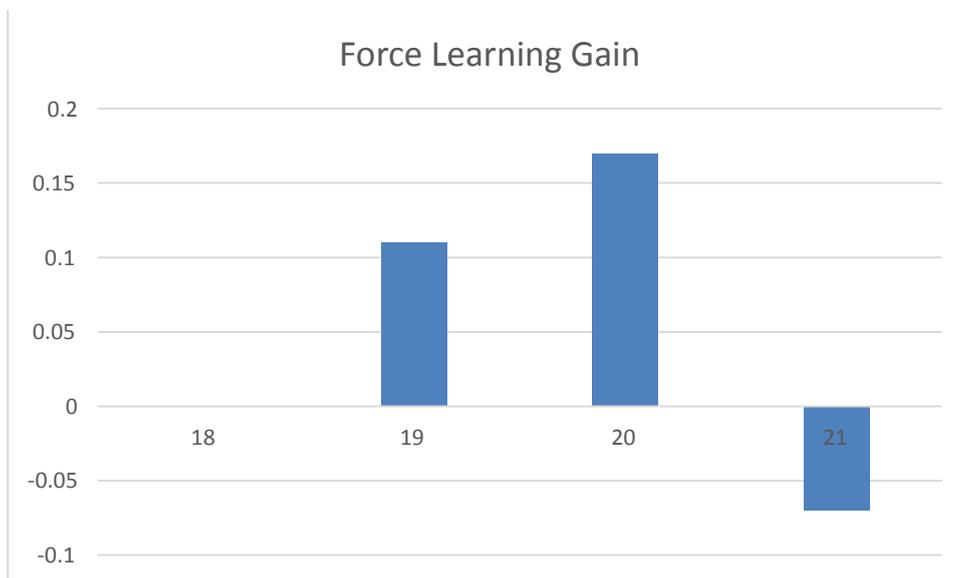


Figure 4.21: Learning gain: Questions 18 to 21: Experimental group

For Question 21 the two groups' performance was almost the same, with both groups having a negative learning gain of -0.07 for Question 21. A summative presentation of the control group's performance is presented in the following section:

4.7.1.12 Questions 18 to 21: Control group

Table 36 below details the performance of the control group in Questions 18 to 21.

Table 4.26: Questions 18 to 21: Control group

Pre-test and Post-test results of Force questions per question(control)																							
Question 18 Pre-test			Question 18 Post-test			Question 19 Pre-test			Question 19 Post-test			Question 20 Pre-test			Question 20 Post-test			Question 21 Pre-test		Question 21 Post-test			
Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %		Frequency	Valid %				
A	6	30	A	4	20	A	4	20	A	2	10	A	4	20	A	6	30	A	5	25	A	4	20
B	1	5	B	7	35	B	4	20	B	5	25	B	4	20	B	4	20	B	3	15	B	4	20
C	6	30	C	1	5	C	2	10	C	7	35	C	5	25	C	3	15	C	5	25	C	4	20
D	4	20	D	5	25	D	7	35	D	3	15	D	6	30	D	2	10	D	4	20	D	3	15
E	3	15	E	3	15	E	3	15	E	3	15	E	1	5	E	5	25	E	3	15	E	5	25
al	20	100	al	20	100	Tot al	20	100	Tota	20	100	Tota	20	100	al	0	0	al	20	0	al		100
Dependent t-test statistics Force(control)																							
Question		Mean	Std deviation	p-value	Effect sizes	Gain																	
18	Pre	5	21.90	0.004	1.37	0.32																	
	Post	35	47.94																				
19	Pre	10	30.15	0.025	0.83	0.28																	
	Post	35	47.94																				
20	Pre	25	43.52	0.203	0.23	-0.13																	
	Post	15	35.89																				
21	Pre	25	43.52	0.353	0.11	-0.07																	
	Post	20	40.20																				

In this section the control group had two negative learning gains that are for Questions 20 and 21. The means for Questions 18 and 19 were moderately high, being 35%. Figure 28 below presents the control group's learning gain for the four questions.

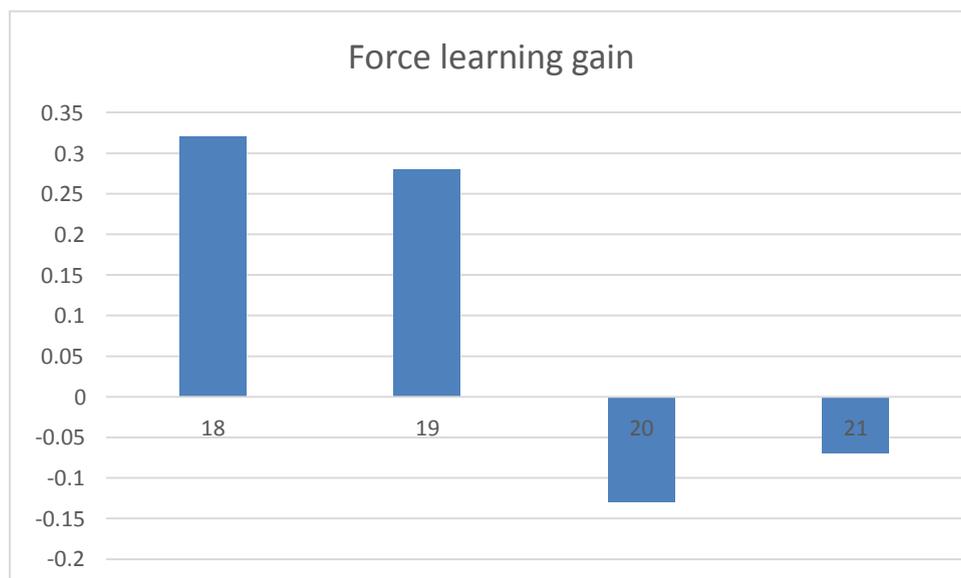


Figure 4.22: Learning gain: Questions 18 to 21: Control group

The four questions had words and/or phrases such as elevator, 6th floor, weighing, decreases, upward speed, average speed, average force, interval, exerted force, depicts, hockey puck, frictionless surface, dashed arrow, constant force, net force, massive, energy in them. Some of these words were incorporated into the English-Southern Sesotho Physics dictionary and/or translated into learners' home language during the multilingual Physics lessons delivered to the experimental group as intervention while others were not due to lack of precise and accurate Sesotho translations.

Question 18 was poorly done by the experimental group in both tests. This question had words such as *exerted force*, *average force*, *interval*, and *upward speed* which were not in the dictionary given to them during intervention. Consequently a mere 25% got the answer correct in both tests translating into zero effect size and no learning gain at all. The control group on the other hand had a learning gain of 0.32 (average) for the same question as the rate rose from 5% in the pre- test to 35% for

the post-test. With the correct choice for Question 19 being letter C, 40% of the experimental group went with choice D in the pre- test and 30% went with option A in the post test. The question read:

The diagram at right depicts a *hockey puck* moving across a horizontal, *frictionless* surface in the direction of the *dashed arrow*. A *constant force* F , shown in the diagram is acting on the *puck*. For the *puck* to experience a *net force* in the *direction* of the *dashed arrow* another force must be acting in which of the *directions labelled* A, B, C, D, E ? The words in italics were not included in the dictionary given to the experimental group during intervention and evidently this presented comprehension barriers to the group.

The control group had an effect size of 0.83 (very high, according to Creswell, 2014) emanating from a vast difference in their performance in the two tests. The group had a pass rate of 10% in the pre- test and 35% in the post test for the same question.

No learner in the experimental group got Question 20 correct in the pre- test. In the post-test 15% got the answer correct for the same question. This yielded a 0.17 conceptual knowledge learning gain which according to Creswell (2014) and McMillan and Schumacher (2010) is low. The control group had a negative learning gain (-0.13) resulting from a decrease in the number of learners who got the correct answer in the post-test compared to the pre- test (from 25% to 15%).

Question 21 is the only question in which the experimental group had a negative learning gain. 30% of the learners got the correct answer in the pre- test compared to 25% in the post test. This resulted in a learning gain of -0.07 and an insignificant effect size index of 0.11. In the pre- test the control group had 25% and a decrease of 5% in the post test for the same question. As a result the group's ES and learning gain were the same as those of the experimental group (0.11 and -0.07 respectively).

Having taken a microscopic view at the individual questions that were written by the two groups, I then went on to present a summative statistical comparison of the overall performance of the control and experimental groups for the two tests.

Table 4.27: Statistical Analysis of the control group pre-test and post-test results

		Dependent t- test statistics				
Control group		Mean	sd	p- value	Effect size	Gain
Pre- test		23.9%	8.26%	<0.001	1.22	0.13
Post test		34.0%	9.07%			

The academic performance of the control group in the two tests was not very different. The group's pass rate for the pre- test was 30% while that of the post- test stood at 20%. The respective means for the two tests were 23.9% and 34%. This, therefore, means that 6 and 4 learners passed the two tests respectively.

Their performance in the two tests is not very different at all, even though the difference in the pass rate between the two tests is 10%, brought about by two more participants that passed the pre- test than the post- test. From the computed t- test values we cannot reject the null hypothesis. *There is insufficient evidence to indicate a difference in the post-test and pre-test results of the control group.*

Table 4.28: Statistical Analysis of the Experimental group pre-test and post-test results

		Dependent t- test statistics				
Experimental group		Mean	sd	p- value	Effect size	Gain
Pre- test		22.7%	8.13	<0.001	2.96	0.31
Post test		46.75%	8.28			

From the computed t- test values above as well as an average conceptual knowledge learning gain (of 0.31) and a very high effect size index of 2.96 we can

reject the null hypothesis. *There is sufficient evidence to indicate a mean increase in the post- test compared to the pre- test.*

From the statistics above learners in the experimental group showed great improvement in the post- test. They obtained higher marks and a higher mean in the post- test than in the pre- test.

Table 4.29: Statistical Analysis of Experimental group and Control group Post-test results

Post test	Dependent t- test statistics			p- value	Effect size	Gain
	Mean	sd				
Control	34%	9.07%		<0.001	1.41	0.19
Experimental	46.75%	8.28%				

This confirms that we can reject the null hypothesis. *There is sufficient evidence to indicate a mean increase for the experimental group.* The mean for the experimental group is way higher than that of the control group (a difference of 12.75% in favour of the experimental group) thus indicating a difference in the academic performance between the two groups.

Comparing the performance of the experimental group in the post- test to that of the control group, the latter had a mean of 34% with the former having 46.75%. There was a huge difference in their performance. The difference in their performance, according to interview responses from learners in the experimental group, was largely due to the translanguaging used as intervention during Physics lessons.

This method (translanguaging) was only afforded the experimental group. Below are responses from some of the learners who were in the experimental group affirming the positive impact of translanguaging in the Physics lessons they received during the intervention:

Learner 11

My highest mark was for the last test. The lowest one [mark] was for the second test. Using my language in the lessons helped me a lot. I was able to understand

and follow what was happening in class. My English isn't good at all so the language [Sesotho] helped me.

Learner 29

Ntate taught us in Sesotho. It made the work easy to understand. He also gave us translations of science words. This made my marks different from the other two tests because I got very high marks for the last test.

Learner 55

There was no way my performance would have been the same. English isn't my favourite subject that's why I did badly in the test. In preparing for the last test we were taught in our home language first something that didn't happen before we wrote the first two tests. Being taught in Sesotho made me understand the work better.

Learner 86

We must be taught all lessons in Sesotho [laughs]. That is why I obtained the highest marks in the last test. The first and second tests, eish, the marks were not that good especially the second test. Using my mother tongue really helped me.

The other contributing factor according to learners who were in the experimental group was the use of the English- Southern Sesotho Physics dictionary.

Learner 55

I really am glad I got it [the dictionary]. It helped me understand some of the vocabulary that was used in the test. I would therefore say it was very useful.

Learner 85

My feeling is that the department [DoE] must give us dictionaries in our mother tongue for all subjects. They help us understand the work better. This one was very, very useful. We can also have work sheets for those difficult topics written in our language.

Learner 91

Personally I found the dictionary extremely useful. It translated words whose meanings I didn't know into my mother language. Words such as velocity, acceleration, constant rate, vector quantity to name but a few were translated and explained well.

Learner 93

Yaah, it was to say the least. It appeared at a time when I thought I was drowning in my Physics work. I had almost given up but the dictionary restored my hope. It made me see things in a different perspective. I would give it a 9/10.

Some of the best performing learners in the experimental group attributed their good performance to the use of both their home language (Sesotho) during the Physics lessons and the Physics dictionary that had Southern- Sesotho translations.

Learner 59

The marks were different, yes. This is because for the first two tests no help was given. We were taught in our mother tongue before writing the last test and that helped a lot. What made it more interesting was the fact that we were taught in Sesotho by a Sotho teacher and also given a Physics dictionary written in Sesotho.

Learner 65

Being taught in my own language by someone who knows my language made a huge difference. He was able to explain words in my language and also gave us dictionaries to use which are written in our language.

Learner 68

My best performance was in the last test. I understood the work better because I was taught in Sesotho and being given that small dictionary written in Sesotho contributed to my good performance.

This is evident that the use of the learners' home language (Sesotho) and an English- Southern Sesotho Physics dictionary with translations in the learners' home language played a pivotal role in their performance. This was an intervention the control group was not afforded and as can be seen made a huge difference to the experimental group's performance. No wonder some of the respondents during

interviews advocated for the use of their home language on a wider scale. For example:

Learner 91

They were good, sir [referring to the multilingual Physics lessons they received during the study]. My suggestion is that we should be re-taught all Physics topics we have done so far in Sesotho. We must also be given similar dictionaries for all subjects and the topics.

Learner 68

Well I understand we have 11 official languages and it will be fair if I could be taught all subjects in Sesotho and also have books and tests in that language. Mr Zuma [the South African president] must allow us to learn in our mother tongue and get books written in that language.

This (the use of the learners' home language and the English- Southern Sesotho Physics dictionary) explains the difference in the experimental group's performance in the pre- and post- tests.

A closer look at the questions answered incorrectly in the post- test by most learners in the experimental group revealed that they (the questions) had language aspects not included in the English – Southern Sesotho Physics dictionary provided nor translated verbally to the learners during the multilingual Physics lessons.

The worst question was Question 7. Only one learner out of the forty got it right. This was followed by Questions 8 and 20. A total of 7 learners from the experimental group got the correct answers to both of the questions in the post test. 45% of learners from each group were able to answer Question 10 correctly in the post test.

40% of the learners in the experimental group had incorrect answers for Question 26. The control group had a negative learning gain in the following questions in the post-test: Questions 6; 11; 14; 16; 20; 21 and 24. The experimental group had only one negative learning gain (Question 21; in the post-test).

The questions most incorrectly answered by the learners in the experimental group contained some terms that were neither translated to the learners into their mother tongue (Sesotho) by the teacher during the Physics lessons nor in the English-Southern Sesotho Physics dictionary that was given to the learners. Examples of such questions (with the words not translated to the learners written in *italics*) are:

Question 8

A small metal cylinder rests on a circular turntable, rotating at a constant speed as illustrated...Which of the following *sets of vectors* best describes the velocity, acceleration, and *net force acting* on the cylinder ...

Question 9

Suppose that the metal cylinder in the last problem has a mass of 0.10 kg and that the *coefficient of static friction* between the surface and the cylinder is 0.12. If the *cylinder* is 0.20m from the centre of the *turntable*, what is the *maximum speed* that the cylinder can move along its *circular path* without *slipping off the turntable*?

The effect of language in learners' performance in Physics can therefore not be overruled. Their (learners in the experimental group) performance in the English Language proficiency test was not very different from their performance in the pre-test (before translanguaging was employed).

For the purposes of determining if there is any correlation between the language of instruction and performance in Physics, the researcher used the learners' marks (experimental group) for Southern Sesotho for term 3; 2016 (July to August), the period during which the study was carried out and compared them to their performance in the post- test.

Null hypothesis: *There is no difference in the academic performance of the experimental group in Southern Sesotho and in the post- test.*

These marks (for Southern Sesotho) were supplied by the learners' respective schools.

Table 4.30: Statistical Analysis of the Experimental group Sesotho test and Physics post-test

Experimental group	Dependent t- test statistics		p- value	Effect size	Gain
	Mean	sd			
Sesotho test	45.65%	6.46%	0.6424	0.17	0.02
Post test	46.75%	8.28%			

The value of t-computed is less than the tabulated t-value. This confirms that we cannot reject the null hypothesis (McMillan & Schumacher, 2010). There is insufficient evidence to indicate a difference in the Sesotho test results and the Physics marks for the experimental group (post test results).

The learners' academic performance in the two subject areas was similar. The difference between a respective learner's performance in Southern Sesotho and the post- test is really small. In most cases, however, the learners' performance was higher in their home language than in the post- test.

The difference could have been caused by the terminology which had not been translated to them neither during the lessons nor in the English- Southern Sesotho Physics dictionary which they were given. The mean for the post- test was 46.75% whereas that for their home language (Southern Sesotho) was 45.65%.

This is undisputed testimony that language surely is a contributing factor to learners' performance in Physics and the use of one's home language in Physics leads to 'academic resurrection'. In my opinion, by continually using a teaching and learning language in which the learners have a low proficiency keeps them being what I would call '*wondering Jews of the Physics academic world*' who would hardly make it in the Physics class.

In sum, the differential performance between the control and experimental groups in the post- test can be explained as the result of translanguaging interaction strategies that included alteration of languages of input and output and multilingual spaces that

allowed fluid conversations in different languages in the experimental group (Makalela, 2015).

4.8 Analysis of Qualitative data

The twenty learners in the experimental group were then interviewed by the researcher on the intervention they had received during the study. Interviews were used as another tool for collecting data during the research (McMillan & Schumacher, 2010). Even though interviews take several forms, for this research the researcher chose the phenomenological interview. This is a type of in-depth interview used to study the meanings or essence of a lived experience among participants (McMillan & Schumacher, 2010).

The purpose of phenomenological study was to describe and interpret the experiences of participants in order to understand their (participants') meanings ascribed to the intervention (McMillan & Schumacher, 2010). In other words phenomenological study is the capturing of the essence of the experience as perceived by the participants in a particular study (Cohen et al., 2011). The essence and basis of phenomenology in this study was that there were multiple ways of interpreting the same experience (Tuckman, 2011).

The data collection involved here was the personal in- depth interviews. The in- depth interviews used open- response questions to obtain data on participants' meanings- how they conceived and experienced the intervention given to them during the research (McMillan & Schumacher, 2010).

Even though the primary data of interviews are verbatim accounts of what transpires in the interview session, in this research tape or digital recording the interview ensured completeness of the verbal interaction and provided material for reliability checks (McMillan & Schumacher, 2010). The use of a tape recorder was not taken as a substitute to note taking (Cohen et al., 2011).

Tape recording the interviews enabled the researcher to be attentive, helped pace the interview, and legitimised the writing of research insights during the interview (McMillan & Schumacher, 2010). Immediately after the interview the researcher completed and typed the handwritten records, transcribed the tape, and analysed the data collected.

Interviews were held with learners in the experimental group. The essence of the interviews was to get the learners' evaluation of the intervention, establish explanations to their performance in the three tests, and hear their recommendations on the best languages to be used in the teaching/learning of Physics. The interpretation of results was the key in this data collection process, as it provided a convergence of evidence in which the results of both methods (quantitative and qualitative) supported each other (McMillan & Schumacher, 2010).

When the results of different research methods converge and support one another, the researcher will have triangulated the findings (Cohen et al., 2011). The researcher resorted to this method of data collection and analysis as the use of different methods resulted in very strong results (McMillan & Schumacher, 2010).

The researcher conducted one-on-one interviews with the twenty learners who were in the experimental group to determine their evaluation of the intervention they had received after they had written the post- test. Each interview lasted approximately 20 minutes and each learner was asked 6 questions in the same order.

The questions were answered orally by the learners. The researcher had written the interview questions before hand. The learners' responses were tape- recorded by the researcher with the learners' permission whilst at the same time the researcher was writing them (the responses) down.

The use of both techniques (note taking and tape recording) was to ensure learners' responses were correctly captured, dismissing any chances of misunderstanding and/or misinterpreting learners' responses. Immediately after the interviews the researcher transcribed the responses while the data was still fresh. The interviews were on learners' experiences during the study, the evaluation of the intervention, as well as possible reasons for their performance in the three tests they wrote during the study.

The researcher then analysed the learners' responses to the interview questions. The process used by the researcher can be summed in Figure 4.23 as follows:

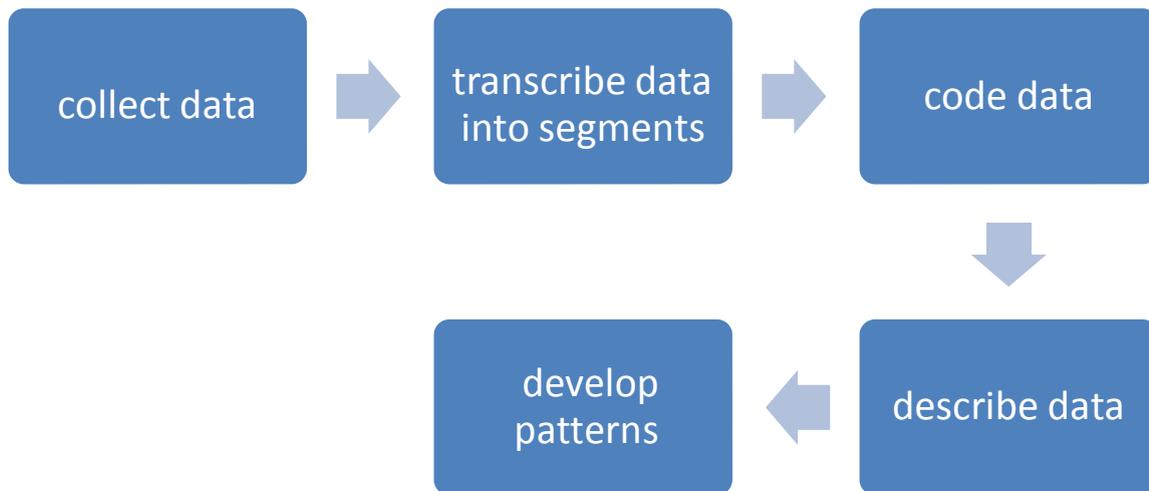


Figure 4.23: Summary of data collection process

(McMillan & Schumacher, 2010)

Data analysis began with the researcher identifying small pieces of data that stood out (Gray, 2011). These data parts, called segments, divided the data set (McMillan & Schumacher, 2010). A data segment is text that is comprehensible by itself and contains one idea, episode, or piece of relevant information. Although a segment can be any size- a word, a sentence, a few lines of text, or several pages- in this research they were typically one to three sentences (McMillan & Schumacher, 2010).

The researcher then analysed the segments and came up with codes. A code is a name or a phrase that was used by the researcher to provide meaning to the segment (McMillan & Schumacher, 2010). Since this study involved short interviews with only 20 participants, the researcher opted to analyse the interview responses manually, without the use of software.

Qualitative content analysis was used by the researcher. It is similar to pure coding in that it does not contain any techniques for pattern recognition or pattern integration. Both coding and qualitative content analysis produce an information base, which must be further analysed in order to answer the research question (Gläser & Laudel, 2013).

Both methods helped the researcher to locate relevant information in the texts that contained the data that is distinguishing raw data from “noise”. The use of both methods ensued each complemented the weaknesses of the other (Bernard & Ryan, 2010). In analyzing the qualitative data the researcher fused both methods adopting a reductionist approach in which the data was re-read several times to arrive at themes until saturation points were reached. The themes are supported with prototypical verbal reports from the learners.

After analysing the raw data the researcher came up with the following four themes:

Theme 1: Impact of language in academic performance in Physics.

Theme 2: Academic benefits of printed learning materials.

Theme 3: Academic support for English Language learners studying Physics.

Theme 4: Psychological effects of using one’s home language in Physics education.

Theme 1: Impact of language in academic performance in Physics

Out of the 20 learners in the experimental group, 17 of them hinted that they did badly in the Physics pre- test due to the inability to comprehend the language used in the test. They claimed that English was their second or third language hence they had limited use of the language. They only use the language in the classroom and once they are outside resort to their home language. Below are examples of such responses:

Learner 59

The Proficiency test was fair and the last one was very easy. It was the second test [referring to the pre- test] that gave me problems. It was too complicated and I couldn’t understand the language. It was difficult for sure.

Learner 48

I liked the last one. I could understand the questions clearly. The first and the second [referring to the English language proficiency and the pre- test] were actually difficult and the language used in them, eish, was deep and too scientific.

This explains why only 4 of the 20 learners passed the pre- test while 8 passed the English Language proficiency test.

Research cited in Chapter 2 of this study highlights the close relationship between the Language of Learning and Teaching (LoLT) and academic achievement in science subjects. The importance of language for effective learning becomes evident if we consider that the ability to use language determines not only the nature of a person's relationship with others and the ability to communicate, but also the ability to think, since language is the medium of much of human thought (Nieman & Monyai, 2013). Because of this close link between language and thinking, the learners' ability to think and learn depends on their ability to use and understand language.

Language and learning are interdependent as language is the means of access to all study material. Cognitive skills are developed by speaking, reading, and writing in a person's own language. Cummins (2008) states that where a language of instruction is concerned, one should accept, in principle, that the home language or primary language which developed within the context of social interaction and which is culture bound is fundamental to the thinking, learning and identity of an individual.

The home language for all learners in this study was Southern Sesotho (also referred to as Sesotho) and are being taught Physics in English language. Researchers investigating the possible causes of underachievement among language minority learners have distinguished between the use of language in informal daily scenarios and language used in academic situations (Aarts et al., 2011; Hornberger & Link, 2012; Madiba, 2014; Makalela, 2015). They argue that reading a textbook or writing a report makes quite different demands on a person compared to talking to a friend.

In educational contexts, it was observed that although language minority learners were able to converse in peer-appropriate ways (Lemmer 2010) in face-to-face situations in a second language (Gu, 2015), the learners encountered difficulties in manipulating language in decontextualized academic situations (Baumann & Graves, 2010; Janks & Makalela, 2013). This discrepancy in what has come to be called

basic interpersonal communicative skills (BICS) and cognitive academic language proficiency (CALP) is a useful distinction for today's teachers (Cummins, 2008).

Cummins (2008) suggests that CALP enables the learner to learn in a context, which relies heavily on oral explanation of abstract or decontextualized ideas, as opposed to BICS. This is often the context in which high school science is taught (Gibbons, 2009), with unfamiliar events or topics being described to learners with little or no opportunity to negotiate shared meaning (Fang, 2006; Miller, 2009).

In this study the learners seemed to be having problems with the LoLT (as was evidenced in their performance in the English Language proficiency test) as well as the subject content (Physics). Their responses during the interviews explain why only 13.3% of the learners passed the proficiency test. Of the 98 learners that wrote the test only 13 achieved a score of 30% or higher, with 86.7% of the learners scoring below 30%.

In the light of what has been discussed above, it is clear that when the LoLT is not the learners' home language, it is of the utmost importance that the learners' home language still be developed thoroughly, because competence in a person's home language lays the basis for the acquisition of another additional language which might be used as the LoLT (Nieman & Monyai, 2013).

After all, educators should not try to replace the learners' home language with the LoLT (subtractive approach), but merely to add another language to the languages the learner already has (Nieman & Monyai, 2013). Therefore in order for learners to perform well in Physics they should be proficient in the LoLT.

Theme 2: Academic benefits of printed learning materials

In both schools from which learners came, learners are given their own Physics textbook written in English language. They are also given additional learning resources in the form of hand-outs, also written in English language. Surprisingly, from the learners' responses these materials are not serving their purpose because of the language in which they are written. Below is a direct quote from Learner 68, who said:

“ I think the lessons [in their home language] helped quite a lot of us. We are from the kasi [townships] and our English is not good at all. The English we speak on the street is different from the one in our Physics textbooks therefore being taught in a language you understand is quite good and really helpful”

Some learners applauded the use of the textbook in the classroom, while others rejected it. Those who responded negatively to the textbook use are usually not so concerned with the quality of the textbook, but rather with the way educators use textbooks and other printed material. In the past- and in some current situations- an educator may have asked the learners to open their textbooks on a particular page and may then have gone through each paragraph, clarifying content.

The learners were- and in some cases still are- passive listeners- not the ideal learning situation (Nieman & Monyai, 2013). It is in such cases that the printed material is meaningless to most learners. In present day South Africa, the majority of Physics educators also have a home language different from the LoLT. Of interest is a quote from Learner 91 who complained that...

“... I don't see the reason why we should be taught in English by our own Sesotho speaking teachers. These same teachers speak to us in Sesotho outside classes, so why not in class also? In any case some of them are not better than us in English.”

Printed material can only be useful if it is written in a language the learners will comprehend. From the interviews it emerged that learners make little use of these materials as they are written in a language they have low proficiency in. In such cases the materials do not serve the purpose they are designed to serve. If learning materials are written in a language learners understand, the story is different.

Considering the views of the following learners:

Learner 34

The Sesotho dictionary helped me understand the work. Even though it's Physics I still want to learn it in Sesotho because I understand it and it's easy to use. Looking at the lessons and dictionary we had in Sesotho I think the school should provide us with more materials in Sesotho.

Learner 55

I found the last test easier than the first two because in preparing for it we were taught in our home language and we were also given Physics dictionaries written in our home language. This helped us greatly and we are proud of the dictionaries written in our own language.

Learners, especially those learning Physics in a language different from their home language, can perform better academically if they are given materials and lessons in their own language. Similarly if learners are tested in a language that is not their home language, the scores will not only reflect their competencies in Physics, but also their mastery of the language of instruction (Haag et al., 2013).

Physics activities are known to impede second language learners since they entail diverse linguistic demands (Gu, 2015; Makalela, 2015) which the learners do not possess from fully understanding the items and, hence, from demonstrating their scientific ability (Haag et al., 2013). This leads to underperforming on the part of the learners.

The relationship between a learner's proficiency in the language of instruction and their performance in science has been found to come to the fore as early as primary school level (Maerten- Rivera et al., 2010). Physics activities involve reading sentences and/or paragraphs. Reading comprehension entails knowledge of specific vocabulary (Martin et al., 2012), text structures, and strategies (Garcia & Wei 2014), which have to be applied in Physics.

As these texts are used more frequently from senior primary school onwards, the ability to comprehend language area material is crucial for learners to succeed in school (Shanahan & Shanahan, 2008; Taboada, 2012). Knowledge of vocabulary significantly contributes to the comprehension of science material with both learners learning in their home language or those whose language of instruction is different from their home language, hence the need for learners to build a strong language base in the LoLT (Taboada, 2012).

In cases where learners fully comprehend the contents of learning materials given to them, their academic performance will undoubtedly improve. This is in line with what the following learners said:

Learner 85

My feeling is that the department [DoE] must give us dictionaries in our mother tongue for all subjects. They help us understand the work better. This one was very, very useful. We can also have work sheets for those difficult topics written in our language.

Learner 91

Personally I found the dictionary extremely useful. It translated words whose meanings I didn't know into my mother language. Words such as velocity, acceleration, constant rate, vector quantity to name but a few were translated and explained well.

Their responses correspond with their performance in the post- test in which all learners that were in the experimental group passed. Learners should therefore be given learning materials written in a language they fully understand if they are to benefit academically from the materials. Learners will only be able to understand the thought processes of a subject or learning area if they can become actively involved with the language of that particular subject (Nieman & Monyai, 2013).

The finding that home language plays a significant role in Physics achievement confirms the theoretical assumption that learners who learn Physics in a language different from their home language experience a greater challenge in reaching a high level for Physics achievement.

Theme 3: Academic support for English Language learners studying Physics

Learners whose home language is different from the LoLT need support from their teachers, parents and all other stakeholders. The support the teacher gives learners should be dual in nature: it should promote learning in the specific subject area, but at the same time improve the learners' proficiency in the LoLT.

The first step South African teachers can take is to move away from monolingualism considering the diversity of today's classrooms. This practice (of monolingualism) began to take shape during the European enlightenment period and used separation as a strategy to control and form nation states.

While the resultant language policing strategy followed the separationist ideology for a long period of time, classroom research has increasingly shown that multilingual learners have always resisted monolingual policy proscriptions in favour of fluid (Makalela, 2015), versatile and mobile discursive resources to accomplish their classroom communicative tasks (Hornberger & Link, 2012). This resistance by learners is therefore full proof that all controlling devices over language use are ineffective, and often counter-productive to content mastery.

The majority of the learners in the experimental group noted that the use of more than one language during their lessons made them understand the concepts better than in typical monolingual interactions. Their responses are represented in the following extracts:

Learner 1

The use of Sesotho in the lessons and also that dictionary helped me a lot. My marks for the third test were higher than the other two tests because of the use of a language I fully understand.

Learner 5

I am proudly Sotho so I would vote for my language. Considering what I experienced during the Physics lessons that were taught in Sesotho, it's possible to be taught in Sesotho and understand better than when I am taught in English.

Here the two learners reveal that the use of their home language during the lessons helped them academically. A lot of studies on translanguaging have averred that the use of more than one language in a classroom set up makes the learners enjoy cognitive advantages when multilingualism is accommodated in the learning and teaching process (Baker, 2011; Garcia, 2011; Hornberger & Link, 2012). The learners' home language can also be brought into the learning process as a scaffold.

Alternative pedagogical approaches for multilingual classroom have begun to recognise simultaneous use of more than one language in classrooms for content subject teaching and learning (Makalela, 2015). The learners themselves are yearning for such pedagogies. One such example is the following extract:

Learner 68

Well I understand we have 11 official languages and it will be fair if I could be taught all subjects in Sesotho and also have books and tests in that language. Mr Zuma [the South African president] must allow us to learn in our mother tongue and get books written in that language.

Using the translanguaging approach, and comparing it to an 'ubuntu' lens of viewing the world from an amorphous and continuous cultural space, the development of a multilingual teaching pedagogy that is premised on this worldview to advance theory and practices of translanguaging as a teachable strategy is suggested in our diverse classrooms (Makalela, 2015).

Monolingual classroom practices in today's multilingual settings can be academically limiting and inhibiting of full creative expressions and academic achievement (Madiba, 2014). Educational policies that favour monolingualism as the target norm place some constraints on multilingual learners' linguistic flexibility and academic achievement in Physics.

One strategy used in this research as intervention (during the Physics lessons) was contrastive elaboration, where learners and the teacher were allowed to criss- cross between languages, extending meanings beyond the language of input, and to enhance deeper understanding of Physics concepts.

Considering the extract from Learner 5 above, the use of Sesotho authenticated the learner's sense of being, therefore reinforcing the learner's personal identities. One would therefore argue that the use of learners' home language in the classroom provides superior cognitive gains for multilingual Physics learners through the simultaneous endorsement of concept literacy and embracing African languages at the multilingual Physics learners' disposal.

The use of the learners' home language, therefore, disorganises ethno-linguistic divisions and separatist ideologies of the past and creates optimal opportunities for pedagogy of integration, which liberates historically excluded languages and affirms the fluid linguistic identities of multilingual speakers, not forgetting their enhanced comprehension of concepts in the different subject areas (Janks & Makalela, 2013; Makalela, 2015; Wei, 2011).

Of interest are the learners' evaluation of the post- test after they had been taught using their home language and were given learning materials in their home language. The responses from the experimental group showed that the use of learners' home language has both cognitive and social advantages that are normally not found in monolingual classroom settings. The results of the post- test and interview responses show that the experimental group had affective and social advantages over the control group, as well as a deep understanding of the concepts through use of their home language.

Teaching Physics to learners whose home language is not the LoLT is a complicated matter where learners have to deal with the new terminology of Physics as well as the new language of instruction in which Physics is taught. Teachers therefore need to develop effective ways of teaching both the language of Physics and the LoLT.

Theme 4: Psychological effects of using one's home language in Physics education

The use of one's home language is also informed by the relationship between identity construction and content learning. Unlike monolingual classes that impose one language in class, the use of a learner's language together with the LoLT reinforces personal identities and makes the speaker feel fulfilled in his/her plural identity (Makalela, 2014b). In a way multilingual speakers use the languages they speak as a marker of who they are or their way of life, as revealed in the following extract:

Learner 76

If someone speaks to me or teaches me in my own language I feel honoured, special and adored. This makes me want to please that person and in the process my marks get better. The problem with us the youth of today is that we are ashamed of

our roots and want to associate with classy languages such as English. So yes I would say being taught in my home language makes a huge difference in my school work.

The use of learners' home language thus enables cultural cohesion of languages and cultural 'tribes' that were exaggerated by Apartheid policies of separate development between 1948 and 1993 (Makalela, 2014a), in the case of having learners from different linguistic backgrounds. Once there is cultural cohesion, this then leads to motivation of all Physics learners. The following extract from Learner 16's response is of interest:

South Africa has eleven official languages so we should be given a chance to choose the language I want to be taught in. No language in this country should be seen as inferior to others so, yes, being taught in my home language motivates me and makes me get high marks in class because I understand better in my language

Motivation is usually defined as an internal state that arouses, directs and maintains behaviour (Woolfolk, 2010). Motivation, however, is a private, internal process. Instead of leading people to follow a socially engineered way of thinking or behaving, what motivation does is endow the person with the energy and direction needed to engage in and to cope with the environment in an open-ended, adaptive, problem-solving sort of way (Reeve, 2015).

When you motivate someone, you energise and direct their behaviour, engagement, and coping. Learners are motivated when their behaviour is strong, purposive, and resilient, or when they use a language of their choice. Psychologists identified two types of motivation: intrinsic and extrinsic. Intrinsic motivation is the natural human tendency to seek out and conquer challenges as we pursue personal interests and exercise our capabilities. When learners are intrinsically motivated, they do not need incentives or punishments, because the activity itself is satisfying and rewarding (Reeve, 2015).

Since learners differ in terms of language, culture, economic privilege, personality, knowledge, and experience, they will also differ in their needs, goals, interests, emotions, and beliefs as well as the nature and level of motivation they would need

to succeed (Woolfolk, 2010). Teachers, therefore, need to encourage motivation by taking this diversity into account, especially where language and culture are concerned. Learners who are intrinsically motivated show more creativity and conceptual learning than do learners who learn out of an extrinsic motivation (Reeve, 2015).

In Physics education, an understanding of motivation can be applied to promote learners' classroom engagement, to foster the motivation to learn and develop talent, to support the desire to stay in school rather than drop out, continues Reeve (2015). The point is that Physics learners are curious, intrinsically motivated, sensation-seeking animals with goals and plans to master challenges, develop warm interpersonal relationships (Lyon et al., 2011), and move toward attractive incentives, psychological development (Van Laere et al., 2014), and growth.

Learners therefore need activities to capitalise on both known and unknown concepts related to their interests, stimulate their curiosity, or are connected to real-life situations (Woolfolk 2010: 414) in a language they fully understand. Besides motivating the learners, the use of their home language also gives them a sense of belonging; the following extract cannot go unnoticed:

Learner 98

I would agree that being taught in my home language made a huge academic difference. As someone who always wants to be ahead of the class I had tried reading the topic [Mechanics] on my own but I didn't understand a thing until it was explained to me in my own language. My parents were also happy that I had been taught in our home language. It surely meant a lot to us learners and our families. It [use of one's home language] gives you a sense of belonging and pride.

Creece and Blackledge's (2010) study of British complementary schools further reveals the benefits of using more than one language as follows:

- (1) Ability to engage audiences through translanguaging and heteroglossia.
- (2) Establishment of identity positions.
- (3) Recognition that languages do not fit into clear bounded entities and that all languages are 'needed' for meaning to be conveyed and negotiated.

(4) Endorsement of simultaneous literacies and languages to keep the pedagogic task on track.

The majority of the respondents noted that the use of more than one language in the classroom interactions gave them a reasoning power that they often do not have in typical monolingual interactions. In the same vein, Wei (2011) has found, for example, that the use of more than one language in a lesson involves 'going between different linguistic structures and systems, including different modalities and going beyond them'.

In this present study it was this going between languages that provided a reasoning power for the respondents in the experimental group accounting for their improved academic performance in the Physics post- test. The results of the experimental group (from the post- test) showed positive effects of using resources written in the learners' home language in the classroom by reinforcing plural identities, bridging linguistic and cultural boundaries and increasing reasoning power through integrated multilingual practices (Garcia, 2011).

These findings resonate with one of the consistent findings in various literature on translanguaging that the use of more than one language and, especially, the languages of the learners in class authenticates their social identities and provides an emotionally safe environment to be themselves and gain positive schooling experience (Wei, 2011). What these results further show is the catalytic role of translanguaging techniques in the development of multilingual identities, which are typically muted by monolingual proscriptions (Makalela, 2014a; 2015).

In order to move away from 'linguistic tribes' of the past, using African languages in the teaching/learning of Physics can be aligned with the African cultural and epistemological conception of being, *ubuntu*, which propagates a communal orientation and continuum of social, linguistic and cultural resources and denotes the interconnectedness of all human existence (Makalela, 2014a; 2014b; Msimanga & Lelliott, 2014).

The use of African languages in today's Physics classrooms promotes the interdependence of multilayered language systems by a simultaneous use of more than two languages (Baker, 2011; Makalela, 2014a; 2015) within one Physics lesson.

This strategy, based on the responses from the learners and their performance in the post- test proves that one language does not exist in isolation from the other, and typifies what is coined as 'ubuntu translanguaging' (Makalela, 2014a, 2014b) from the African epistemological orientation of complex continuity found in the injunction: '*I am because you are; you are because we are*' (Makalela, 2015).

4.9 Summary of research findings

Presented below is a summary of the research findings from the present study:

4.9.1 English Language Proficiency test

Control group

The highest mark obtained by a participant in the control group was 34% with the lowest being 18%. The group had a mean of 25.2% and a pass rate of 35%. This therefore means that 6.5 in every 10 participants failed the test, considering the DoE's pass mark of 30% for additional languages. The standard deviation for this group was 6.09%.

Experimental group

The highest mark obtained in this group was 40% with the lowest being 15%. The experimental group had a mean of 24.9% and a pass rate of 30% for the proficiency test. This also means that 7 in every 10 participants in this group failed to score 30% or higher in the English Language Proficiency test. The standard deviation for the group was 6.17%.

Some participants from the experimental group tied this poor performance to difficult vocabulary. This came to light during the interviews where one such respondent said:

I liked the last one. I could understand the questions clearly. The first and the second were actually difficult and the language used in them, eish, was deep and too scientific (Learner 48).

There was a difference of 5% in their respective pass rates for the test and 0.3% in their means. Their performance was not, therefore, very different as evidenced by the statistical analysis.

4.9.2 Pre-test

Control group

The highest mark in this group was 42% and the lowest was 15%. The group's mean stood at 23.9%, with a standard deviation of 8.26%. The pass rate for this group stood at 25%. The pass rate was calculated using the DoE's pass mark of 30%. Conclusively 3 out of every 4 participants in the group failed the pre- test.

Experimental group

The highest mark obtained in this group for the pre- test was 42% with the lowest being 15%. Their pass rate was 15%, translating to 10% lower than that of the control group. The control group had a mean of 23.9% whereas that of the experimental group was 22.7%. The standard deviation for the experimental group's marks in the pre- test was 8.13%. Considering the means for the two groups as well as their standard deviations, the performance of the two groups was almost the same.

Both groups did not do so well in the pre- test. During interviews most learners in the experimental group attributed their poor performance in the pre- test to the language used during the lessons prior to writing the test. Examples of such responses came from Learners 59 and 76 included below:

Learner 59

The Proficiency test was fair and the last one was very easy. It was the second test that gave me problems. It was too complicated and I couldn't understand the language. It was difficult for sure.

Learner 76

My performance obviously differed. My lowest mark was for the second test. The questions were tricky and the language difficult. However I did well in the last test. The teacher explained the work I didn't understand in my mother language and also gave us a dictionary written in my language [Sesotho].

The average pass rate for the two groups for the pre- test was 20%.

4.9.3 Post- test

Control group

The group had a negative learning gain in 4 questions. The group's highest learning gain was 0.32 for Question 18. Not a single learner in this group was able to get the correct answer for Question 7 in both tests, pre- and post-test. Half of the group was, however, able to get Question 5 correct in the post test.

The mean for the group was 34% with the highest mark obtained in this group for the post- test being 54% while the lowest stood at 23%. The group had a pass rate of 60%, implying that 4 in every 10 learners in the group failed the post-test considering the DoE's pass mark of 30%. The mean for the group is a clear indication of how low the group's marks were in this particular test.

Experimental group

The mean for this group in the post- test was 46.75% with a standard deviation of 8.28%. The group fared badly in Questions 7; 19; 20 where 95%; 85% and another 85% wrote the wrong answers respectively. The highest learning gain was for Question 5 which was 0.643 following a difference of 45% in the group's performance between the pre- and post-test. The highest mark attained in this group was 69%.

Question 7 presented the hardest challenge to the group. Only one learner was able to get the answer correct. More than half of the group got Questions 1; 3; 5; 6; 11; 12; 13; 15; 16; 17; 23; 24; and 25 correct. These were questions that had most of their wording translated into the learners' home language during Physics lessons held and/or in the English- Southern Sesotho Physics dictionary used during the intervention lessons.

Clearly from the above comparison it can be safely deduced that all learners in the experimental group performed better in the post- test than in the pre- test. Most of them (experimental group participants) improved their performance by above 10% after the intervention (the use of their home language during Physics lessons and the provision of an English- Southern Sesotho Physics dictionary).

4.10 Discussion of research findings: Quantitative and Qualitative

Research on language in Physics education has focused on a variety of topics, such as the particular functions of language in Physics classrooms, the relationship between the language practices familiar to non-dominant learners and those found in science classrooms, and the ways in which language in Physics may alienate some learners and preclude them from participating in scientific discourse (Lyon et al., 2012).

In terms of assessment, several studies document significant links between learners' level of proficiency in the LoLT and their performance on content-based assessments (Lyon et al., 2012; Van Laere et al., 2014). As societies become more culturally and linguistically diverse, many learners enter the classroom with a home language that is different from the language of instruction used at school (Maerten-Rivera et al., 2010; Martin et al., 2012).

The study sought to answer the following research questions:

1. What is the role of language in the teaching/learning of Physics?
2. How does language affect the academic performance of Grade 11 Physics learners?
3. To what extent can Southern Sesotho be used as a medium of instruction in the teaching/learning of Physics to Grade 11 learners?

The study also sought to determine whether or not the null and research hypotheses could be accepted. The hypotheses were:

Research hypothesis: *There is no relationship between language and academic performance in Physics.*

Null hypothesis: *There is no significant difference between the academic performance of the control and experimental groups in Physics.*

This study took into account both the home language and literacy in the language of instruction (English) in relation to learner achievement in Physics. Multilevel hierarchical regression analyses show that the home language and literacy in the language of instruction play an important role in science achievement at the learner level, next to gender and socioeconomic status. Learners with a home language that is different from the language of instruction experience difficulties with science subjects (Van den Branden, 2010).

Moreover, the higher learners' performance on reading comprehension and self-assessed proficiency in the language of instruction, the higher their score on Physics achievement tests (Van den Branden, 2010; Van Laere et al., 2014). Most of the learners' proficiency in the language of teaching/learning in this present study correlates with their performance in Physics, examples being Learners 1;5;8;17;21;37;43;59;68;69;72;82 and 85.

This is because language is considered to be both a precondition for thought and a bearer of thought and therefore influences the extent to which a learner's intelligence is actualised (Botes & Mji, 2010). Language is critical for cognitive development as it provides the concepts for thinking and therefore a means for expressing ideas and asking and answering questions (Botes & Mji, 2010).

In my opinion if learners do not possess an 'adequate language bank', this might be a problem, as evidenced in the learners' performance in the English language proficiency and pre- tests. The majority of the learners (in both groups) did not have a difference of more than 10% between English Language and the pre- test. When it came to the post- test, however, it was a different story with the experimental group as all the learners passed the test with at a level 3. It has been pointed out that the difference between everyday language and science terminology also leads to first language speakers learning a new language when learning Physics (Botes & Mji, 2010).

Based on the interview responses and the learners' performance in the post- test, teaching the experimental group using a language they understood and giving them Physics learning materials translated into their home language accounted for the difference in performance compared to the control group.

The results from the post- test clearly show that the use of learners' home language has both cognitive and social advantages (as can be witnessed from interview responses from the following respondents) that are normally not associated with monolingual medium classroom interactions.

Learner 76

If someone speaks to me or teaches me in my own language I feel honoured, special and adored. This makes me want to please that person and in the process my marks get better. The problem with us the youth of today is that we are ashamed of our roots and want to associate with classy languages such as English. So yes I would say being taught in my home language makes a huge difference in my school work.

Learner 85

.... One gets to understand the work clearer and get motivated by the fact that my home language will be recognised at last instead of being taught in someone else's language.

Learner 76's response is echoed by an icon, the former President of the Republic of South Africa, the late Nelson Mandela when he said if you talk to a man in a language he understands, that goes to his head. If you talk to him in his own language, that goes to his heart (Stengel, 2010). This (talking to someone in his own language) motivates them and no doubt propels learners to perform better academically.

The performance of the experimental group in the post- test is clear indication that translanguaging strategies are effective in improving the academic performance of multilingual Physics learners as long as the teacher uses the learners' home language in cases where the LoLT is different from the learners' home language.

In my opinion, if all factors were constant among all learners, then the use of the learners' home language indeed had a positive impact on their academic performance. Also, based on the participants' interview responses, breaking boundaries between ranges of linguistic resources in multilingual classrooms affords learners a positive schooling experience and affirms their multilingual identities thereby enhancing their academic performance (Makalela, 2015).

The diverse nature of multilingualism around the world is reflected in the wide range of multilingual classrooms in which Physics is taught (Rowe, 2013). We see a classroom as being multilingual if any of the participants (learners, teachers or others) is potentially able to draw on more than one language as they go through their work (Baker, 2011).

The difficulty the language of Physics poses for many low-literacy English language learners (those who learn Physics in a language different from their home language) has long been documented in the literature. The academic language of a textbook is far removed from the everyday conversational language use with which learners are familiar (McCallum & Miller, 2013), hence the need to help break the language barriers.

The language of instruction for the control group was not changed during the lessons. They were taught in English language, a language they have a low proficiency in, according to the results of the English Language proficiency test they wrote. Cummins has made a distinction between 'basic interpersonal communicative skills' (BICS) and 'cognitive academic language proficiency' (CALP).

While BICS deals with the social use of language in daily activities, which is context-embedded and characterised by non-verbal support (for example conversations), CALP refers to the more complex and cognitively demanding language used at school in several subjects (Van Laere et al., 2014). Classroom activities are mostly characterised by context-reduced and cognitively demanding communication, with Physics education as one of the most obvious examples: Physics is concerned with describing phenomena, conceptual reasoning, as well as organising, applying, and evaluating new information (Van den Branden, 2010).

This clearly explains why the learners in this study had a higher pass rate and mean for the English Language proficiency test than the pre- test. The demands posed by CALP also explain the repeated low performance by the control group in the post- test. The pre- test and post- test required a higher level of academic language proficiency, which judging from the results, the learners did not have.

According to the English Language Proficiency standards, in order for one to do well in science subjects the learner should attain a Level 4 (between 60 and 79%) in the language of instruction. At this proficiency level these learners communicate information, ideas, and concepts necessary for academic success in the content area of Physics and are referred to as competent users.

The learners generally have adequate command of the language despite some misunderstandings and inaccuracies. They have a good understanding of some conventions in writing, and can interpret a text, know the structures, and exhibit confidence in using the language of instruction (Gottlieb, 2004; Lambert, 2015; Landsberg et al., 2011).

Research argues that proficiency in a language of instruction correlates to Physics achievement (Van Laere et al., 2014). This therefore leads to underperforming in subjects that are taught in a language different from the learners' home language. If the learners are proficient in the language of instruction, their performance in Physics will no doubt be high.

In this vein the researcher sought to compare the experimental group's performance in the post- test against that of their language of instruction used during the study (Southern Sesotho). The cause of the difference in performance between the two groups in the post- test was due to the change in the language of instruction used for the experimental group before the learners wrote the post- test.

This is in line with previous research which suggests that proficiency in the language of instruction influences learners' performance in science subjects (Taboada, 2012). Science plays a central role in society, as it is a catalyst for development and the cornerstone of culture. Because this implies a need for a scientifically informed citizenry, education in this area is an important outcome of schooling (Bellens & De Fraine, 2012; Maerten-Rivera et al., 2010).

This is problematic, as different countries worldwide are faced with a serious and persistent gap in academic achievement in science subjects, particularly between learners who are being taught in their home language and those whose home language is different from the LoLT (Bellens & De Fraine, 2012; OECD, 2010). This was confirmed in the present study in which the experimental group academically outperformed the control group as a result of the difference in LoLT used for the two groups.

The results from this study concurred with previous studies which suggest that one of the key factors associated with this achievement gap is the relationship between language spoken at home and the LoLT (Van Laere et al., 2014). Learners who are taught Physics in a language different from their home language experience greater difficulty attaining the same level in science education than those who are taught in their home language (Martin et al., 2012; OECD, 2010).

As seen in this study, language does influence academic achievement in Physics in that all learners must acquire scientific knowledge and skills through gradually mastering a new kind of language, characterized by a specific vocabulary, a high level of abstraction, and limited contextual support (Van den Branden, 2010).

In sum, the present study affirmed previous research findings which detail that learners' proficiency in the language of instruction and particularly their reading abilities are related to science achievement (Van Laere et al., 2014). These factors become more critical when learners speak a home language that is different from the language of instruction where they lack comprehension skills, namely vocabulary knowledge and reading comprehension (Cremer & Schoonen, 2013; Van Laere et al., 2014).

Based on the results from the English language proficiency test in which 13.3% of the participants achieved a mark of 30% or above, it can be argued that many learners' vocabulary and comprehension are too limited to access mainstream textbooks, or follow teacher-centred explanations (McCallum & Miller, 2013) in Physics when the LoLT is English. The new literacy that learners must acquire in order to perform well in Physics is known under different but related names:

disciplinary literacy, decontextualized language, and cognitive academic language proficiency.

Disciplinary literacy is closely related to the concept of decontextualized language, which refers to abstract language that is distant from the here and now (Rowe, 2013). Learning to master decontextualized language is often very challenging due to the associated skills required, such as abstract thinking, an underlying assumption of causality, and mastering a relatively complex vocabulary and grammar, all of which imply an advanced level of language proficiency (Van Laere et al., 2014). This therefore makes it difficult for language minority learners to perform at par with language majority learners in Physics.

The researcher, in this present study, concluded that the use of one's home language in Physics lessons helped learners understand Physics vocabulary and concepts so well resulting in an improvement of their academic performance in the post- test. Researchers have repeatedly argued that learners who learn science in a language different to their home language are at a disadvantage (Cremer & Schoonen, 2013; Lyon et al., 2011; Van Laere et al., 2014), this assertion was confirmed through the control group's performance in both the pre- and post- tests.

Besides having Physics lessons in Southern Sesotho, the experimental group was also given an English- Southern Sesotho Physics dictionary to assist in alleviating the disadvantages posed by the LoLT and to add to the numerous Physics teaching/learning resources for use in the country's undeniably diverse multilingual classes. Many South African learners who come from linguistically hybrid townships where they speak at least four identifiable languages (or 'have at their disposal at least four language systems'), for example, tend to be disadvantaged educationally because they do not fit the profile of schools who think 'monolingually' (Makalela, 2013).

If the country is to prosper, according to findings of this research, learners need to be educated in a language they have maximum proficiency. This view is also shared by the late Nelson Mandela when he said that education is the great engine of personal development (Mandela, 2010).

It is through meaningful education that the daughter of a peasant can become a doctor, that the son of a mineworker can become the head of the mine that the child of farmworkers can become the president of a great nation. It is what we make out of what we have, not what we are given, that separates one person from another (Crwys- Williams, 2011). What we have are the numerous home languages, which when the experimental group in this study was allowed to use theirs, it had a positive impact on their academic performance (as witnessed in their post- test marks).

On the contrary learners in most present day Physics classes are given textbooks and/or supplementary teaching and learning materials written in a language they have minimal proficiency yet the Language-in-Education Policy (LiEP) for the Republic of South Africa makes room for mother tongue instruction or an additive and careful approach to multilingualism in the classes (Department of Education, 2002). There can be no keener revelation of a society's soul than the way in which it treats its learners (Mandela, 2010).

4.11 Chapter Summary

The 40 learners wrote the same pre- and post- tests under the same conditions. The results of the study show that the experimental group performed better than the control group. The experimental group had been taught in their home language and were also given an English- Southern Sesotho Physics dictionary to consult.

The performance of the experimental group in the post- test show that translanguaging techniques used afforded the learners cognitive advantages as they seemed to have had a deeper understanding of the concepts learnt. The interview responses from the experimental group also indicated social and affective advantages for learners who are taught in their home language. the findings of this study, therefore call for development of multilingual pedagogies in the Physics class.

4.12 Conclusion

A good head and good heart are always a formidable combination. But when you add to that a literate tongue or pen, then you have something special (Mandela, 2010). Based on the post- test results from this study, for the world in general and the country in particular to have a literate pen, learners need to be taught Physics in a language in which they have high proficiency.

It should be pointed out that proficiency in conversational English, where it is the language of instruction, is not the only requirement for learners to master Physics. Learners also need to be familiar with scientific English. In fact it has been argued that mastery of a specialised subject like Physics is in large part mastery of its specialised language (Botes & Mji, 2010). Scientific English entails the use of abstract generalisations and logical relationships that learners have to master.

The aim of this study was to establish whether language was a contributing factor to the academic performance of learners in Physics. During the study the experimental group was taught using both English and their home language (Sesotho). They were also given an English- Southern Sesotho Physics dictionary to use. The results indicated that the marks of learners in the experimental group improved from the pre-test (where the average was 22.7%) to the post- test (where the average was 46.75%).

The findings were in line with previous research which suggests that learners with a home language that is different to the language of instruction seem to have great difficulties in performing at a high level in science subjects, with the opposite being true (Maerten- Rivera et al., 2010; Taboada, 2012; Van Laere et al., 2014).

The results of the experimental group in the post- test in this study clearly confirm that proficiency in the language of instruction should not be underestimated when it comes to Physics achievement. These results, in both the pre- test and post- test, show the role language plays in Physics achievement: if the language of instruction differs from learners' home language learners face an extra challenge in achieving high marks in Physics.

Without understanding a language, one cannot talk to people and understand them, one cannot share their hopes and aspirations, grasp their history, savour their songs, or grasp the meaning of spoken or written word in any context (Stengel, 2010).

This therefore leads to underperforming in subjects that are taught in a language different from the learners' home language. If the learners are proficient in the language of instruction, their performance in Physics will no doubt be high, as evidenced in the above statistical analysis as a result of clear understanding of the concepts being taught to them. Considering the significant increase in the

experimental group's performance after the intervention was given, African languages can undoubtedly be used successfully in the teaching/learning of Physics.

While high achievement in Physics may seem to have little to do with language skills at first sight, research suggests that literacy plays a significant role in science education (Van Laere et al., 2014): all learners must acquire scientific knowledge and skills through gradually mastering a new kind of language, characterised by a specific vocabulary, a high level of abstraction, and limited contextual support (Van den Branden, 2010).

The decontextualized language needed for Physics is an obstacle for such learners, as the Physics language and its vocabulary become increasingly complex and less connected to directly observable contexts (Janssen & Crauwels, 2011; Van Laere et al., 2014) and this can only be alleviated through using a language of instruction that is completely understood by all learners, such as their home language.

It was hypothesised that there is no relationship between language and academic achievement in Physics. This proved not to be the case as results from the 3 tests written during the study indicated a close link between the LoLT and academic performance in Physics. Based on the results of the present study, African languages can successfully be used in the teaching/learning of Physics in cases where the learners have high proficiency in the languages, Southern Sesotho included.

At the end of the research the control group was then given the intervention and also post- tested. All learners in the group passed the test with marks higher than in the previous test and the group's mean rose from 34% to 44%.

Results from the present study also indicate that proficiency in the language of instruction plays a pivotal role in learners' academic achievement in Physics. The next chapter details summary of the research, suggestions, recommendations, and a conclusion to the present research.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of the research, conclusions and recommendations arising from the research are presented in this chapter.

5.1 INTRODUCTION

The purpose for conducting this study was to establish whether or not language is a contributing factor to the academic performance of Physics learners in the Fezile-Dabi district. The aim of the study was to investigate the effect of language on the academic performance of Grade 11 Physics learners whose home language is Southern Sesotho. These are learners who are being taught Physics using a language different from their home language.

Of grave concern is also the fact that these learners study English as an additional language whereas the Physics learning materials are written in English Home language (this is the communication level of native English speakers).

The study sought to answer the following research subquestions:

1. How does language affect the academic performance of Grade 11 Physics learners?
2. To what extent can Southern Sesotho be used as a medium of instruction in the teaching/learning of Physics to Grade 11 learners?

In answering the research questions, the researcher divided the research sample into two groups, namely the control and experimental groups. The control group was taught using English language only whereas the experimental group was taught in English as well as Southern Sesotho (their home language). The advent of the eleven official language policy in South Africa presented institutions of learning with opportunities to embrace the use of more than one language.

Sadly “*black schools*” seem to have almost regressed by going for English- only default policy practices, regardless of the widely reported low literacy rates among their learner populations (Makalela, 2013). The experimental group was also allowed to switch between the two languages in explaining concepts and answering

questions. Contrary to the monolingual approach to which the control group was exposed, the experimental group had the leeway to engage bilingualism during lessons. Both the teacher and learners code switched for clarity purposes and emphasis of key concepts, definitions, and explanations of various scientific phenomena.

After the intervention phase, the two groups wrote a post- test which enabled the researcher to determine whether or not to accept the research hypothesis. The study hypothesised that there would be no significant statistical difference in the academic performance of the two groups regardless of the LoLT.

The results of the study highlight the benefits of a bifocal language policy practice where schools can serve as catalysts for best Multiliteracy development practices that translate into substantial content gain, comprehension, and retention by using more than one language during academic instruction, one of which should be the learners' home language.

In order not to disadvantage learners who were in the control group as well as those who did not participate in the study, arrangements were made to afford them the same lessons and learning resources as those accorded to the experimental group. This chapter focuses on chapter overview, summary of the research, conclusions drawn, and recommendations tabled based on the data collected during the study.

5.2 Chapter overview

Chapter 1

This chapter dealt with the background of the research problem. Although the use of more than one language in Physics lessons has become the norm of the day in some countries, very few African states have embraced the practice. Under the aegis of the eleven official language policy and the Education Language policy of the land, South African schools are in a position to transform into multilingual institutions where the learners' home language can be incorporated into the daily lessons. Research, however, paints a different picture.

Most Physics classes in South Africa are still oppressed under the monolingual paradigm, mostly having a LoLT different from the learners' home language. Research on the relationship between language and ways of knowing and conceptual knowledge assimilation has convincingly established that using a LoLT which is different from the learners' home language puts the learners under immense pressure to use a monolingual lens to make sense of the world and of who they are (Garcia & Wei, 2014; Makalela, 2015).

This orthodoxy of monolingual orientation in the school curricula was imbued by a one-ness ideology (that is one language, one nation; one classroom, one language), which was central to the formation of European nation states in the 18th century (Baker, 2011; Makalela, 2014a).

From this European Enlightenment period, schools have always created situations where one language was pitted against another while teachers have, invariably, adopted a protective approach to guard against cross-contamination between languages (Makalela, 2013).

Research has however proved that separation of language systems and attempts to control their continuum are artificial and more often than not, counter-productive (Garcia & Wei, 2014). It is in this connection that research on causes of underachievement in Physics can be apportioned to the imposed monolingual orientations on multilingual speakers in cases where the LoLT is different from the learners' home language (Van Laere et al., 2014).

As more recent scholarship on super diverse schooling communities has shown, the use of a LoTL which is different from the learners' home language has proved to be ineffective and does not provide positive school experiences as well as pedagogic and cognitive support needed for underperforming multilingual learners (Creese & Blackledge, 2010).

The advent of super diverse settings in the 21st century has increasingly required classroom practices, curricula and policies to build on multiple repertoires of the learners and to acknowledge the linguistic fluidities that overlap into one another (Creese & Blackledge, 2010; Garcia, 2011; Wei, 2011).

There is, however, a paucity of studies that report on alternative pedagogical strategies that may be suitable to these changing contexts, hence the relevance of the present study. Little empirical research has actually been conducted on the use of South Africa's African languages in general and Southern Sesotho in particular in the teaching and learning of Physics. The chapter also details the aim of the study, research questions, hypotheses, limitations, and definition of key terms used in the study.

Chapter 2

This chapter focused on literature relevant to the problem under study. From the literature reviewed, it was evident that language does contribute to the academic performance of Physics learners across the globe. Learners with a home language that is different to the language of instruction seem to have great difficulties in performance at a high level in science subjects (Martin et.al, 2012; OECD, 2010).

Considering literature reviewed, being proficient in the language of instruction and particularly in reading comprehension is positively related to science achievement: the higher learners' self- assessed proficiency in the language of instruction and especially their performance on reading comprehension, the higher their Physics achievement (O'Reilly & McNamara, 2007; Taboada, 2012).

Consequently, competence in the language of instruction should not be underestimated when it comes to science achievement (Maerten- Rivera et al., 2010; Taboada, 2012): in order for learners to successfully acquire scientific knowledge and skills, they need to master science literacy (Shanahan & Shanahan, 2008).

This, then, calls for learners to become familiar with the cognitively demanding and decontextualized language that is commonly used at school (Van den Branden 2010), particularly as learners will be confronted with more content area texts, such as science texts during their further school career (Van Laere et al., 2014).

Regarding the role of language in science achievement, research shows that language minority learners (these are learners whose LoLT is different from their home language) face an extra challenge in performing highly in Physics (Clark et al., 2012; Janssen & Crauwels, 2011; Martin et al., 2012; Msimanga & Lelliott, 2014).

The researchers concur that these language minority learners (LMi) face a double challenge in the Physics class: they have to acquire academic knowledge and skills through a language that they have not yet mastered fully.

The decontextualized language needed for school proves to be a big obstacle for many learners, especially LMi learners, as the language and its vocabulary become increasingly complex and less connected to directly observable contexts (Clark et al., 2012; Msimanga & Lelliott, 2014; Van Laere et al., 2014).

Research has also advocated for the use of learners' home language in Physics education, where the home language can be used in conjunction with the school's LoLT (Baker 2011; Clark et al., 2012; Maerten- Rivera et al., 2010; Msimanga & Lelliott, 2014; Van Laere et al., 2014), terming it multilingualism.

Current research on local and global multilingualism has questioned the validity of thinking about languages as static, reified and sealed categories with clear boundaries and has favoured porous and complex systems of communication that overlap (Garcia, 2011; Garcia & Wei, 2014; Hornberger & Link, 2012; Makalela, 2015; Wei, 2011).

This epistemic shift from the orthodoxy of monolingual paradigms is generally referred to as the 'multilingual turn' (May, 2013) to signal the focus on multilingualism as the beginning point in understanding language practices. These academics have revealed that a monoglossic orientation towards language systems has lost space in the global, fluid and mobile communicative spaces (Makalela, 2015) as it hinders learners' achievement in various content areas. From the literature reviewed, language surely does affect learners' academic achievement in several content areas, Physics included.

Chapter 3

The research design, methodology, research ethics as well as data analysis procedures followed in this study are presented in this chapter. This research assumed a mixed method design where the researcher made use of both quantitative and qualitative methods in answering the research questions and investigating the correctness of the research hypothesis.

The researcher used sequential explanatory, resulting in quantitative and qualitative data being collected (triangulation) in two phases and analysed separately (Tuckman, 2011), with primary emphasis on quantitative methods. Initially quantitative data was collected and analysed followed by qualitative data collection and analysis. The notation for this research was:

QUANT→ qual

Triangulation enabled the researcher to get a better understanding of the problem being investigated (Gray, 2011) through the use of different theories (Cohen et al., 2011), methods of research and methods of data collection (de Vos et al., 2011).

In order for the researcher to explore all aspects related to the extent to which language can be a contributing factor to the academic performance of Physics learners, it was prudent of the researcher to employ such a design.

In this research data was collected from learners' performance in the English Proficiency test, the pre- test, the post- test, and responses from interviews that were held with the experimental group on their views and feelings about the use of their home language (Southern Sesotho) in the teaching/learning of Physics, as well as the effectiveness and relevance of the English- Southern Sesotho Physics dictionary which they used in class during the study.

In analyzing qualitative data, qualitative content analysis was used by the researcher. It is similar to pure coding in that it does not contain any techniques for pattern recognition or pattern integration. The researcher followed steps enshrined in Gläser & Laudel's (2010) model.

The researcher sought permission to conduct the study from the Provincial Director of Education, Free State province, the District Director of Education (Fezile- Dabi district), as well as from the respective principals, and the learners' parents. The researcher was cleared to carry out the research by Unisa's College of Education (CEDU) Research Ethics Review Committee (Ref: 2016/04/13/48166413/08/MC).

Chapter 4

The data collected during the study was presented, and analysed in this chapter. This research took into account the learners' home language and their proficiency in the LoLT in relation to their academic performance in Physics. Three achievement tests were administered to the learners, namely an English Language Proficiency test, a pre- test, and a post- test. The learners' marks in the three tests were recorded and analysed.

In analysing quantitative data in this research bivariate analysis was used. The researcher compared the frequencies, percentages, learning gains, p-values, standard deviations, effect size indices, and means obtained in the different tests by the learners in the two groups (control and experimental) participating in the research. These quantities of measure were calculated for each group using R-computing and compared using the two- sample t - test with independent (different) groups described above.

The two- sample t - test is considered to be the most common use of the t - test and is also referred to as an independent samples t - test (Leedy & Ormrod, 2010). The purpose of this statistical procedure is to determine if there is a statistically significant difference in the dependent variable between two different populations of participants in a research (McMillan & Schumacher, 2010).

Considering the English Language proficiency test the mean for the 98 learners was 12.95% while the pass rate stood at 15.3%. This means only 15.3% of the 98 participants managed to achieve a mark of at least 30% in the English Language Proficiency test. This pass rate in itself is enough testimony of the low proficiency the group had in the LoLT.

There was a difference of 0.25% between the means of the two groups in the English Language proficiency test and 0.08% in the standard deviations. A total of 8 participants from both groups achieved a score of 30% or higher in the pre- test. This represents a pass rate of 20%. The highest participant got 11 out of 26 which translates to 42% while the lowest had 15%.

The average mark for the pre- test was 24.3%. This shows how badly participants performed in the pre-test. With a pass rate of 20% this means 80% of the research

sample (or 4 in every 5) failed the test. After writing the pre- test the forty learners were then randomly assigned to either the control or experimental group.

Regarding the performance of the two groups separately, the mean for the 20 learners assigned to the control group was 23.9% with a standard deviation of 8.26%. 5 of the 20 learners assigned to this group attained a mark above 30%. The calculated p- value was 0.6461. Since the p- value falls between 0.05 and 0.10, this shows a marginally significant difference (McMillan & Schumacher, 2010).

Only 3 of the 20 learners assigned to the experimental group passed the pre- test. The mean for this group was 22.7% with a standard deviation of 8.13%. Considering the DoE's pass mark of 30%, the group's pass rate stood at 15%.

From the statistical analysis above the researcher can accept the null hypothesis considering the negligible difference in the means of the two groups as well as the p- value obtained (McMillan & Schumacher, 2010). *There was insufficient evidence to indicate a difference in the academic performance in the pre-test results for the experimental and control group.*

The post- test results were however different from the pre- test. The mean for the experimental group was higher than that of the control group (a difference of 12.75% in favour of the experimental group) thus indicating a difference in the academic performance between the two groups.

The control group had a mean of 34% while that of the experimental group stood at 46.75%. There was sufficient evidence to indicate a difference in academic performance between the two groups. The difference in their performance, according to interview responses from learners in the experimental group, was largely due to the translanguaging used as intervention during Physics lessons. This method (translanguaging) was only afforded to the experimental group.

In analysing qualitative data in this study the researcher followed the guidelines provided by Gläser and Laudel (2010) to analyse the data systematically, by segmenting it into words or categories that subsequently formed the basis of the emerging story of the phenomenon under scrutiny. During the data collection process it was essential to use codes that disguised the learners' real names mainly

for ethical reasons. Learners were assigned numbers from 01 to 98. The researcher reduced and placed the findings into four main themes as follows:

Theme 1: Impact of language in academic performance in Physics.

Theme 2: Academic benefits of printed learning materials.

Theme 3: Academic support for English Language learners studying Physics.

Theme 4: Psychological effects of using one's home language in Physics education.

The interview responses were analysed manually because only a small number (20) was interviewed. To produce a rich information base the researcher used both coding and qualitative content analysis (Gläser & Laudel, 2013). The researcher fused both methods adopting a reductionist approach in which the data was re-read several times to arrive at themes until saturation points were reached.

17 of the 20 learners who were in the experimental group, confessed that they did badly in the Physics pre- test due to their inability to comprehend the language used in the test. They claimed that English was their second or third language hence they had limited use and comprehension of the language. They only use the language in the classroom since it is the LoLT.

The learners' responses during the interviews explain why only 13.3% of the learners passed the English Language proficiency test. Of the 98 learners that wrote the test only 13 achieved a score of at least 30% signifying a failure rate of 86.7%. It was therefore clear that when the LoLT is not the learners' home language, it is of the utmost importance that the learners' home language still be developed thoroughly, because competence in a person's home language lays the basis for the acquisition of another additional language which might be used as the LoLT (Nieman & Monyai 2013).

The learners' responses during the interviews correlated with their performance in the post- test in which all learners who were in the experimental group passed. This was suggestive evidence that learners should therefore be given learning materials written in a language they fully understand if they are to benefit academically from the materials (Nieman & Monyai, 2013). The research findings that home language

plays a significant role in Physics achievement confirms the theoretical assumption that learners who learn Physics in a language different from their home language experience a greater challenge in reaching a high level for Physics achievement (Clark et al., 2011; Msimanga & Lelliott, 2014; Van Laere et al., 2014).

Most of the learners interviewed noted that the use of more than one language during their lessons, especially if one of them tends to be their home language, made them understand the concepts better than in typical monolingual interactions. These findings resonate with one of the consistent findings in various literature on translanguaging that the use of more than one language and, especially, the languages of the learners in class authenticates their social identities and provides an emotionally safe environment to be themselves and gain positive schooling experience (Wei, 2011).

5.3 SUMMARY OF RESEARCH FINDINGS

I was really fascinated by the interface between language and literacy in Physics in the 21st century and intrigued by the prospects of alternating languages of input and output to enhance content comprehension as well as identity construction and epistemic access for learners who can speak more than one language.

5.3.1 English Language Proficiency test

All 98 learners sat for the English Language proficiency test and only 15.3% of them managed to attain a score of at least 30%. This was evidence of the learners' low proficiency in a language that happens to be their LoLT. The highest mark was 40%. The researcher then selected the top 40 learners based on the results of the proficiency test and invited them to partake in the study.

The learners were allocated into one of the research groups (control or experimental) after writing the pre- test. Analysis of the English Language proficiency of learners assigned to the control group revealed that the highest mark obtained was 34% with the lowest being 18%. The group had a mean of 25.2%, a pass rate of 35%, and a standard deviation of 6.09%.

The highest mark obtained in the control group was 40% with the lowest being 15%. Those assigned to the experimental group had a mean of 24.9%, a pass rate of

30%, and a standard deviation of 6.17% for the English Language proficiency test. This was crystal clear evidence of how much the groups under study are struggling with a language that, surprisingly, is their LoLT.

5.3.2 Pre-test

The best mark obtained in this group was 42%. The 20 learners in this group had a mean of 23.9%, with a standard deviation of 8.26%. Only 5 of the 20 learners in this group attained a score of at least 30%, representing a pass rate of 25%. This shockingly means 3 in every 4 learners in this group failed the test, according to the DoE's pass mark of 30%.

The best achiever in the experimental group got 42% for the Physics pre- test. Their pass rate was 15%, 10% lower than that of the control group. The control group had a mean of 23.9% whereas that of the experimental group was 22.7% for the same test. The standard deviation for the experimental group's marks in the pre- test was 8.13% compared to the control group's 8.26%.

Considering the means for the two groups as well as their standard deviations, the performance of the two groups was almost the same.

5.3.3 Post- test

Control group

12 learners in this group achieved a minimum of 30% in the Physics post- test and the group's mean stood at 34%. The best learner attained 54%. The group had a negative learning gain in 4 questions. The group's highest learning gain was 0.32 for Question 18. Not a single learner in this group was able to get the correct answer for Question 7 in both tests, pre- and post-test.

A pass rate of 60%, implies that 4 in every 10 learners in the group failed the post-test considering the DoE's pass mark of 30%. The mean for the group is a clear indication of how low the group's marks were in this particular test. A pass rate of 60% is way below the district's target of 90% (for Physics) by end of year 2017.

Experimental group

All learners in this group scored above 30% in the Physics post- test, with a mean of 46.75% and a standard deviation of 8.28%. Questions 7; 19; 20 were badly done by the group where 95%; 85% and another 85% wrote the wrong answers respectively. The highest learning gain was 0.643 (for Question 5) following a difference of 45% in the group's performance between the pre- and post-test. The highest mark obtained in this group was 69%.

Question 7 was the most difficult. Only one learner was able to get the answer correct. Learners did well in questions that had most of their wording translated into the learners' home language during Physics lessons held and/or in the English-Southern Sesotho Physics dictionary used during the intervention lessons.

For the post- test, the control group had a mean of 34% against 46.75% for the experimental group. This represents a difference of 12.75% in their respective means. This clearly dismisses the null hypothesis as there exists significant statistical difference between the performances of the two groups.

The control group had a pass rate of 60% whereas the experimental group had 100%.

5.3.4 Qualitative data (Interviews)

Responses from the interviews held with the experimental group accredited the group's better performance to the use of Southern Sesotho during the lessons. The learners' home language (Southern Sesotho) was used as intervention with the experimental group only. The group's results of the post- test highlight a constant finding that the use of learners' home language together with the LoLT, is a norm on which all classroom pedagogy should be based.

Most learners hinted that if given the chance they would prefer using their home language in conjunction with the LoLT during Physics lessons as it made them comprehend better at the same time giving them a sense of belonging. They cited that their poor performance in the Physics pre- test was a result of the gap that exists between their proficiency in English and the academic language enshrined in Physics texts.

This revelation goes against the grain of orthodox with a monolingual bias of one language as a point of reference (Makalela, 2015). The researcher concluded that using more than one language in the Physics class has cognitive and acquisition advantages that are not associated with monolingual classrooms. This therefore brings to fore that there are various risks of putting learners into monolingual programmes in a manner that contradicts the sociolinguistic milieus in which they learn through a range of languages.

From the learners' responses it is evident that education tends to make people monolingual in a dominant language in that the higher one goes in schooling, the greater is the demand for the lesser number of languages and that language deficiency has a cumulative effect (Garcia & Wei, 2014; Makalela, 2015; Wei, 2011).

The employment of unilingualism does not only threaten the survival of other languages considered inferior but creates deficiencies in concept comprehension and assimilation. One of the consequences of this monolingual approach to Physics education is that Fezile- Dabi is one of the districts with a low pass rate in Physics. Physics teachers should not, therefore, hold a dichotomous view of languages in opposition to one another but rather use both languages to enhance concept comprehension and retention.

5.4 RESEARCH CONCLUSIONS

The research sought to answer two research subquestions:

Research subquestion 1: How does language affect the academic performance of Grade 11 Physics learners?

As evidenced from the learners' performance in the pre- test (both control and experimental), the marks were relatively low. The cause, according to learners who were in the experimental group, was their low proficiency in the LoLT (English). The learners could not comprehend some of the words used in the test making it a mammoth task to answer questions related to the words. This came to light during interviews held with the experimental group.

With regard to policy options at schools, two are identifiable: namely a diffusion – of – English paradigm and an ecology – of –language paradigm (Makalela, 2015). The

first option is influenced by capitalism, science and technology, and the monolithic view of globalisation, which has a strong appeal in the developing world where English has clout over indigenous languages (Skuttnab- Kangas, Philipson and Mohanty, 2009).

This use of a single language (for the control group) in Physics has proven to hinder the academic achievement of LMi learners when taught in a language different from their home language. Unilingualism in Physics robbed the control group learners of both the symbolic and material resources which should enhance their modes of thoughts and knowledge. Research suggests that this has led to a serious and persistent gap in academic achievement in science subjects particularly between native speakers of the LoLT and minority groups (Bellens & De Fraine, 2012).

Research has also repeatedly exposed the role language plays in academic achievement in Physics. Learners in this present study (all LMi learners) have a home language that is different from the LoLT. These learners experience greater difficulty attaining the same level in Physics education than those who are taught in their home language (Martin et al., 2012; OECD, 2010), as evidenced in the two groups' performance in the post- test.

All Physics learners must acquire scientific knowledge and skills through gradually mastering a new kind of language, characterised by a specific vocabulary, a high level of abstraction, and limited contextual support (Van den Branden, 2010). This becomes challenging and cumbersome for Southern Sesotho learners whose home language and LoLT differ: not only do they have to acquire these new literacy skills, but must also do so in English, the LoLT, which they have not yet fully mastered (as evidenced from their results in the English Language Proficiency test written at the beginning of the study).

The new literacy that these Southern Sesotho Physics learners must acquire in order to perform well in the subject area is known as decontextualized language. Learning to master decontextualized language seems challenging to these Southern Sesotho learners due to the associated skills required, such as abstract thinking (Van Laere et al., 2014), an underlying assumption of causality (Rowe, 2013), and mastering a relatively complex vocabulary and grammar, all of which imply an advanced level of language proficiency (Fang, 2006).

The Physics content outlined in the policy document (Department of Education, South Africa, *Physical Sciences Curriculum and Assessment Policy Statement*, 2011), is largely characterised by context- reduced and cognitively demanding communication.

Physics is concerned with describing phenomena, conceptual reasoning, as well as organising, applying, and evaluating new information (Van den Braden, 2010). Several scholars have unearthed a negative correlation between the use of a LoLT that is different from the learners' home language and their academic performance in science (Janssen & Crauwels, 2011; Martin et al., 2012; OECD, 2010).

In this context, as well as revealed in the present study, proficiency in the language of instruction influences learners' academic performance in Physics. The learners in the present study had a high proficiency in Southern Sesotho (their home language). When the experimental group was taught in Sesotho and allowed to translanguage during lessons, this, based on their performance in the post- test, was very fruitful. All learners in the experimental group did well in the post- test.

There was a difference of 12.75% between the means of the control and experimental groups (in favour of the experimental group) in the post- test compared to a difference of 1.2% between the same groups in the pre- test. The pedagogical difference was the LoLT. The control group used English language only whereas the experimental group used both English and Southern Sesotho.

This, undoubtedly, accounted for the difference in their academic achievement in the post- test (see Tables 39 and 40). The researcher also compared the experimental group's academic performance in Southern Sesotho language and the Physics post- test. The group had a mean of 45.65% in the former and 46.75% in the latter, confirming findings from previous research that learners' proficiency in the LoLT is related to their academic achievement in Physics (Msimanga & Lelliott, 2014).

Conclusively, if learners have a high proficiency in the LoLT this will impact positively on their academic performance in Physics, and the reverse is true.

Research subquestion 2: To what extent can Southern Sesotho be used as a medium of instruction in the teaching/learning of Physics to grade 11 learners?

The experimental group was taught Physics in English and Southern Sesotho languages and also had an English- Southern Sesotho Physics dictionary to use during Physics lessons. Afterwards they wrote a Physics post- test which was the same as that written by the control group. The academic performance of the two groups was different, with the experimental group outperforming their counterparts.

All learners in the experimental group passed the post- test, and as revealed during interviews with them, credit was given to the use of their home language (Southern Sesotho). Although not all Physics terms could be translated into Southern Sesotho, that shortcoming was overshadowed by the gross academic benefit harvested from the terms and concepts which were translated.

This was evidence that Southern Sesotho, being an African language, can successfully be used in the teaching and learning of Physics alongside the school's LoLT. African multilingualism has always been construed from a monoglossic (that is, one language at a time) lens despite the pretensions of plural language policies in Sub- Saharan Africa (Makalela, 2015).

The intervention used in this study (use of English and Southern Sesotho languages interchangeably) explored the efficacy of alternating languages of input and output in the same Physics lessons in a bid to offset linguistic fixity that is often experienced daily in monolingual Physics lessons across the country.

Considering the experimental group's academic performance in the post- test as well as their responses during the interviews, the use of Southern Sesotho language by these multilingual learners during Physics lessons provided both cognitive and social advantages for the learners. The use of only one language in the Physics class, in cases where learners have a low proficiency in that language, can be limiting and inhibiting of full Physics concepts' comprehension and retention, hence the need to use the learners' home language.

The results from the pre- test show negative effects of monolithic and linear pedagogies to Physics education. Some renowned scholars in education observe that although English dominates in educational spheres, there are new emerging ecological spaces where African languages may thrive (Skuttnab- Kangas et.al, 2009), Physics education being one of them.

The use of Southern Sesotho (learners' home language) together with Cummins' BICS and CALP framework depict an opportunity for rich linguistic cross fertilisation between home languages and English (used as LoLT) that may be used as invaluable capital to transform language and literacy pedagogy in 21st century Physics classes. As highlighted in Tables 39 and 40 above, the use of Southern Sesotho in Physics lessons has a positive effect in the academic performance of learners.

Research hypothesis: There is no relationship between language and academic performance in Physics.

Calculated p- values, means, effect size indices, and standard deviations indicated that the learners' academic performance in the pre- test (from both the control and experimental groups) correlated with their academic achievement in the English Language proficiency test.

The mean for the control group in the English Language proficiency test was 25.15% and their mean in the pre- test was 23.9%, a difference of 1.25%. The experimental group had a mean of 22.7% in the pre- test and 24.9% in the proficiency test, a difference of 2.2%.

In both scenarios the null hypothesis was accepted as there was no significant statistical difference between the respective groups' performances in the pre- and proficiency tests, therefore signifying a relationship between language and academic achievement in Physics.

The researcher then compared the experimental group's academic performance in Southern Sesotho against their performance in Physics (post- test). The group had a mean of 45.65% in their second term Southern Sesotho examination (the

examination written during the time the study was undertaken) and a 46.75% in the post- test.

The standard deviations were 6.46 and 8.28 respectively. Considering the means for the post- test and the results from the Southern Sesotho examination one can safely conclude that there surely is a relationship between language and academic performance in Physics.

This present study contributes to the existing research on the relationship between language and learners' academic achievement in Physics. The results from the study demonstrate the importance of language in general and speaking a different home language than the LoLT in particular.

The results from this and previous studies indicate that numerous linguistic aspects prevent English minority learners (LMi) from fully understanding science word problems (Van Laere et al., 2014). Similarly reducing the linguistic complexity of concepts and test items in terms of lexical and grammatical features tend to improve the performance of these LMi learners in Physics (Haag et al., 2013).

The unveiled implications are that LMi learners experience a greater challenge in attaining the same academic achievement levels in Physics as learners taught in their home language. In educational circles it is always suggested that it is time to adjust the lesson when every learner has a blank stare. Good teachers know this and adjust while bad teachers know this but do not.

Consequently and evidently, home language can be brought into the learning process as a scaffold since there surely exists a relationship between language and academic achievement in Physics.

5.5 RECOMMENDATIONS

In order to better understand the role of language in learners' academic achievement in Physics and improve the academic performance of LMi learners, the following recommendations are made:

Research subquestion 1: How does language affect the academic performance of Grade 11 Physics learners?

Finding 1:

Learners with a low proficiency in the language of instruction attain low marks in Physics. This was evidenced in the pre- test written by the 40 learners in the study. 8 learners of the 40 that wrote the pre-test achieved a score of 30% or higher representing a pass rate of 20%. The highest mark achieved in the test was 11 out of 26 which translates to 42% with the lowest being 15%. The average mark for the 40 learners for the pre-test was 24.3.

Interview responses from learners in the experimental group pointed to learners' inability to comprehend most of the words that were in the test. The learners' academic performance in the post- test was however different. Those in the experimental group performed way better than the control group.

Recommendation 1:

- The DoE can introduce a new subject in schools which will teach English in the context of Physics, for example English for Physics Learners. The activities enshrined in the subject will be science related. This can help improve learners' scientific literacy from a different perspective and using a different approach.

Recommendation 2:

- The DoE can extend ANA examinations up to grade 11 level, including all grades instead of the current position where only grades 3, 6, and 9 sit for the examinations. This will help teachers identify literacy gaps and needs, especially on the literacy rates of Physics learners. The ANA examinations can also focus on CALP skills rather than focusing just on BICS. Consequently, teachers will be able to identify if their Physics learners are able to cope with the demands of English language as LoLT.

Recommendation 3:

- Schools to engage in language development activities to promote learners' proficiency in the LoLT encouraging Physics teachers to do away with the belief that language in the Physics classroom will automatically take care of itself. Teachers should try to narrow the language gap in the subject by designing language activities suitable for their Physics classes.

The inclusion of such language strategies in Physics might assist learners in understanding the Physics concepts better. Further, schools can tease out the content- language relationship by including separate components for demonstrating writing structure, vocabulary use, communicative competence, and interactive competence, as proposed by Lyon et al. (2011).

Research subquestion 2: To what extent can Southern Sesotho be used as a medium of instruction in the teaching/learning of Physics to grade 11 learners?

Finding 2:

Learners in the experimental group were taught in their home language (Southern-Sesotho). These learners were also given a dictionary that had Southern Sesotho translations and/or explanations for some Physics words found in the topic under discussion (Mechanics). When they wrote the post- test all 20 learners passed the test with an average of 46.75% (compared to 22.7% for the pre- test). During the interviews the learners attributed their high academic performance to the use of their home language (Southern- Sesotho) as the language of learning and teaching.

Recommendation 1:

- DoE to promote the use of learners' home language in Physics lessons in all schools across the country and staff develop teachers on this aspect. DoE can also develop and/or assist in the development of Physics learning materials in learners' home language.

Recommendation 2:

- Colleges of Education at various universities to teach importance and use of multilingualism to Physics education students. This will make the future teachers understand and realise that the use of learners' home language in Physics is effective in increasing the scientific vocabulary pool of Physics learners which favours a positive schooling experience and enhances their academic performance in the subject area.

Recommendation 3:

- Physics teachers to adopt and encourage translanguaging in Physics lessons where learners are allowed to use a language they have high proficiency in. The use of translanguaging approaches during Physics lessons disorganises ethno- linguistic divisions and separatist ideologies of the past and creates optimal opportunities for pedagogy of integration, which liberates historically excluded languages and affirms maximum concept comprehension by multilingual learners (Creese & Blackledge, 2010; Makalela, 2015).

Recommendation 4:

- The Physics teacher can develop and use materials written in both the learners' home language as well as the LoLT. Teachers can situate assessments in a context relevant to learners' home language and cultural orientation, thus incorporating language and culture, as opposed to controlling it.

Also, by understanding the particular Physics learner context, such as the learner's LoLT proficiency, teachers can unearth particular challenges LMis might face and find ways to scaffold language so that the challenges become opportunities. For example, the Physics teacher can scaffold learners' writing of common scientific genres such as experimental reports.

5.6 AVENUES FOR FURTHER RESEARCH

- Future study using a longitudinal design could shed more light on the relationship between language and academic achievement of Southern

Sesotho Physics learners. Further research will hopefully also clarify the relationship between the use of African languages in conjunction with a different LoLT and learners' academic achievement in Physics. Research on translanguaging, and use of translanguaging strategies in Physics is still in its infancy and should be pursued further.

- Further research is also suggested on the use of Southern- Sesotho in setting up examination papers and other assessment tasks.

5.7 CONCLUDING REMARKS

The present study adds to the limited research on the role language plays in the academic performance of Physics learners in South Africa, in particular those whose home language is Southern Sesotho. The study unveiled the demonstrated importance of language particularly when Physics learners speak a different home language than the language of instruction.

The finding that home language plays a significant role in learners' academic achievement in Physics confirms the theoretical assumption that learners whose home language is different from the LoLT experience difficulties in trying to attain the same performance levels as those learning Physics in their home language. The study further unearthed a high degree of identity investment realised through the use of learners' home language in Physics.

The differential mean gain between the control and experimental groups in the post-test was evidence of how much LMi learners are disadvantaged when the Physics teacher sticks to a LoLT which the learners have a low proficiency in. As stated earlier in this report, a good teacher is one who when his/her learners exhibit a blank stare then the teacher adjusts the lesson accordingly. When intervention was given to the experimental group the learners' academic achievement in the post- test was better than that of the control group which stuck to the use of a LoLT which they had low proficiency in.

Conclusively, the findings in this study are in line with previous research which exhibit the challenges faced by LMi learners in Physics, and it also came to light that African languages, in particular Southern Sesotho can be brought into the learning process as a scaffold and enhance the learners' academic achievement in Physics.

After the control group was given the interevntion when the research was over, the researcher gave them the post- test and this time all of them passed it and the group's mean rose from 34% to 44% confirming the importance of language in Physics education.

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APPENDIX A

English- Southern Sesotho Physics dictionary

Grade 11

Topic: Mechanics

“If you talk to a man in a language he understands, that goes to his head. If you talk to him in his language, that goes to his heart,” Nelson Mandela.

“Ha o bua le motho ka puo a e utwisisang, sena se ya hlohong ya hae. Empa ha o bua le yena ka puo ya hae, sena se ya pelong ya hae” Nelson Mandela.

By E. Charamba

Word (English)**Translation (Southern- Sesotho)**

<i>Accelerate</i>	<i>phakisa; akofisa</i>
<i>Accident</i>	<i>kotsi e, sewelo, kotsi</i>
<i>Accidentally</i>	<i>ka tshohanyetso</i>
<i>Accurate</i>	<i>nepahetseng</i>
<i>Addition</i>	<i>keketso</i>
<i>Against</i>	<i>kgahlanong le</i>
<i>Analyse</i>	<i>mandla; hlopholla</i>
<i>Angle</i>	<i>sekgutlo; huku</i>
<i>Answer</i>	<i>karabo</i>
<i>Apply</i>	<i>sebedisa</i>
<i>Approximate</i>	<i>akanyang</i>
<i>Arrow</i>	<i>motsu</i>
<i>Arrows</i>	<i>metsu</i>
<i>Average</i>	<i>mahareng</i>
<i>Balance</i>	<i>botsitso</i>
<i>Balanced equation</i>	<i>tekanyo e lekanang</i>
<i>Below</i>	<i>tlasa</i>
<i>Black</i>	<i>tse ntsho; e ntsho; bobotsho; se setsho</i>
<i>Blue</i>	<i>e tala; bobotala</i>
<i>Cable</i>	<i>mohala</i>
<i>Calculation</i>	<i>manolotsoeng, bala</i>
<i>Change</i>	<i>tjhentjhe; phetoho; fetolwa; fetoha</i>
<i>Choice</i>	<i>boikgethelo</i>
<i>Circular</i>	<i>lengolo la potolohang</i>

<i>Classify</i>	<i>hlophisa</i>
<i>Collide</i>	<i>thulana</i>
<i>Compare</i>	<i>bapisa; tshwantsha; lekanya</i>
<i>Conclusion</i>	<i>qeto</i>
<i>Conclusions</i>	<i>diqueto</i>
<i>Consecutive</i>	<i>latellanang</i>
<i>Conservation</i>	<i>paballo</i>
<i>Contact</i>	<i>kopana; amana; kamano</i>
<i>Decelerate</i>	<i>ho theolalebelo</i>
<i>Decimal point</i>	<i>kgutlotesimale</i>
<i>Define</i>	<i>hlalosa</i>
<i>Demonstrate</i>	<i>bontsha</i>
<i>Dependent</i>	<i>hlokang</i>
<i>Depict</i>	<i>tshwantsha</i>
<i>Diagrams</i>	<i>lifoto</i>
<i>Dimension</i>	<i>ditekantsho</i>
<i>Direction</i>	<i>nqa</i>
<i>Directions</i>	<i>ditaelo</i>
<i>Directions</i>	<i>dinqa</i>
<i>Distance</i>	<i>bohole; sebaka</i>
<i>Division</i>	<i>lekala</i>
<i>Draw</i>	<i>tshwantsha; ntsha; hula</i>
<i>Earth</i>	<i>lefatshe</i>
<i>East</i>	<i>botjhabela</i>
<i>Eastern</i>	<i>botjhabela</i>
<i>Electricity</i>	<i>motlakase</i>
<i>Endothermic</i>	<i>e nkamotjheso</i>

Energy.....matla, mokoka
 Enlarge.....hodisa
 Equations.....ditekanyo
 Example.....mohlala
 Examples.....mehlala
 Exothermic.....e fana ka motjheso
 Express.....bontse, hlahisa
 Fact.....nnete
 Fatalities.....dikotsi
 Figure.....setshwantsho
 Five.....hlano
 Flash.....mmane
 Force.....susumetsa; matla; hapeletsa
 Four.....nne
 Freezing point.....ntlha ya leqhweng
 Graph.....kerafo
 Gravitational potential energy.....khohelibokgonibamatla
 Gravity.....ntho e o hulelangfatshe
 Green.....tse tala; se tala
 Heat energy.....eneji ya motjheso
 Heavy.....boima
 Hour.....hora
 Hours.....dihora
 Illustrate.....tswantsha

 Illustration.....setshwantsho
 Improve.....lokisa

<i>Independent</i>	<i>boipuso</i>
<i>Indicate</i>	<i>supa</i>
<i>Interpret</i>	<i>toloko</i>
<i>Investigate</i>	<i>batlisisa</i>
<i>Investigation</i>	<i>patlisiso</i>
<i>Investigation</i>	<i>etsa lipatlisiso</i>
<i>Investigations</i>	<i>dipatlisiso</i>
<i>Kinetic energy</i>	<i>eneji ya motsamaobobedi</i>
<i>Large</i>	<i>holo</i>
<i>Length</i>	<i>bolelele</i>
<i>Light/lamp</i>	<i>lebone</i>
<i>Mass</i>	<i>boima</i>
<i>Mechanical energy</i>	<i>eneji ya motjhini, matlaphethamolao</i>
<i>Metal</i>	<i>tshepe</i>
<i>Minute (time)</i>	<i>motsotso</i>
<i>Minutes (time)</i>	<i>metsotso</i>
<i>Move to</i>	<i>fallela</i>
<i>Move</i>	<i>rea sisinyeha; treka; sutha; sisinyeha; falla</i>
<i>Multi-flash</i>	<i>ntho e mabone a mangata</i>
<i>North</i>	<i>leboya</i>
<i>Object</i>	<i>ntho</i>
<i>Objects</i>	<i>dintho</i>
<i>Occur</i>	<i>etsahala</i>
<i>Off-ramp</i>	<i>mmilao kgelohang On-</i>
<i>ramp</i>	<i>ho o mong</i>
<i>Opposite</i>	<i>tse satshwaneng ka bong</i>

Parallel (be...)	bapile Parallel
(become)	bapa
Parallel	thapallo
Penetrate	phunyeletsa
Physical quantity	mangata 'meleng
Point	ntlha, supa
Position	boemo, bodulo, sebaka
Precaution	ditlamora
Predict	porofeta
Prediction	boporofeta
Pull down	qhaqha
Pull	hula
Push	sututsa; susumetsa
Question	potso
Rectangle	kgutlonne
Red	tse kgubedu; se sefubedu; o mofubedu
Refer	lebisa
Reflection	seipone
Regarding	ha e le
Relationship	kamano
Represent	emela
Resistance	kganetso
Rotate	dikolosa
Scalars	ke ntho e nang le boholo le bonyanefeela
Scale	sekala
Second (time)	motsotswana

Seconds (time).....	metsotswana	Separate
from (to...).....	kgaohanya	
Separate.....	arohaneng; arohana	
Shape.....	sebopeho	
Slide.....	thella	
Small.....	e nyenyane, se senyane	
South.....	borwa	
Speed of light.....	lebelo la kganya	
Speed.....	lebelo	
Square.....	kgutlonnetsepa	
Stone.....	tlepetsa; lejwe	
Stop abruptly.....	kgiritsa	
Stop.....	tlekelele; thiba; kgekgenene; emisa; ema	
Three dimensional.....	mahlakoremararo	
Three.....	tharo	
Triangle.....	kgutlotharo	
Two dimensional.....	mahlakoremabedi	
Two.....	pedi	
Unit of length.....	yuniti ya bolelele	
Unit.....	motso	
Vectors.....	ke ntho e nang le tsela (direction) le boholo kappa bonyane	
Vehicle.....	sepalangwang	
Weight.....	boima	
West.....	bophirimela	
Western.....	bophirimela	

White.....tse tshweu; o mosweu; le
lesweu; e mesweu

With reference to.....mabapi le; ha e le

APPENDIX B

Interview responses: Experimental group

Question 1

How do you feel about your performance in the 3 tests?

Learner 1

The **last test was the best** for me. I **did quite well** in that one. The **first and second were really difficult for me.**

Learner 5

The **first two were difficult [English Proficiency and pre-test]** but **the third one was o.k.** I feel disappointed because I expected to do well in all the tests.

Learner 11

I **aced the last one** [laughs] but the **first and second were like University material.** I feel like I wasn't prepared enough.

Learner 16

The first two tests were confusing and difficult. I did badly in both and feel like forgetting about them. **The easiest was the last one.**

Learner 17

The **last one was the best of them all.** I **hammered it on the head** [laughs]. If only all tests could be like that. I feel the **English Proficiency one was difficult.**

Learner 29

The **second test was the hardest.** The **last one was pap and fleece** [laughs]. If all tests could be like that. **The first one was also difficult.**

Learner 34

The **second test, umm, it hit me hard.** **The last one was the easiest.** The **first one, eish, sekhoa, but it was fair.**

Learner 43

I feel the **first test was fair,** **the second one (points thumb to the ground),** the **third one was monnate.**

Learner 48

I liked the last one. I could understand the questions clearly. The first and the second were actually difficult and the language used in them, eish, was deep and too scientific.

Learner 55

I feel I did well in the last one because it was easy. The English test and the one on Force were tough really.

Learner 59

The Proficiency test was fair and the last one was very easy. It was the second test that gave me problems. It was too complicated and I couldn't understand the language. It was difficult for sure.

Learner 65

They were difficult, difficult, easy in that order. Whoever set the last test really wants us to pass. I feel betrayed by the first two tests.

Learner 68

I enjoyed writing the first and third tests because I think both were easy. The second one was out of my league [laughs].

Learner 72

I would give the first one a 3/10, the second one, ummm, a 2/10 and the last one a 7/10. In my view the first two tests were more than challenging.

Learner 76

I felt great. The tests were really challenging but all of them were easy.

Learner 85

The person who set the first test is a cool guy because his test was, eh, average. The coolest dude is the one who set the last one, I understand it and did well. It was easy. The second test was average.

Learner 86

I feel terrible. The first two tests were pretty challenging and difficult for me. The last one was great, I understood the work. It was actually easy [sighs].

Learner 91

I feel I could re-write the third test over and over again. It was easy. The first and second ones [sighs], were "the tests" [shows quotation marks with fingers]. They were difficult.

Learner 93

I did well in the **easy one, the last test** of course. **The English test was fair** but the second one kicked and knocked me down [laughs]. Seriously speaking it was **difficult**.

Learner 98

All three tests were wonderful. I feel over the moon. They were actually **easy**. Thanks for the tests meneer.

Codes:

Easy

Fair/average

Difficult

Question 2

If your performance differed in the three tests what could have caused the difference?

Learner1

The use of **Sesotho in the lessons and also that dictionary** helped me a lot. My marks for the third test were higher than the other two tests because of the use of a language I fully understand.

Learner 5

I give thanks to my teacher for giving me a **dictionary in my mother tongue**. It explained words I didn't know well. I got very high marks in the third test **because of the lessons and the dictionary**.

Learner 11

My highest mark was for the last test. The lowest one [mark] was for the second test. **Using my language** in the lessons helped me a lot. I was able to understand and follow what was happening in class. My English isn't good at all so the language [Sesotho] helped me.

Learner 16

The marks were very different. I obtained very high marks in the last test. I think this was because the teacher explained the work **in my language.**

Learner 17

My marks were different. I got high marks for the last test. The teacher explained the work in **Sesotho and also gave me a dictionary** to use. This dictionary translated English words to Sesotho so it made me understand very well.

Learner 29

Ntate taught us **in Sesotho.** It made the work easy to understand. He also gave us **translations of science words.** This made my marks different from the other two tests because I got very high marks for the last test.

Learner 34

I give credit to the language used by the teacher. Even though he is the same teacher but now he was explaining in **Sesotho** and that made us understand the work very well. My best performance was in the last test.

Learner 43

I got high marks for the Mechanics Baseline test. The other two were low. What helped me was the use of **Sesotho in the Physics lessons and also the translations and explanations we got in Sesotho.**

Learner 48

My performance in the three tests was different. It's because before we wrote the last test we were taught in **Sesotho** and am sure this helped everyone including myself.

Learner 55

There was no way my performance would have been the same. English isn't my favourite subject that's why I did badly in the test. In preparing for the last test we were taught in our home language first something that didn't happen before we wrote the first two tests. Being taught in **Sesotho made me understand** the work better.

Learner 59

The marks were different, yes. This is because for the first two tests no help was given. We were taught in our mother tongue before writing the last test and that helped a lot. What made it more interesting was the fact that we were taught in **Sesotho by a Sotho teacher and also given a Physics dictionary written in Sesotho.**

Learner 65

Being taught in my language by someone who knows my language made a huge difference. He was able to explain words in **my language and also gave us dictionaries to use which are written in our language.**

Learner 68

My best performance was in the last test. I understood the work better because I was taught in **Sesotho and being given that small dictionary written in Sesotho** contributed to my good performance.

Learner 72

My performance was different. I scored very high marks in the Mechanics Baseline test. It's a topic I understood well and it's easy to me. I **studied very hard** for the test.

Learner 76

My performance obviously differed. My lowest mark was for the second test. The questions were tricky and the language difficult. However I did well in the last test. The teacher explained the work I didn't understand in **my mother language and also gave us a dictionary written in my language [Sesotho].**

Learner 85

For difficulty words I kept on checking them up in **the dictionary** the teacher gave me [laughs]. That helped me a lot and made me score high marks in the last test. My marks for the first two tests were low because I didn't have anything to help me and the teacher had taught us in English only.

Learner 86

We must be taught all lessons in **Sesotho** [laughs]. That is why I obtained the highest marks in the last test. The first and second tests, eish, the marks were not that good especially the second test. **Using my mother tongue** really helped me.

Learner 91

There was great difference in my performance in the three tests. I did best in the last test. I think it was **the dictionary** that kind of helped me because I kept on referring to it for translations of words I didn't know.

Learner 93

The difference in my performance was caused by the fact that we were taught first in our own language before we wrote the last test. The teacher tried to explain some of the work **in Sesotho and it sort of helped me as well as the dictionary** I was given by sir.

Learner 98

My performance was different throughout. The lowest was in the second test. I **studied hard** for the tests especially the last one that's why I got [a] very high mark.

Codes:

Studied hard

Use of Southern Sesotho during lessons

Use of English- Southern Sesotho Physics dictionary

Use of both Sesotho and the dictionary

Question 3

Comment on the lessons you received during the study.

Learner 1

The lessons were **really interesting**. We got to be taught in my language that made me understand very well. They were good actually.

Learner 5

Wow! For the first time in high school i was taught in Sesotho. I wish this could happen everyday. This is **helpful** because the teacher explained difficult words in my language.

Learner 11

They were **good and interesting**. I learnt a lot and understood most of the work due to the translations we got and being taught in Sesotho also.

Learner 16

They were short, **interesting and good**.

Learner 17

Meneer taught us in Sesotho. This made me understand the terms clearly. However i wish they [lessons] were held during school hours. This was kind of **helpful** and should be extended to all students.

Learner 29

I learnt a lot. He [the teacher] was able to explain the work clearly and went to the extent of using our mother tongue.

Learner 34

Interesting actually. I understood the topic quite well. All difficult topics should also always be taught in Sesotho. If our examination papers were also written in Sesotho we would definitely pass.

Learner 43

I enjoyed every single one of them. I can still remember what I learnt though I can't explain it in English [laughs].

Learner 48

We must be exposed to more studies like this one because it was interesting. We actually had an interesting time getting a chance to learn in our mother tongue. This means a lot to us and helps all students understand the work.

Learner 55

The lessons were all good. I learnt a lot, actually more than I had in the past six months combined. The teacher was on fire [laughs], even teaching us in Sesotho.

Learner 59

I enjoyed them. They [lessons] were beneficial in the sense that I understood the topic. This thing of explaining to us in Sesotho helped me a lot as I am not good in English.

Learner 65

The explanations from the small dictionary helped me. This became more interesting when the teacher was now teaching us in Sotho. I learnt a lot.

Learner 68

I think the lessons helped quite a lot of us. We are from the *kasi* and our English is not good at all. The English we speak on the street is different from the one in our Physics textbooks therefore being taught in a language you understand is quite good and really helpful.

Learner 72

They were fine. The use of my mother tongue assisted me a lot. You know some of these words are difficult to understand so if they are explained in your mother language it then makes sense.

Learner 76

Fabulous. I personally need more Physics lessons in Sotho and dictionary for all the topics. After the lessons I realised that **Physics is not as difficult as people** say it is.

Learner 85

I would say they were fine. The teacher tried to make us understand by even explaining some of the work in Sesotho and gave us a dictionary he had prepared and this made it **interesting**. The dictionary was however small and focused on one topic only.

Learner 86

My groupies and I enjoyed. For once we were allowed to use our mother language in a Physics class. Even the teacher also taught us in Sesotho. **It was interesting and helped us understand the topic better.**

Learner 91

They **were good**, sir. My suggestion is that we should be re-taught all Physics topics we have done so far in Sesotho. We must also be given similar dictionaries for all subjects and the topics.

Learner 93

Great. I liked them. *Ntate* made the lessons **exciting**. He broke the school rule and taught us in Sesotho. This was an A for him. **I understood everything.**

Learner 98

They were fine. We were taught one topic for all lessons and the teacher tried to make us understand by explaining in Sesotho. He also gave us dictionaries to use and this kind **of helped** us prepare for the Mechanics test.

Codes:

Interesting

Helpful

Interesting and helpful

Question 4

Did you find the English- Southern Sesotho Physics dictionaries useful?

Learner 1

It **was very useful** indeed.

Learner 5

I would definitely say the dictionary was **useful**. There were some words I didn't understand their meanings.

Learner 11

Not really. I wouldn't say it was useful at all.

Learner 16

You kidding me! It **was very useful** indeed. I will keep it for good.

Learner 17

I wouldn't ask for any thing more. The dictionary was **more than useful**. That topic is difficult and has confusing words which I didn't know what they meant.

Learner 29

To some extend, **yes it was**.

Learner 34

I wouldn't really say it was at all. I know most of those words that were in the dictionary.

Learner 43

Indeed! It was. I really appreciate the effort our teacher put in to try and make us understand.

Learner 48

It helped me understand some of the words I didn't know, so I would confidently say **yes**.

Learner 55

I really am glad I got it [the dictionary]. It helped me understand some of the vocabulary that was used in the test. I would therefore say it was **very useful**.

Learner 59

It [dictionary] rocked. I didn't struggle with the meanings of words at all. It was **very useful**.

Learner 65

It helped me ace the last test. I wish I had similar dictionaries for the first two tests, my parents would have been very proud of me. It really was **useful**.

Learner 68

That dictionary **was excellent**. All difficult words were translated there and some even explained. We are normally given those difficult words and asked to google their meanings.

Learner 72

It was actually **useful**. It assisted me understand some of the words I didn't know their meanings.

Learner 76

Yes it was **useful**. It made my preparation for the test easier. I didn't need to study because I had already understood all the work.

Learner 85

My feeling is that the department [DoE] must give us dictionaries in our mother tongue for all subjects. They help us understand the work better. This one was very, **very useful**. We can also have work sheets for those difficult topics written in our language.

Learner 86

It definitely was useful, **very useful** actually. I don't know what mark I would have got without it because the test was very challenging.

Learner 91

Personally I found the dictionary **extremely useful**. It translated words whose meanings I didn't know into my mother language. Words such as velocity, acceleration, constant rate, vector quantity to name but a few were translated and explained well.

Learner 93

Yaah, it was to say the least. It appeared at a time when I thought I was drowning in my Physics work. I had almost given up but the dictionary restored my hope. It made me see things in a different perspective. I would give it **a 9/10**.

Learner 98

The dictionary I was given was **very useful** for that topic. It helped me get through my work and understand the topic very well.

Codes:

Not useful

Useful

Very useful

Question 5

Which language do you think is the best for you to learn Physics in?

Learner 1

I would prefer **Sesotho**. I also wish examinations could be in Sesotho.

Learner 5

I am proudly **Sothoso I would vote for my language**. Considering what I experienced during the Physics lessons that were taught in Sesotho, it's possible to be taught in Sesotho and understand better than when I am taught in English.

Learner 11

The best is **English** because it's an international language so yes I would want to be taught in that language and be like those students from the city and boarding schools.

Learner 16

After the lessons we had I think **Sesotho** is the best. It [Sesotho] made me understand the work fully.

Learner 17

Though I am Sotho speaking, I did my primary at a Pedi speaking school and was exposed to that language from an early age. Therefore I **would go for Sepedi**.

Learner 29

English is the best language. Everyone speaks it and our Physics books are also written in English. We also write examinations in English hence I would **go for English**.

Learner 34

The Sesotho dictionary helped me understand the work. Even though it's Physics I still want **to learn it in Sesotho** because I understand it and it's easy to use. Looking at the lessons and dictionary we had in Sesotho I think the school should provide us with more materials in Sesotho.

Learner 43

I want to be taught in Sepedi. I grew up staying with my granny and that's the language we were using. I like it and it gives me a sense of belonging.

Learner 48

Meneer gave us good Physics lessons in Sesotho so yes there is no way I wouldn't vote for that language. The other thing is that that's my mother tongue and it gives me joy learning in my own language than a foreign one.

Learner 55

English. It's the cool language but to understand things better in class I would say Sesotho.

Learner 59

After those Physics lessons that were taught in Sesotho, I think that's the language that makes me understand the work perfectly well.

Learner 65

I understand better if someone explains to me in my mother tongue, and that's Sesotho. So that's the language I want to be taught in.

Learner 68

Well I understand we have 11 official languages and it will be fair if I could be taught all subjects in Sesotho and also have books and tests in that language. Mr Zuma [the South African president] must allow us to learn in our mother tongue and get books written in that language.

Learner 72

The lessons and that dictionary were an eye-opener for me. I realised I can learn and understand Physics in Sesotho. In this case I think Sesotho is the best language for me.

Learner 76

The whole world say it's English so I will also say English. You should flow with the tide you know [laughs].

Learner 85

One's everyday language is the best. I would love to be taught in Sesotho if it's possible *ntate*.

Learner 86

I understand better and feel honoured if someone talks to me in my mother tongue. The other thing is that I understood a lot when we were taught Physics in Sesotho. **Therefore I would confidently say Sesotho.**

Learner 91

Sesotho rocks. It's my mother tongue. I like it and understand it. I wish the whole school could be taught in **Sesotho.** I don't see the reason why we should be taught in English by our own Sesotho speaking teachers. These same teachers speak to us in Sesotho outside classes, so why not in class also?

Learner 93

Sesotho. I have no reason but I just understand it better than English.

Learner 98

The world is changing and we are now a global village. Even people in China are now going for English. But I still think that us students we understand better when **we are taught in our mother language so I would say for me Sesotho is the best.**

Codes:

English

Sepedi

Southern Sesotho

Question 6

Do you think being taught Physics in your home language makes any academic difference?

Learner 1

Yes I do. That's why I scored higher marks for the last test unlike in the first two tests.

Learner 5

Being taught in **my home language makes me feel appreciated and it also makes me understand the work better.**

Learner 11

It surely does. I was able to understand the topic that I was taught in Sesotho better than all topics I was taught in English.

Learner 16

South Africa has eleven official languages so we should be given a chance to choose the language I want to be taught in. No language in this country should be seen as inferior to others **so, yes, being taught in my home language** motivates me and makes me get high marks in class because I understand better in my language.

Learner 17

I get to understand the work. It [the work] becomes easier and more clear to me hence **I would say yes being taught** in my home language makes academic difference because my marks will improve as they did in the last test.

Learner 29

Yes I think so. If I compare my performance for the three tests I did really well in the last one after we had been taught Physics in Sesotho which happens to be my home language. There is also pride in using one's own language unlike using these borrowed ones from overseas which are even difficult to understand.

Learner 34

Idon'tthinkso because the books and tests are written in English and Afrikaans. All we need to do as students is to practice English harder as we are being taught in that language.

Learner 43

In my opinion one's mother language makes you **understand properly and clearly** unlike being taught in another language. We are Sothos and must be proud of our language. I therefore say Sesotho is the best language for me.

Learner 48

Yes.The lessons meneer taught us in Sesotho, I still remember everything. It also made me be able to find the test easy and *meneer* is not ashamed of being Sotho. If only all teachers and schools could recognise our languages that will be excellent.

Learner 55

I found the last test easier than the first two because in preparing for it we were taught in our home language and we were also given Physics dictionaries written in our home language. **This helped us greatly and we are proud of the dictionaries written in our own language.**

Learner 59

Being taught in my home language surely helped me a lot. I was able to understand everything and for the words I had forgotten what they meant I looked them up in the

Physics dictionary which I had been given by the teacher. The dictionary was also written in my home language.

Learner 65

Not at all. All we need to do is study hard. The department [DoE] gave us textbooks and qualified teachers therefore we should not complain at all. We need education in a language that is recognised internationally.

Learner 68

In my case it surely did. I was able to get high marks after being taught in Sesotho which happens to be my home language. The lessons were also interesting and the fact that I got a chance to be taught in my own language motivated me and made me proud.

Learner 72

Definitely it does. My groupies and I found the last test to be easy because we had been taught in our own language. You see the problem is that we don't understand English well so our own language makes a huge difference. I am proudly Sotho.

Learner 76

If someone speaks to me or teaches me in my own language I feel honoured, special and adored. This makes me want to please that person and in the process my marks get better. The problem with us the youth of today is that we are ashamed of our roots and want to associate with classy languages such as English. **So yes I would say being taught in my home language makes a huge difference in my school work.**

Learner 85

Yes sir it does. One gets to understand the work clearer and get motivated by the fact that my home language will be recognised at last instead of being taught in someone else's language.

Learner 86

I don't think so, I know so [laughs]. On a serious note, being taught in my home language makes a huge difference in my academic work. I get to understand the work, get high marks and also excited about having to use my own language in the class. It feels like real independence which some youths sacrificed for on [the] 16th of June 1976.

Learner 91

Yes I think it does. In my case I saw the fruits in the last test. After being taught in my language, Sesotho, I understood everything and found the questions easy to

answer. It also gave me joy to learn in my language unlike being taught using a language that is difficult.

Learner 93

Absolutely sir, it really does. After talking to some of my group mates I realised we all enjoyed the lessons and benefitted a lot through the use of our own language, at our school, in our country. It was an excellent thing to be done and we felt our language being honoured instead of [it] being used only during Sesotho lessons.

Learner 98

I would agree that being taught in my home language made a huge academic difference. As someone who always wants to be ahead of the class I had tried reading the topic [Mechanics] on my own but I didn't understand a thing until it was explained to me in my own language. My parents were also happy that I had been taught in our home language. It surely meant a lot to us learners and our families. It [use of one's home language] gives you a sense of belonging and pride.

Codes:

Yes/ agree

No/ disagree

APPENDIX C



PARTICIPANT INFORMATION SHEET

28th January 2016

REC Approval ref: 2016/04/13/48166413/08/MC

Title: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

Dear Prospective Participant

My name is Erasmus Charamba and I am doing research with Prof A.T. Motlhabane, a professor in the Department of Science and Technology Education towards a DEd at the University of South Africa. We are inviting you to participate in a study entitled Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to find out if language is a contributing factor to the academic performance of Southern Sesotho learners who are taught Physics through a language different from their home language. The research will seek to establish if Southern Sesotho learners can perform better academically if they are taught Physics in their home language while also using English- Southern Sesotho Physics dictionaries on a selected topic.

WHY AM I BEING INVITED TO PARTICIPATE?

You were chosen to participate in this study because you are in Grade eleven (11), taking Physics as one of your subjects and also your home language is Southern Sesotho. I obtained this information about you from your school principal.



There will be approximately forty (40) Grade eleven (11) Southern Sesotho Physics learners taking part in the study, from two different high schools in the Fezile- Dabi district. There will also be an equal number of boys and girls in each of the two groups.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

All participants will write an English language proficiency test to determine the level of their command of the language. Participants will then write a Physics pre-test. Afterwards participants will be drawn randomly into one of the two groups (the experimental or the control group).

Those in the control group will be taught concepts found under the topic Mechanics in English language while those in the experimental group will be taught the same concepts in English and Southern Sesotho languages, as well as being allowed to use English- Southern Sesotho dictionaries during lessons and revision sessions.

All forty (40) participants will then write the same test based on the topic learnt to determine their mastery of the concepts learnt. The lessons and tests are expected to last about four weeks. Participants in the experimental group will also be interviewed on their experiences in the lessons as well as with the dictionaries they were using. Six interview questions will be asked:

- (1) How does your performance in the three tests relate?
- (2) If the performance differed what could have caused the difference?
- (3) Comment on the lessons you received during the study.
- (4) Did you find the dictionaries useful? Comment on your answer.
- (5) Which language do you think is the best for you to learn Physics in?
- (6) Do you think being taught Physics in your home language makes any academic difference?
Provide reasons for your answer.

The interviews are expected to last twenty minutes per participant.

CAN I WITHDRAW FROM THE STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. There is no penalty or loss of benefit for non- participation.



WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

By participating in the study, whether you will be in the experimental or control group, all grade 11 Physics learners will get to be taught Physics in their home language (experimental group during the study, and the rest at the end of the study) and will all be given an English- Southern Sesotho Physics dictionary to keep.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The lessons will be conducted during the afternoon (after school) so as not to disrupt the smooth running of the schools. This might take some of your free time and might result in you missing your normal transport home. However money will be available for you to make alternative transport arrangements.

All participants will be referred to using numbers ranging from 01 to 40 hence no one will be able to link a number to a name or any responses to a participant's name. No names will be used during the study and no one will be able to know the names of any participants.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. You will be given a code (numbers ranging from 01 to 98) and you will be referred to in this way in the data, any publications, or other research methods such as conference proceedings.

Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report. Numbers representing participants will be used and not individual names.



HOW WILL THE RESEARCHER PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked filing cabinet at the researcher's office, at number 205 Vaal Property, Lethabo Power station, Vereeniging in South Africa, for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After the five years hard copies will be shredded and electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

Since the study will be conducted in the afternoon and you will have missed your normal transport home, money to pay for your alternative transport will be provided.

All material you will have used during the study including the English- Southern Sesotho Physics dictionaries will be given to you for free.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

The study has received written approval from the Research Ethics Review Committee of the College of Education, Unisa (Ref 2016/04/13/48166413/08/MC). A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS /RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Erasmos Charamba, on +2778 546 1420 or email erasmuscharamba@live.com or fax 016 457 2013. The findings are accessible for 2 years. Should you require any further information or want to contact the researcher about any aspect of this study, please contact Erasmos Charamba on +277 8546 1420 or email erasmuscharamba@live.com or fax 016 457 2013. Should you have concerns about the way in which the research has been conducted, you may contact Professor A.T. Motlhabane on +27 124 29 2840 or email motlhat@unisa.ac.za. Alternatively, contact the research ethics chairperson of the College of Education, Dr Madaleen Claassens on mcdtc@netactive.co.za

Thank you for taking your time to read this information sheet and for participating in this study.

Thank you.

Erasmos Charamba

CONSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the interview.

I have received a signed copy of the informed consent agreement.

Participant Name and Surname (please print)

Participant Signature

Date

Researcher's Name and Surname (please print) ERASMOS CHARAMBA

Researcher's Signature

Date

APPENDIX D



Title of study: Language as a contributing factor to the performance of Southern Sesotho Physics learners.

REC ref: 2016/04/13/48166413/08/MC

INTERVIEW ASSENT AND CONFIDENTIALITY AGREEMENT

I _____-grant consent/assent that the information I share during the interview may be used by Erasmos Charamba, for research purposes. I am aware that the interview discussions will be digitally recorded and grant consent/assent for these recordings, provided that my privacy will be protected. I undertake not to divulge any information that is shared in the discussions to any person in order to maintain confidentiality.

Participant's Name (Please print) _____

Participant's signature: _____

Researcher's Name (Please print): ERASMOS CHARAMBA

Researcher's signature: _____

Researcher's contact details: erasmuscharamba@live.com, Cell number +277 8546 1420

Date: _____

Supervisor's Name: Prof A.T. MOTLHABANE

Supervisor's contact details: motlhat@unisa.ac.za, Telephone 012 429 2840.

REC ref: 2016/04/13/48166413/08/MC

If you are an adult who gives permission you **consent** then delete assent.

If you are a learner who gives permission you **assent** then delete consent.

APPENDIX E



LETTER REQUESTING ASSENT FROM LEARNERS IN A SECONDARY SCHOOL TO PARTICIPATE IN A RESEARCH PROJECT

REC ref: 2016/04/13/48166413/08/MC

Title of study: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

Dear.....

I am doing a research on Language as a contributing factor to the academic performance of Southern Sesotho Physics learners, in which I want to find out if one's home language does affect their academic performance in Physics, as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special part of my study. I am doing this study so that I can find ways that your teachers can use to teach Physics better. This will help you and many other learners of your age in different schools.

This letter is to explain to you what I would like you to do. There may be some words you do not know in this letter. You may ask me or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

I would like you to write three tests (one on English proficiency and two in Physics). I would also like to interview you (if you happen to be in the experimental group) on the effectiveness of the use of Southern Sesotho in teaching/learning Physics, as well as your evaluation of the English- Southern Sesotho dictionaries that will be given to you. The whole process should not take more than four weeks.

I will write a report on the study but I will not use your name in the report or say anything that will let other people know who you are. You do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time. You may tell me if you do not wish to answer any of my questions. No one will blame or criticise you. When I am finished with my study, I shall return to your school to give a short talk about some of the helpful and interesting things I found out in my study. I shall invite you to come and listen to my talk.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another

adult call me at +2778 546 1420. Do not sign the form until you have all your questions answered and understand what I would like you to do.

Researcher: Erasmos Charamba
erasmuscharamba@live.com.

Cell number +2778 546 1420; email

Supervisor: Prof A.T. Motlhabane

Telephone 102 429 2840; email motlhat@unisa.ac.za.

REC ref: 2016/04/13/48166413/08/MC

APPENDIX F



LETTER REQUESTING PARENTAL CONSENT FOR MINORS TO PARTICIPATE IN A RESEARCH PROJECT

Title of study: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

REC ref: 2016/04/13/48166413/08/MC

Your child is invited to participate in a study entitled Language as a contributing factor to the academic performance of Southern Sesotho Physics learners. I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to determine whether language does affect the academic performance of Southern Sesotho Physics learners and the possible benefits of the study are the improvement of the teaching of Physics in high schools. I am asking permission to include your child in this study because the child's home language is Southern Sesotho and is taking Physics as a subject in Grade 11. I expect to have 39 other children participating in the study.

If you allow your child to participate, I shall request him/her to:

- Take part in an interview (if s/he will be in the experimental group)
- Complete three tests

All children will write an English language proficiency test first. After that they will then write a pre-test in Physics. The children will then be randomly assigned to one of the groups (either the experimental or the control). Children in the control group will have their Physics lessons in English language while those in the experimental group will have their lessons in Southern Sesotho and will also be given English- Southern Sesotho Physics dictionaries to use. The two groups will then write the same post-test.

Those in the experimental group will be interviewed on their assessment of the lessons as well as the effectiveness of the dictionaries given to them. In order not to disadvantage any child, after the study all children will then be taught in Southern Sesotho and will be given Southern Sesotho Physics dictionaries as well. Lessons will be conducted after school and children will be given money to pay for their alternative transport home.

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His or her responses will not be linked to his or her name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in this study. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education are that teachers will get to know the best language to use when teaching Physics and whether a Physics dictionary in the child's home language helps improve the child's academic performance in that subject area. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly you can agree to allow your child to be in the study now and change your mind later without any penalty.

This study will take place after school with the approval of the school and your child's teacher. However, if you do not want your child to participate, an alternative activity will be available.

In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for five years after the study. Thereafter, records will be erased.

If you have any questions about this study please ask me or my supervisor, Prof A.T. Motlhabane, Department of Science and Technology Education, College of Education, University of South Africa. My contact number is +2778 546 1420 and my email is erasmuscharamba@live.com. The email of my supervisor is motlhat@unisa.ac.za and his telephone number is 012 429 2840. Permission for the study has already been given by the Free State Department of Education and the Ethics Committee of the College of Education, UNISA.

You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Name of child:

Sincerely

Parent/guardian's name (print)

Parent/guardian's signature

Date

ERASMOS CHARAMBA

Researcher's name (print)

Researcher's signature

Date

REC ref: 2016/04/13/48166413/08/MC

APPENDIX G



LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH IN FREE STATE PROVINCE

Title of study: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

REC ref: 2016/04/13/48166413/08/MC

I, Erasmos Charamba am carrying out a study entitled **Language as a contributing factor to the academic performance of Southern Sesotho Physics learners**. I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to determine whether language does affect the academic performance of Southern Sesotho Physics learners and the possible benefits of the study are the improvement of the teaching of Physics in high schools. I am asking permission to carry out this study in the Free State province, Fezile-Dabi district. The study will involve children whose home language is Southern Sesotho and are taking Physics as a subject in Grade 11. I expect to have 40 children participating in the study.

The participants are expected to:

- Take part in an interview (if s/he will be in the experimental group)
- Complete three tests

All children will write an English language proficiency test first. After that they will then write a pre-test in Physics. The children will then be randomly assigned to one of the groups (either the experimental or the control). Children in the control group will have their Physics lessons in English language while those in the experimental group will have their lessons in Southern Sesotho and will also be given English- Southern Sesotho Physics dictionaries to use. The two groups will then write the same post-test.

Those in the experimental group will be interviewed on their assessment of the lessons as well as the effectiveness of the dictionaries given to them. In order not to disadvantage any child, after the study all children will then be taught in Southern Sesotho and will be given Southern Sesotho Physics dictionaries as well. Lessons will be conducted after school and children will be given money to pay for their alternative transport home.

Any information that is obtained in connection with this study and can be identified with the children will remain confidential and will only be disclosed with the parent/guardian's permission.

The children's responses will not be linked to their names or the schools' names in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to the children by participating in this study. The participants will receive no direct benefit from participating in the study; however, the possible benefits to education are that teachers will get to know the best language to use when teaching Physics and whether a Physics dictionary in the child's home language helps improve the child's academic performance in that subject area. Neither the child nor the parent/guardian will receive any type of payment for participating in this study.

The children's participation in this study is voluntary. They may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly they can agree to be in the study now and change their mind later without any penalty.

This study will take place after school with the approval of the Department of Education and the schools. However, for those children who will not participate, an alternative activity will be available.

In addition to your permission, the child must agree to participate in the study and their parent/guardian and the child will also be asked to sign the consent and assent forms respectively. The information gathered from the study will be stored securely on a password locked computer in my office for five years after the study. Thereafter, records will be erased.

If you have any questions about this study please ask me or my supervisor, Prof A.T. Motlhabane, Department of Science and Technology Education, College of Education, University of South Africa. My contact number is +2778 546 1420 and my email is erasmuscharamba@live.com. The email of my supervisor is motlhat@unisa.ac.za and his telephone number is 012 429 2840. Permission for the study has already been given by the Ethics Committee of the College of Education, UNISA (Ref: 2016/04/13/48166413/08/MC).

APPENDIX H



LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH IN FEZILE-DABI DISTRICT

Title of study: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

REC ref: 2016/04/13/48166413/08/MC

I, Erasmos Charamba am carrying out a study entitled **Language as a contributing factor to the academic performance of Southern Sesotho Physics learners**. I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to determine whether language does affect the academic performance of Southern Sesotho Physics learners and the possible benefits of the study are the improvement of the teaching of Physics in high schools. I am asking permission to carry out this study in the Free State province, Fezile-Dabi district. The study will involve children whose home language is Southern Sesotho and are taking Physics as a subject in Grade 11. I expect to have 40 children participating in the study.

The participants are expected to:

- Take part in an interview (if s/he will be in the experimental group)
- Complete three tests

All children will write an English language proficiency test first. After that they will then write a pre-test in Physics. The children will then be randomly assigned to one of the groups (either the experimental or the control). Children in the control group will have their Physics lessons in English language while those in the experimental group will have their lessons in Southern Sesotho and will also be given English- Southern Sesotho Physics dictionaries to use. The two groups will then write the same post-test.

Those in the experimental group will be interviewed on their assessment of the lessons as well as the effectiveness of the dictionaries given to them. In order not to disadvantage any child, after the study all children will then be taught in Southern Sesotho and will be given Southern Sesotho Physics dictionaries as well. Lessons will be conducted after school and children will be given money to pay for their alternative transport home.

Any information that is obtained in connection with this study and can be identified with the children will remain confidential and will only be disclosed with the parent/guardian's permission. The children's responses will not be linked to their names or the schools' names in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to the children by participating in this study. The participants will receive no direct benefit from participating in the study; however, the possible benefits to education are that teachers will get to know the best language to use when teaching Physics and whether a Physics dictionary in the child's home language helps improve the child's academic performance in that subject area. Neither the child nor the parent/guardian will receive any type of payment for participating in this study.

The children's participation in this study is voluntary. They may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly they can agree to be in the study now and change their mind later without any penalty.

This study will take place after school with the approval of the Department of Education and the schools. However, for those children who will not participate, an alternative activity will be available.

In addition to your permission, the child must agree to participate in the study and their parent/guardian and the child will also be asked to sign the consent and assent forms respectively. The information gathered from the study will be stored securely on a password locked computer in my office for five years after the study. Thereafter, records will be erased.

If you have any questions about this study please ask me or my supervisor, Prof A.T. Motlhabane, Department of Science and Technology Education, College of Education, University of South Africa. My contact number is +2778 546 1420 and my email is erasmuscharamba@live.com. The email of my supervisor is motlhat@unisa.ac.za and his telephone number is 012 429 2840. Permission for the study has already been given by the Ethics Committee of the College of Education, UNISA (Ref: 2016/04/13/48166413/08/MC).

APPENDIX I



LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH AT A SCHOOL

Title of study: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

REC ref: 2016/04/13/48166413/08/MC

I, Erasmos Charamba am carrying out a study entitled **Language as a contributing factor to the academic performance of Southern Sesotho Physics learners**. I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to determine whether language does affect the academic performance of Southern Sesotho Physics learners and the possible benefits of the study are the improvement of the teaching of Physics in high schools. I am asking permission to carry out this study in the Free State province, Fezile-Dabi district. The study will involve children whose home language is Southern Sesotho and are taking Physics as a subject in Grade 11. I expect to have 40 children participating in the study.

The participants are expected to:

- Take part in an interview (if s/he will be in the experimental group)
- Complete three tests

All children will write an English language proficiency test first. After that they will then write a pre-test in Physics. The children will then be randomly assigned to one of the groups (either the experimental or the control). Children in the control group will have their Physics lessons in English language while those in the experimental group will have their lessons in Southern Sesotho and will also be given English- Southern Sesotho Physics dictionaries to use. The two groups will then write the same post-test.

Those in the experimental group will be interviewed on their assessment of the lessons as well as the effectiveness of the dictionaries given to them. In order not to disadvantage any child, after the study all children will then be taught in Southern Sesotho and will be given Southern Sesotho Physics dictionaries as well. Lessons will be conducted after school and children will be given money to pay for their alternative transport home.

Any information that is obtained in connection with this study and can be identified with the children will remain confidential and will only be disclosed with the parent/guardian's permission. The children's responses will not be linked to their names or the schools' names in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to the children by participating in this study. The participants will receive no direct benefit from participating in the study; however, the possible benefits to education are that teachers will get to know the best language to use when teaching Physics and whether a Physics dictionary in the child's home language helps improve the child's academic performance in that subject area. Neither the child nor the parent/guardian will receive any type of payment for participating in this study.

The children's participation in this study is voluntary. They may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly they can agree to be in the study now and change their mind later without any penalty.

This study will take place after school with the approval of the Department of Education and the schools. However, for those children who will not participate, an alternative activity will be available.

In addition to your permission, the child must agree to participate in the study and their parent/guardian and the child will also be asked to sign the consent and assent forms respectively. The information gathered from the study will be stored securely on a password locked computer in my office for five years after the study. Thereafter, records will be erased.

If you have any questions about this study please ask me or my supervisor, Prof A.T. Motlhabane, Department of Science and Technology Education, College of Education, University of South Africa. My contact number is +2778 546 1420 and my email is erasmuscharamba@live.com. The email of my supervisor is motlhat@unisa.ac.za and his telephone number is 012 429 2840. Permission for the study has already been given by the Ethics Committee of the College of Education, UNISA (Ref: 2016/04/13/48166413/08/MC).

APPENDIX J

INTERVIEW SCHEDULE



Title: Language as a contributing factor to the academic performance of Southern Sesotho Physics learners.

REC ref: 2016/04/13/48166413/08/MC

Objectives:

The objectives of this interview are:

- (1) To find out the causes in the difference in the participant's performance, if any, in the three tests.**
- (2) To evaluate the effectiveness of the lessons delivered as well as resources used.**

Interview questions:

- (1) How does your performance in the three tests relate?**
- (2) If the performance differed what could have caused the difference?**
- (3) Comment on the lessons you received during the study.**
- (4) Did you find the dictionaries useful? Comment on your answer.**

(5) Which language do you think is the best for you to learn Physics in?

**(6) Do you think being taught Physics in your home language makes any academic difference?
Provide reasons for your answer.**

Researcher's Name _____ **Date** _____

Researcher's Signature _____ **Date** _____

Supervisor's Name Prof A.T. Motlhabane

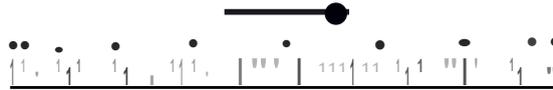
Supervisor's contact details: Telephone 012 429 2840; email motlhat@unisa.ac.za.

REC ref: 2016/04/13/48166413/08/MC

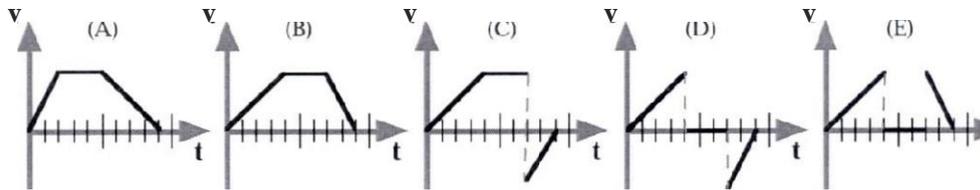
APPENDIX K: MECHANICS BASELINE TEST

Mechanics Baseline Test

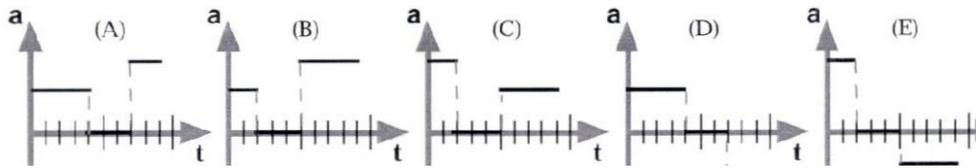
Refer to the diagram below when answering the first two questions. This diagram represents a multiflash photograph of an object moving along a horizontal surface. The positions as indicated in the diagram are separated by equal time intervals. The first flash occurred just as the object started to move and the last flash just as it came to rest.



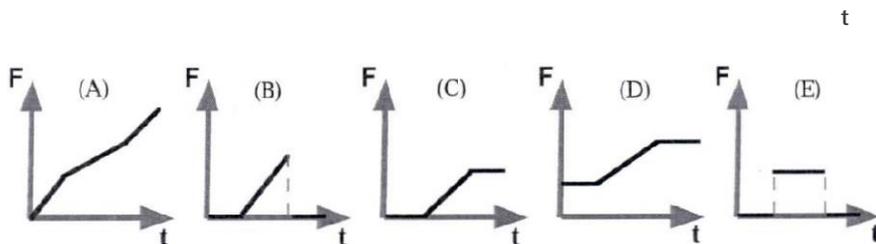
1. Which of the following graphs best represents the object's velocity as a function of time?



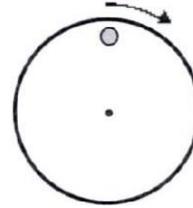
2. Which of the following graphs best represents the object's acceleration as a function of time?



3. The velocity of an object as a function of time is shown in the graph at the right. Which graph below best represents the net force vs time relationship for this object?



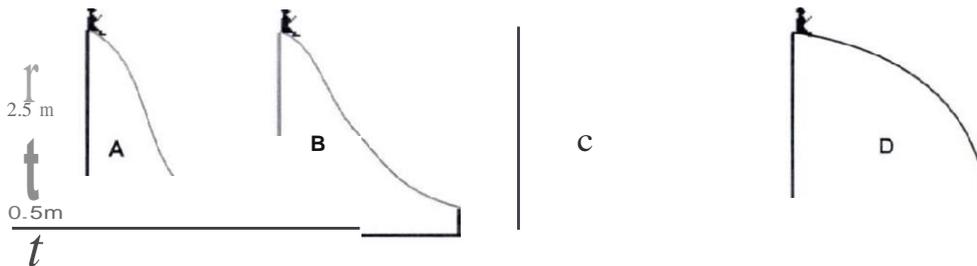
8. A small metal cylinder rests on a circular turn table, rotating at a constant speed as illustrated in the diagram at the right. Which of the following sets of vectors best describes the velocity, acceleration, and net force acting on the cylinder at the point indicated in the diagram?



- (A) \vec{v} is a horizontal vector pointing right, \vec{a} is a horizontal vector pointing left, and \vec{F} is a horizontal vector pointing right.
- (B) \vec{v} is a horizontal vector pointing right, \vec{a} is a horizontal vector pointing right, and \vec{F} is a horizontal vector pointing right.
- (C) \vec{v} is a horizontal vector pointing right, \vec{a} is a vertical vector pointing down, and \vec{F} is a vertical vector pointing down.
- (D) \vec{v} is a vertical vector pointing down, \vec{a} is a vertical vector pointing down, and \vec{F} is a vertical vector pointing down.
- (E) \vec{v} is a vertical vector pointing down, \vec{a} is a horizontal vector pointing left, and \vec{F} is a horizontal vector pointing left.

9. Suppose that the metal cylinder in the last problem has a mass of 0.10 kg and that the coefficient of static friction between the surface and the cylinder is 0.12. If the cylinder is 0.20 m from the center of the turntable, what is the maximum speed that the cylinder can move along its circular path without slipping off the turntable?

- (A) $0 < v \leq 0.5$ m/s
 (B) $0.5 < v \leq 1.0$ m/s
 (C) $1.0 < v \leq 1.5$ m/s
 (D) $1.5 < v \leq 2.0$ m/s
 (E) $2.0 < v \leq 2.5$ m/s
10. A young girl wishes to select one of the frictionless playground slides illustrated below to give her the greatest possible speed when she reaches the bottom of the slide.

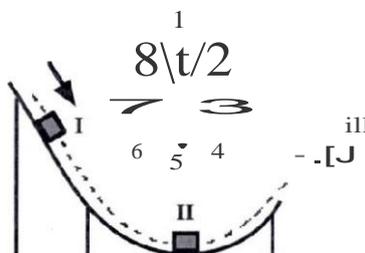


Which of the slides illustrated in the diagram above should she choose?

- (A) A
 (B) B
 (C) C
 (D) D
 (E) It doesn't matter; her speed would be the same for each.

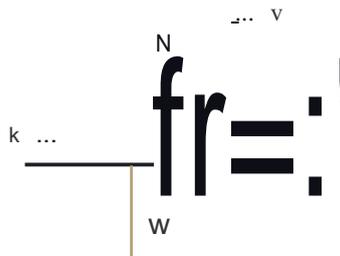
Refer to the diagram on the right when answering the next three questions.

The diagram depicts a block sliding along a frictionless ramp. The eight numbered arrows in the diagram represent directions to be referred to when answering the questions.



4. The direction of the acceleration of the block, when in position I, is best represented by which of the arrows in the diagram?
 (A) 1 (B) 2 (C) 4 (D) 5
 (E) None of the arrows; the acceleration is zero.
5. The direction of the acceleration of the block, when in position II, is best represented by which of the arrows in the diagram?
 (A) 1 (B) 3 (C) 5 (D) 7
 (E) None of the arrows; the acceleration is zero.
6. The direction of the acceleration of the block (after leaving the ramp) at position III, is best represented by which of the arrows in the diagram?
 (A) 1 (B) 3 (C) 5 (D) 6
 (E) None of the arrows; the acceleration is zero.

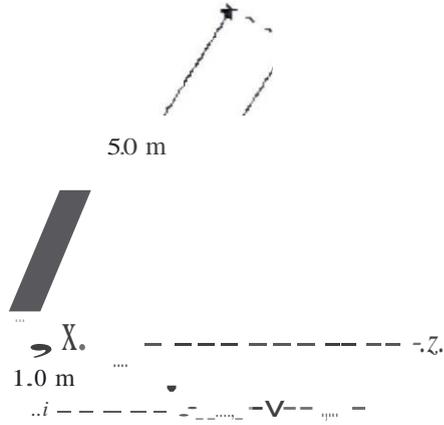
7. A person pulls a block across a rough horizontal surface at a constant speed by applying a force F . The arrows in the diagram correctly indicate the directions, but not necessarily the magnitudes of the various forces on the block. Which of the following relations among the force magnitudes W , k , N and F must be true?



- (A) $F = k$ and $N > W$
- (B) $F > k$ and $N > W$
- (C) $F > k$ and $N < W$
- (D) $F > k$ and $N = W$
- (E) None of the above choices

Refer to the diagram below when answering the next two questions.

X and Z mark the highest and Y the lowest positions of a 50.0 kg boy swinging as illustrated in the diagram to the right



11. What is the boy's speed at point Y?

- (A) 2.5 m/s
- (B) 7.5 m/s
- (C) 10. m/s
- (D) 12.5 m/s
- (E) None of the above.

12. What is the tension in the rope at point Y?

- (A) 250
- (B) 52.5 N
- (C) 7.5 x 10² N
- (D) 1.1 x 10³ N
- (E) one of the above.

Refer to the diagram below when answering the next two questions.

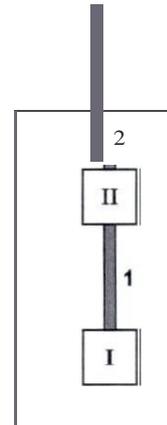
Blocks I and II, each with a mass of 1.0 kg, are hung from the ceiling of an elevator by ropes 1 and 2.

13. What is the force exerted by rope 1 on block I when the elevator is traveling upward at a constant speed of 2.0 m/s?

- (A) 2 N
- (B) 10 N
- (C) 12 N
- (D) 20 N
- (E) 22 N

14. What is the force exerted by rope 1 on block II when the elevator is stationary?

- (A) 2 N
- (B) 10 N
- (C) 12 N
- (D) 20 N
- (E) 22 N

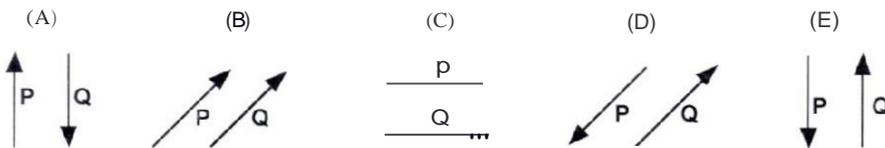


Refer to the following diagram when answering the next two questions.

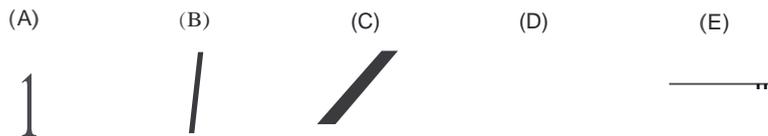
The diagram to the right depicts the paths of two colliding steel balls, P and Q.



15. Which set of arrows best represents the direction of the change in momentum of each ball?



16. Which arrow best represents the direction of the impulse applied to ball Q by ball P during the collision?



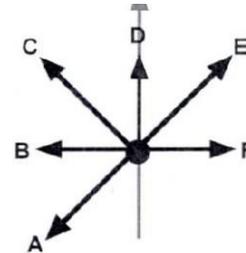
17. A car has a maximum acceleration of 3.0 m/s^2 . Which would its maximum acceleration be while towing a second car twice its mass?

(A) 2.5 m/s^2 (B) 2.0 m/s^2 (C) 1.5 m/s^2 (D) 1.0 m/s^2 (E) 0.5 m/s^2

18. A woman weighing $6.0 \times 10^2 \text{ N}$ is riding an elevator from the 1st to the 6th floor. As the elevator approaches the 6th floor, it decreases its upward speed from 8.0 m/s to 2.0 m/s in 3.0 s . What is the average force exerted by the elevator floor on the woman during this 3.0 s interval?

(A) 120 (B) 480 (C) 600 (D) 720 (E) 1200

19. The diagram at right depicts a hockey puck moving across a horizontal, frictionless surface in the direction of the dashed arrow. A constant force F , shown in the diagram, is acting on the puck. For the puck to experience a net force in the direction of the dashed arrow, another force must be acting in which of the directions labeled A, B, C, D, E?



- (A) A (B) B (C) C (D) D (E) E

Refer to the diagram below when answering the next three questions.

The diagram depicts two pucks on a frictionless table. Puck II is four times as massive as puck I. Starting from rest, the pucks are pushed across the table by two equal forces.

20. Which puck will have the greater kinetic energy upon reaching the finish line?

- (A) I (B) II

(C) Too little information to answer.

21. Which puck will reach the finish line first?

- (A) I (B) II

(C) They will both reach the finish line at the same time.

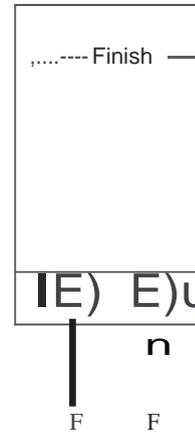
(D) Too little information to answer.

22. Which puck will have the greater momentum upon reaching the finish line?

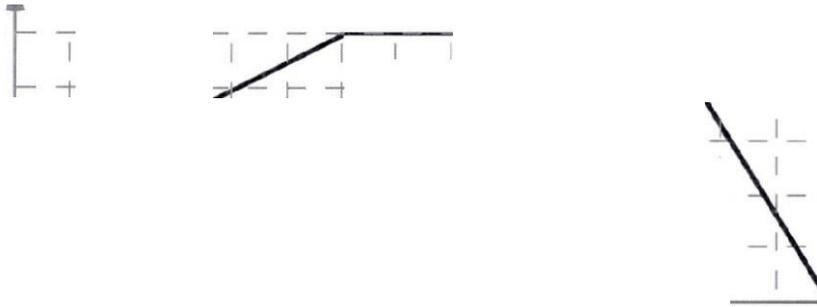
- (A) I (B) II

(C) They will both have the same momentum.

(D) Too little information to answer.



Refer to the following graph of velocity vs time when answering the next three questions.



This graph represents the motion of an object moving in one dimension.

23. What was the object's average acceleration between $t = 0$ s and $t = 6.0$ s?
 - (A) 3.0 m/s^2
 - (B) 1.5 m/s^2
 - (C) 0.83 m/s^2
 - (D) 0.67 m/s^2
 - (E) None of the above.

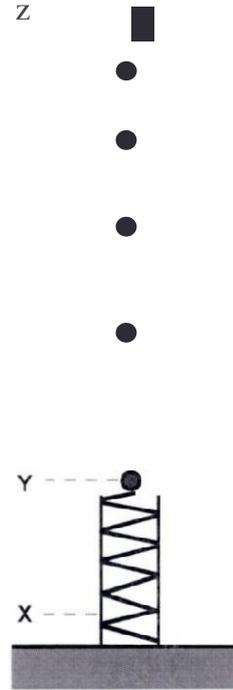
24. How far did the object travel between $t = 0$ s and $t = 6.0$ s?
 - (A) 20. m
 - (B) 11.0 m
 - (C) 6.0 m
 - (D) 1.5 m
 - (E) one of the above.

25. What was the average speed of the object for the first 6.0 s?
 - (A) 3.3 m/s
 - (B) 3.0 m/s
 - (C) 1.8 m/s
 - (D) 1.3 m/s
 - (E) None of the above.

Refer to the diagram in the right margin to answer the following question.

The figure represents a multiple-exposure photograph of a ball being thrown straight up by a spring. The spring, with the ball atop, was initially compressed to the point marked X and released. The ball left the spring at the point marked Y, and reaches its highest point at the point marked Z.

26. Assuming that air resistance is negligible:
- (A) The acceleration of the ball was greatest just before it reached point Y (still in contact with the spring).
 - (B) The acceleration of the ball was decreasing on its way from point Y to point Z.
 - (C) The acceleration of the ball was zero at point Z.
 - (D) All of the above responses are correct.
 - (E) The acceleration of the ball was the same for all points in its trajectory from points Y to Z.



APPENDIX L: ENGLISH LANGUAGE PROFICIENCY TEST

Yeditepe University
Sample Proficiency Test



USE OF ENGLISH

In questions 1 – 18, choose the correct word or phrase that best completes the sentence.

1. _____ were not placed under the government's protection disappointed many people.
a. That some historic buildings in the city centre
b. Some historic buildings in the city centre
c. Being 'historic, some buildings in the city centre
d. Some historic buildings that are in the city centre
2. France refused to admit into the country hundreds of illegal immigrants arriving from North Africa and _____
a. either did Germany
b. so did Germany
c. neither did Germany
d. nor did Germany
3. The old man managed to tell his son _____ he kept all his money only a few minutes before he died.
a. whether
b. which
c. when
d. where
4. Robin Smith's first novel enjoyed enormous success. It was first published in January and by the beginning of May it _____ over three million copies.
a. sold
b. has sold
c. was selling
d. had sold
5. Jessica and her husband have been arguing a lot recently. She wants to move to Boston but _____ in New York.
a. he'd rather live
b. he'd rather living
c. he'd rather I ved
d. he'd rather to live
6. This room is freezing cold. _____ you mind _____ the air-conditioner?
a. Would / I' llur- of'
b. Do / if llturned off
c. Would / turning off
d. Do / having turned off
7. The Prime Minister's speech caused a lot of anger and dissatisfaction among immigrants and ethnic minorities. Many officials wish he _____ that speech.
a. has never made
b. would neve- make
c. never made
d. had never made
8. If I _____ that learning Russian was going to be so difficult, I _____ that course.
a. had known / would never take
b. knew / would never take
c. had known / would never have taken
d. knew / would never have taken
9. The Johnsons _____ their luxurious house anywhere. _____ simply do not understand why they chose such a bad location.
a. must have built
b. could have built
c. can build
d. might build
10. Last time I decided to travel, I _____ my ticket _____ directly to my office. I suggest you do the same as it is really convenient.
a. have / sent
b. had / sent
c. get / send
d. got / send



11. I think my mother-in-law really appreciated _____ giving her a hand.
a. my b. I was c. mine d. from
12. Last week, the Colombian President denied _____ the imprisonment of several famous journalists.
a. to order b. having ordered
c. to have ordered d. have been ordering
13. Today, the word "emigrant" refers to a person who leaves his own country to settle in another country, _____ the word "immigrant" refers to a person who enters and settles in a new country.
a. whereas b. therefore c. in as much as d. among
14. The more he thought about the problem, _____ the solution seemed to be.
a. easier b. the easiest c. easiest d. the easier
15. I remember very clearly my mother _____ me how to write. She would spend hours writing down the letters of the alphabet one by one.
a. to teach b. to have taught
c. teaching d. teach
16. Scientists have speculated that the destruction of the Amazon Forest would _____ plants and animals to dangerous acid rain.
a. have been exposed b. have been exposing
c. expose d. be exposed
17. By the end of the course the students _____ the most important grammar structures.
a. have mastered b. will have mastered
c. have been mastering d. are mastering
18. I'm sure you will get a high grade in your exam _____ you study systematically and do all your homework.
a. unless b. nevertheless c. provided that d. hence

In questions 19 – 20, choose the appropriate statement for the situation given.

19. A friend of yours complains that apart from her, all the other colleagues in her office have received a pay raise. She feels hurt so she wants to quit immediately. You think she is behaving unreasonably. Since she cannot afford to remain unemployed, you advise her to be more careful. You say:
- a. Your colleagues are not better than you. Why does your boss refuse to give you a pay raise?
b. How can you survive on such a low salary? I would suggest that you start looking for another job.
c. I understand how you feel, but why don't you find another job before you quit?
d. I feel sorry for you. I think your boss simply does not trust you. It is better to be unemployed than work for him.



20. You get stuck in heavy traffic on your way to an important job interview. You arrive there thirty minutes late and when you finally meet your interviewer, you offer your apologies and try to explain why you were late. You say:
- a. I apologize for being late. I know that there would be a lot of traffic on the roads today.
 - b. I am terribly sorry that you had to wait for me. I have no excuse for being so late.
 - c. Please forgive me for keeping you waiting. I apologize for all the inconveniences that I might have caused.
 - d. I apologize for being so late. If there had not been a lot of traffic on the roads, I would have arrived here on time.

In questions 21 – 30, choose the correct sentence with the closest meaning to the given sentence.

21. It was not until they watched the evening news that people realized how much damage the storm had caused.
- a. People did not know how much damage the storm had caused until they watched the evening news.
 - b. People watched the evening news because they realized that the storm had caused a lot of damage.
 - c. Before watching the evening news, people knew that the storm had caused a lot of damage.
 - d. After they realized that the storm had caused a lot of damage, people watched the news until late in the evening.
22. In the 19th century, Europeans wanting to immigrate to the USA could do so as long as they did not have any infectious diseases.
- a. European Immigrants of the 19th century suffered from infections for as long as they stayed in the USA.
 - b. In the 19th century, only healthy Europeans could immigrate to the USA.
 - c. In the 19th century, whenever Europeans got sick, they tried to immigrate to the USA.
 - d. Europeans with infectious diseases could stay in the USA only for a short time in the 19th century.
23. The new sports centre will provide more opportunities for students and teachers alike.
- a. The new sports centre will provide more opportunities for students than for teachers.
 - b. The opportunities that the new sports centre will offer are similar for both teachers and students.
 - c. Both teachers and students will be provided with more opportunities by the new sports centre.
 - d. Teachers like the fact that the new centre will provide more opportunities for their students.



24. No sooner had the administration announced the policy change than the students began their protest.
- The administration changed the announced policy as a result of the students' protest.
 - The students began protesting because the policy change was announced too late.
 - As soon as the students began to protest, the administration announced the policy change.
 - The students began protesting the moment the administration announced the policy change.
25. Since nitrogen is one of the constant components of protein, scientists can measure protein by measuring nitrogen.
- Scientists can measure protein by measuring nitrogen because nitrogen is a constant component of protein.
 - Scientists can measure protein by measuring nitrogen only if the level of nitrogen is not constant.
 - Measuring protein enables scientists to measure nitrogen as nitrogen is made up of constant components.
 - By measuring nitrogen, the scientists can measure the constant components of protein.
26. London is second only to Paris as the most visited city in the world.
- Both Paris and London are considered to be the most visited cities in the world.
 - Paris is the second most visited city in the world after London.
 - London is the second city in the world which is visited more than Paris.
 - After Paris, London is the most visited city in the world.
27. The hormone aspirin acts as a painkiller and is six times as strong as morphine or acetaminophen.
- Aspirin is a painkiller which can be as powerful as morphine or acetaminophen.
 - Aspirin acts as a painkiller only when it is six times stronger than morphine.
 - Neither acetaminophen nor morphine is as strong as aspirin in killing pain.
 - Although aspirin is a hormone, it can be used up to six times as a painkiller.
28. I am amazed that we arrived at the airport on time.
- We made an amazing appointment to meet at the airport on time.
 - I did not expect to get to the airport on time but surprisingly, we did.
 - I am surprised that we had so much time left before we boarded the plane.
 - My friend and I were amazed to see each other at the airport at the same time.
29. When used in small amounts, antibiotics do not kill bacteria; they only help them become stronger.
- Bacteria become stronger if low doses of antibiotics are used.
 - Strong amounts of antibiotics do not kill bacteria but make them less dangerous.
 - Antibiotics which fail to kill bacteria should be used in small amounts.
 - When the number of bacteria is small, antibiotics do not work.
30. You only have to visit your local hospital to see that the system is not working.
- In order to visit the local hospital, you have to see that the system isn't working.
 - It is enough to visit the local hospital to understand that the system isn't working.
 - Since the system does not work, you have to go and visit your local hospital.
 - Because this system works only at your local hospital, you have to visit it.



In questions 31- 40, choose the correct answer that best completes each sentence.

31. Many pharmaceutical companies are conducting clinical trials, _____
- in the hope that they find anti-cancer drugs
 - which they have discovered anti-cancer drugs
 - whether or not the government sponsors them is not important
 - if they want to discover powerful drugs and reduce pain
32. Even though adding a new floor to the museum is not advisable, _____.
- which is what the council is planning to do
 - therefore, the council won't put its project into practice
 - the council is planning to go ahead with the project
 - so that the council's project has been cancelled
33. _____ that the basic needs of tomorrow's travelers will be much different from the needs of today's travelers.
- Since transportation has changed considerably
 - Further changes in technology will result
 - The argument put forward by several agencies
 - There is more than one reason to assume
34. _____ despite all the attempts the government has made to control inflation.
- In 2008, the economic slowdown affected the country
 - As the country has rarely enjoyed economic stability
 - A general rise in the prices of goods has been noticed
 - Witnessing the economic crisis which hit the country
35. _____ takes three to five days.
- For a patient to recover from eye surgery
 - To the patient who recovers from eye surgery
 - That a patient who is recovering from eye surgery
 - In most patients, recovering from eye surgery
36. They have invested so much time and energy in this project _____
- for as long as they work together as a team
 - that everyone expects them to succeed
 - as they have put great effort every single day
 - since people do not have trust in them
37. Since his family is the most important part of his life, _____
- whenever he thinks about his children and wife
 - he makes sure he is always present in his children's lives.
 - so that he does not have any regrets in the future
 - that's the reason why he tries to satisfy all his children's desires



38. Teachers who believe homework helps students learn better _____.

- a. because more practice increases students' confidence
- b. and assist them in acquiring a second language faster
- c. should design exercises according to the students' needs
- d. which is what many parents and education specialists think

39. Alex asked to be excused from class _____.

- a. if he had not been feeling well all day
- b. why he was feeling so sick and tired
- c. since he had apologized for doing so
- d. as he felt a terrible pain in his stomach

40. It has only recently been discovered _____.

- a. in case deadly viruses can develop resistance to drugs
- b. that bacteria can be transmitted through household plants
- c. because nowadays technology has made everything easier
- d. why are children developing more health problems than before

VOCABULARY

In questions 41 - 50, choose the correct word that has the closest meaning to the underlined word.

41. The anti-smoking campaign of the government made quite an **impact** on young people as the number of young smokers is in decline.

- a. effect
- b. increase
- c. problem
- d. respect

42. The Black Sea region is **renowned** for its outstanding natural beauty and the sincere hospitality of its local people.

- a. exciting
- b. famous
- c. protected
- d. deserted

43. Research **indicates** that over 81% of teachers are dissatisfied with their salaries and want more money.

- a. clears
- b. represents
- c. prevents
- d. shows

44. Several colleges in Turkey have **rigid** rules about student behavior and do not tolerate lack of discipline.

- a. strict
- b. valuable
- c. creative
- d. responsible

45. Many businesswomen find it difficult to **cope** with the pressure of working with more superiors and quit their jobs.

- a. create
- b. deal
- c. try
- d. leave

46. The majority of the local inhabitants had to **abandon** their houses after the earthquake and moved to safer locations.

- a. live
- b. destroy
- c. leave
- d. build



47. After the president of the IMF was taken into custody, he was given no special **privileges** and was treated just like every other prisoner.
- a. favors b. excuses c. practices d. commands
48. The school is required to **notify** parents if their children fail to come to school.
- a. notice b. annoy c. confirm d. inform
49. Despite the developments in science and technology, it's still not possible to **accurately** predict the occurrence of earthquakes.
- a. constantly b. variably c. frequently d. correctly
50. I still can't **figure out** why he killed his wife after 50 years of marriage.
- a. explain b. understand c. convince d. criticize

In questions 51 – 60, choose the correct word that best completes the sentence.

51. Although it was the last day of school, students expressed _____ interest in the class.
- a. genuine b. indifferent c. attractive d. impulsive
52. The school will give _____ to science, maths and modern languages rather than arts and physical education.
- a. productivity b. priority c. privacy d. practicality
53. Since the attacks on the World Trade Center in 2001, the Muslim population in the USA has been suffering from _____ and unfair treatment because of their religion.
- a. justice b. disservice c. prejudice d. sacrifice
54. The New York Times used to have the highest _____ in the USA but today the Herald Tribune sells more.
- a. circulation b. combination c. calculation d. constitution
55. Scientists are working on new methods to make plants more _____ to disease and harsh weather.
- a. dependent b. convenient c. resistant d. consistent
56. Changes in the _____ of the atmosphere are thought to be responsible for global warming.
- a. composition b. connection c. conservation d. cooperation
57. The _____ of bacteria inside the mouth leads to bad breath and tooth infections.
- a. accumulation b. acceleration c. addiction d. alienation



58. The mayor is trying to _____ local businesses to play a more active role in the project.
- a. preserve b. persuade c. control d. compensate
59. Before deciding to _____ in a company, one should do some research into how much profit it makes every year.
- a. invent b. involve c. invade d. invest
60. When you are working such long hours, it's inevitable that your marriage will start to _____.
- a. suffer b. strike c. sacrifice d. steal

READING

Answer questions 61 – 80 according to the reading passages.

HOW DID THEY DIE ?

I When Napoleon Bonaparte died in exile in 1821, autopsy reports pointed to stomach cancer as the possible cause of his death. However, when a study in 1961 found "high levels of arsenic in Napoleon's hair, some historians wondered if the former emperor had been poisoned. Some speculated that enemies who feared Napoleon had poisoned him; others blamed the arsenic in the paints that were used for coloring the wallpaper in his home. But many scientists reject these possibilities. A 2002 French analysis called the poisoning theory unlikely, and a 2005 study added support to the cancer theory by recording the decreasing waist sizes of Napoleon's final pairs of trousers, suggesting that he lost a lot of weight in his final days due to stomach cancer.

II In 2008, Italian researchers asked museums for samples of Napoleon's hair cut at different times -- during his childhood in Corsica, during an earlier exile in Elba, and after his death. Under laboratory conditions, the team measured the concentrations of arsenic in the samples. They found the levels were much higher than today's standards, but the amounts did not change throughout Napoleon's life. The arsenic levels were also similar to those found in the hair samples from his wife and child, which means everyone was more or less exposed to the poison in those days.

III When it comes to Wolfgang Amadeus Mozart's death, researchers do not have much to go on. After his death in December 5, 1791, no autopsy was performed and the poor musician was buried in an unmarked grave in Vienna.

IV In 2009, a group of researchers attempted to determine the most probable cause of Mozart's death by looking at how everyone else in Vienna died. They analyzed the causes of death for 5,011 adults who died in November, December, and January of the same year as Mozart. They found out that the majority of these people had died of streptococcal infection. Based on these findings, the researchers concluded that the cause of the death of the famous composer must have been an untreated streptococcal infection.



61. What finding increases the possibility that Napoleon died of stomach cancer?

- a. There were high concentrations of arsenic in his hair samples.
- b. The waist size of his trousers became smaller and smaller towards the end of his life.
- c. The hair samples of his wife and child exhibited relatively high levels of arsenic.
- d. The walls of his house were covered with wall paper that contained arsenic

62. All of the following are true about arsenic EXCEPT;

- a. It was found naturally in the environment in the nineteenth century.
- b. People used it to kill their enemies.
- c. It is a substance that can be traced by examining body hair.
- d. It is a major cause of stomach cancer.

63. We can UNDERSTAND from the text that _____

- a. streptococcal infection can be fatal if it is not treated properly
- b. it was normal to bury people in unmarked graves in the 18th century in Vienna
- c. streptococcal infection is more dangerous in adults than in children
- d. Mozart refused to be treated for his illness because he was poor

64. The word "they" in paragraph III refers to _____

- a. arsenic concentrations
- b. hair samples
- c. Italian researchers
- d. laboratory conditions

65. The word "attempted" in paragraph IV is closest in meaning to _____

- a. joined
- b. arrived
- c. concluded
- d. tried

A NEW WAY TO POWER YOUR HOME

A super efficient system that has the potential to power, heat and cool homes is being developed at Newcastle University. The system works by burning vegetable oil to power a generator and provide electricity for the home. The waste heat from this process is then used to provide heating and hot water, and is also **converted** to cool a fridge. This three-way utilization of energy is known as *micro-trigeneration*.

Created by experts at the Institute for Energy Research at Newcastle University, the design also includes a unique energy storage system. The energy storage system is designed to allow home owners to store the extra electrical energy during 'off-peak' times, for example during the night, and to efficiently release energy when it is needed most.

One of the potential oils to be used in the system comes from the seeds of the *Croton tigliarius* plant which grows in East Africa. *Croton tigliarius* brings with it the advantage of growing fast and on poor soil that is not suitable for traditional farming or food production. This means providing a fuel without sacrificing land for food crops. In addition, the *Croton tigliarius* plant cleans the air by absorbing carbon while growing.

66. All of the following are reasons why we could call the system unique EXCEPT;

- a. It provides electricity in the home by burning vegetable oil.
- b. It heats and cools without wasting energy.
- c. Its source of power helps reduce air pollution.
- d. It turns excess hot water into ice water in the fridge.



67. The energy storage system _____

- a. gives out extra energy during the night
- b. saves energy to be used when it is needed
- c. does not allow home owners to use energy efficiently
- d. releases extra energy at a time

68. All of the following may be reasons for choosing the seed of *Croton Megalocarpus* as a fuel for the new system EXCEPT:

- a. It helps the development of traditional farming in East Africa.
- b. It can grow in poor soil where other crops cannot easily grow.
- c. It sheds the leaves while it grows.
- d. It does not require a long time to grow.

69. What does "it" in paragraph III refer to?

- a. design
- b. rough
- c. energy
- d. storage systems

70. The word "converted" in paragraph II is closest in meaning to _____

- a. engaged
- b. transformed
- c. abandoned
- d. separated

AUTOCRATIC MANAGEMENT STYLE

I Autocratic management is based on a belief system that says workers will not try to improve their performance unless they are motivated to do so. This belief system behind autocratic management style is called Theory X. According to Theory X, workers have no interest in work, including the quality of their work. The job of managers is to deal with them by using "carrots and sticks." The "carrots" is usually money, such as a pay raise or a bonus. The "stick" is pay cuts for poor quality or missed production target. Simply, Theory X claims that only money can motivate the lazy, disinterested worker.

II In addition to using "carrots and sticks" for motivation, autocratic managers try to control all aspects of work as much as possible. A major threat to control is job complexity. Complex jobs are more difficult to learn and workers who are able to perform complex tasks are difficult to find. Thus, autocratic managers aim to simplify work to reduce worker responsibility and gain maximum control.

III In times of stress or emergency, some workers may actually prefer to be managed by an autocratic style. Indeed, autocratic management can be very effective when times are stressful and workers need to be told exactly what to do. However, in less stressful times, it presents certain disadvantages. First, the communication style of autocratic manager is usually one way. In other words, it is only the manager who communicates with the workers. This can be frustrating if the manager only criticizes the employees when they make mistakes, and provides little praise when they do something right. In addition, autocratic management style can create an environment of fear and resentment. Such an environment causes an increase in the number of absent workers and can slow down progress and production. Moreover, it can discourage creative ideas that might make the company more competitive.

71. Which of the following BEST summarizes the main idea behind Theory X?

- a. Workers are not willing to make a contribution to their own work voluntarily.
- b. The only way for a manager to improve quality is to threaten the workers.
- c. Pay raises or bonuses only work if the workers are disinterested.
- d. Pay cuts require workers to miss their production targets.



72. In paragraph I, "them" refers to — — — — —

- a. carrots b. workers c. strcks d. managers

73. Which of the following is NOT a disadvantage of autocratic management style?

- a. It leads to fear and dislike for their jobs among workKers.
b. t discour-ages workers 'rom coming to work every day.
c. It leads to unfair competition among workers.
d. ■ results in slower progress and production rates.

74. In paragraph III, "praise" is closest in meaning to — — — — —

- a. approval b. approach c. apology d. appeal

75. It can be UNDERSTOOD from the text that autocratic management can be useful in times of_____.

- a. competition b. peace c. stability d. crisis

THE MELTING POT OR THE SALAD BOWL?

■ For many years, tre cultural model that was widely accepted in the United States was that the country was a meltrng pot for rmmigrants. The meltrng pot symbolizes the different groups of people who migrated to the United States and brought their own characteristics with them. Once they were Ir the United States, these people and therr cultures were expected to mix and assimilate into a un'form United States culture m whch It is impossible to notice the diverse cultures that made !! up.

■■ In -ecent years, however, the rdea of the meltrng pot is ::>eing replaced by a new one. Many new immigrants to the Unrted States do no:feel they should be required to change. They believe that t1ey can contribute and belong to the Un ted States, a"ld be its citizens while strll keepng some of the culture, be refs and even the language that they brought with them. Therefore, the new model that is being suggested for the United States rs the salad bowl. The salad bowl descroies a mult cultural society where people do not have to conform to make a new unity, but keep the r original character while living side by side with eac'1 other.

■■■ It is not certain whether either of these two models is correct for the modern United States. The melting pot seems to be over-rdealstrc and outdated. Also, older Americans may be suspicious of newer arrivals and do not welcome them, whereas newer Americans may feel that it is impossible to give up their past and their cultural characteristics. The salad bowl is not a perfect model, either. New immigrants who have not learned English or accepted the culture and beliefs common in the United States have difficulty in being a part of the American society. As a result, they are often accused of being unwilling to change, in other words, of not being Amerrcan enough.

76. Which of the following is WRONG about the "melting pot" model?

- a. It requires Imm grants to change their culture and beliefs.
b. It used to be the dominant cultural model for a long tme.
c. t is an up-to-date and realistic model for the United States.
d. Its main purpose is to create a un'form natrona! culture.



77. Which of the following BEST explains the "salad bowl" model?

- a. Immigrants are expected to change and assimilate into a single culture.
- b. Immigrants are allowed to keep their original cultural identities and beliefs.
- c. Immigrants are no longer a part of the United States if they refuse to change.
- d. Immigrants are asked to learn English and be American as soon as possible.

78. In paragraph 1, "it" refers to _____

- a. United States culture
- b. noticing diverse cultures
- c. cultural model
- d. migration to the United States

79. In paragraph 2, "conform" is closest in meaning to _____

- a. adapt
- b. arrange
- c. acquire
- d. absorb

80. It can be UNDERSTOOD from the text that _____

- a. the salad bowl is a more acceptable model than the melting pot for older Americans.
- b. new immigrants prefer the salad bowl model rather than the melting pot model.
- c. learning English makes it more difficult for immigrants to adapt to American culture.
- d. older Americans always welcome new immigrants if they choose to be American.

APPENDIX M: ETHICS CLEARANCE CERTIFICATE



COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE

13 April 2016

Ref: 2016/04/13/48166413/08/MC
Student : Mr E Chhramba
Student Number : 48166413

Dear Mr Charamba

Decision: Ethics Approval

Researcher: Mr E Charamba
Tel: +2716 457 2010-2
Email: er_asmusc:haramba@live.com

Supervisor: Prof. A.T Motlhabane
College of Education
Department of Science and Technology
Tel: +2712 429 2840
Email: motlhatl@unisa.ac.za

Proposal: Language as a contributing factor to the academic performance of Southern
Sesotho Physics learners

Qualification: D Ed in Didactics

Thank you for the application for research ethics clearance by the College of Education
Research Ethics Review Committee for the above mentioned research. Final approval is
granted for the duration of the research.

*The application was reviewed in compliance with the UMSA Policy on Research Ethics by the
College of Education Research Ethics Review Committee on 13 April 2016.*

The proposed research may now commence with the proviso that:

- 1) The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
- 2) Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*



University of South Africa
P.O. Box 17003, Roseburg, 2018
Tel: +27 11 712 429 4150
Fax: +27 11 712 429 4150
WWW.UNISA.AC.ZA

3) The researcher will ensure that the research project adheres to all applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.

Note:

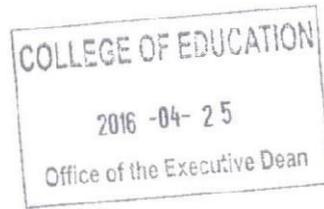
The reference number 2016/04/13/48166413/08/MC should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] With the intended research participants, as well as with the College of Education RERC

Kind regards,



D. M. Claassens
CHAIRPERSON: CEDU RERC
medtc@netactove.co.za

Prof V. McKay
EXECUTIVE DEAN



APPENDIX N: CLEARANCE FROM DISTRICT OFFICE

dh ;ation

FREESTATEPR<1>.ta:
-0169J3 91SI/9U8/11150
Fax.no: 086 219 4929
g n.zwaneOeduh.gov.:ta

To : MR E CHARAMBA

Priority: High

Dear Sir

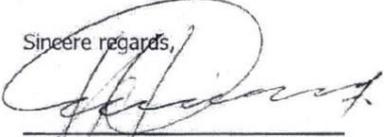
NOTIFICATION OF RESEARCH PROJECT OY E CHARAMBA

1. The above mentioned candidate is hereby granted permission to conduct research in Fezile Dabi Education District.

Topic: language as a contributing factor to the academic performance of Southern Sesotho Physics Learners.

Schoolinvolved: Pele Ya Pele SIS

2. The research seeks to establish if language plays a role in the academic performance of Southern Sotho Physics Learners. The findings from the research will enable the Department to consider interventiOn steps with regard to the teaching of Physics to Sesotho Home Language learners.
3. The attached letter from Dr JEM Sekolanyane must be adhered to in the discourse of your study in our district.
4. The collection of data should not interfere with normal tuition time or teaching process.

Sincere regards,

V.H. CHUTA
DISTRICT DIRECTOR FEZILE DABI
DATE: 20/6/2016

APPENDIX P: LANGUAGE CLEARANCE CERTIFICATE

15 Nile Crescent
KLOOF
3110
Phone 031 7075912
0823757722
Fax 031 - 711 0458
E-mail:
drjacym@iim.ac.za

Dr Saths Govender

II AJ>RTI.201?

TO W.HOI\fitMAY CONct:.IL'

T.ANC.UAGE CLE-.A.RAN I: CERTIFJCATF.

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mccn et-'l1crall) accepted academic smnell:rJ..

Your.; litilfully


DR S. GOVENDER
B Ed. (Arts), B.A. (Hons), B Ed.
Cambridge Certificate for English Medium Teachers
MPA, D Admin.