PRE-SERVICE SCIENCE TEACHERS' MEANING OF NON-TECHNICAL WORDS USED IN THE SCIENCE CLASSROOM CONTEXT: A CASE STUDY AT AN ENGLISH MEDIUM UNIVERSITY IN SOUTH AFRICA

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ABSTRACT

This dissertation is a report of a study that investigated the understanding of the meaning of non-technical words commonly used in the science classroom at an English medium university in South Africa. The study was performed on 184 pre-service science teachers, which included second year student participants registered for the Natural Science Methodology Course, as well as third and fourth year student participants enrolled on the respective levels of the Physical Science Methodology Courses. Data were collected using questionnaires and interviews. The collection of data therefore included participants answering multiple choice questionnaires and focus group interviews. The study used a Mixed Method (MM) research approach since this was seen as the most appropriate approach, because the analysis of the data required both numeric (quantitative) and narrative (qualitative) methods. Since MM research approach involves the combination of two methods, the weakness of one method can be improved by the strength of the other. As such, MM provides accurate and increased levels of confidence in research findings.

The findings of this study have revealed that pre-service science teachers had difficulties with non-technical words, when used in the science classroom context. The pre-service science teachers harboured alternative contextual meanings to the non-technical words, which consequently led to incorrect interpretations of the word items as it appeared in the questionnaire. Vygotsky (1978) argues for a tangled web that is woven between languages and thought, such that the concepts that teachers teach cannot be fully understood if they are not represented in words. As such, the conceptual framework that guided this study recognised words as a language and as knowledge (Postman & Weingartner, 1971). As transpired from this study, the lack of knowledge of the contextual meanings of non-technical words due to the lack of explanation during the classroom talk, has led to incorrect interpretations of these words. Apparently, the participants had been influenced by the word meaning from other contexts, when selecting response options that resulted in incorrect answers on the questionnaire, according to science classroom context.

These findings are regardless of their enrolment level and home languages. The message from this study is that lack of preparation; both at school and at tertiary levels in science language; are major contributing factors. Since there is no component in pre-service science teachers’ training regarding the science language, research outcomes such as this, has suggested a need to adjust the education curriculum of the science teachers accordingly. Hence, the findings from this present research study regarding science teacher preparation can be considered timely.

Key Words: Pre-service science teachers, Non-technical words, Contextual proficiency.

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DECLARATION

I LUFEYO YOHANE MPAHA declare that, apart from the assistance acknowledged, this Dissertation is my own work. It is being submitted in fulfilment of the requirements for the degree of Master of Education by research at the University of the Witwatersrand, Johannesburg, South Africa. This is an original work, which has not been previously submitted by me for a degree or examination at this or any other University.

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DEDICATION

This dissertation is dedicated to my late Mum and Dad.

Grant them Eternal Rest, Lord and may Your Light shine on them forever.

Amen!

LIST OF ACRONYMS

CMM	Congregation of the Missionaries of Mariannhill
DBE	Department of Basic Education
DHET	Department of High Education and Training
DoE	Department of Education
EFLs	English First Language speakers
EMS	English Medium School
EMU	English Medium University
ESLs	English Second Language speakers
EWS	Everyday words used in science
FET	Further Education and Training
ITE	Initial Teacher Education
LOLT	Language of Learning and Teaching
MM	Mixed Methods
MoI	Medium of Instruction
MRTEQ	Minimum Requirement for Teacher Education
NSC	National Senior Certificate
SCL	Science Classroom Language
TE	Teaching Experience
TIMMS	Trends in Mathematics and Science study
ZPD	Zone of Proximal Development

CHAPTER ONE: Introduction to the study and dissertation overview

1.1. Background Issues

The important roles of language in science education have been widely debated and recognised over the past years. The classroom discourse whether written or spoken uses language to accomplish its teaching and learning endeavours. Seah and Yore (2017) highlighted that language is used to disseminate information (communicative function), create understanding (epistemic function), and argue and justify knowledge claims (rhetoric or persuasive functions). In addition, Vygotsky (1978) argues for a tangled web that is woven between language and thought. He claims that a dynamic relationship exists between language and thought such that the concepts that teachers teach cannot be fully understood if they are not represented in words (Vygotsky, 1978). However, every subject has its own language hence the words used in each subject must be understood within the contextual parameters of that particular subject (Ncube, 2016). As such, the issue of language in science cannot only be confined to proficiency in the language of learning and teaching (LOLT), but also has to include proficiency in the language of science itself as experienced in textbooks and teachers talk (Oyoo, 2012).

The language of science as used in both textbooks and teachers talk can be divided into two components namely: A technical component and a non-technical component (Oyoo, 2017; Oyoo & Semeon, 2015). Science teachers use a non-technical component (everyday words) to teach a technical component (science words). As such, the understanding of the meanings of non-technical words in the context of use is essential for teaching and learning. This study has explored pre-service science teachers' understandings of non-technical words used in the science classroom context. Since pre-service science teachers are being prepared to teach at high school level upon completion of their studies, a good understanding of these everyday words is not only important but is crucial in their pedagogical practices. Science teachers use non -technical language to teach and explain technical words. This means that it is the everyday (non-technical) words, which make out a higher percentage of the science vocabulary of the science classroom language (Wellington & Osborne, 2001). It follows then that a poor understanding of non-technical words may result in poor understanding of the science content (Gardner, 1971; Ncube, 2014; Tao, 1994). Since language helps in concept formation, lack of understanding of science language may affect development of understanding of the content itself (Vygotsky, 1978).

Research shows that everyday words of the non-technical component of science language have a tremendous contribution in understanding of science content (Farrell &Ventura, 1998; Oyoo, 2017; Oyoo & Semeon, 2015). This is in line with the already mentioned fact that language is a tool that is used to aid concept formation (Vygotsky, 1978). However, as discussed already, every science subject has its own language hence words that form the language must be understood in the context of that particular subject. Some everyday words that are used in science become concepts such as *acceleration* and *resistance*. When these words are used as science words, they cease to hold the meanings as they ordinarily would as in any English language dictionary. These words become science concepts; and lead into calculations. For example; Average acceleration= $\frac{\text{change in velocity}}{\text{Time elapsed}}$ ($\frac{\Delta V}{\Delta t}$) and Resistance = $\frac{\text{Potential difference}}{\text{Current}}$ ($\frac{\Delta V}{I}$) respectively (Giancoli, 2014). Therefore, a good understanding of the language of science is the key for learners to be able to interpret concepts like these.

Some everyday words gain meanings that need to be understood in the science context such as *disintegrate* and *reaction*. The word '*disintegrate'* means to break into small pieces or to become weaker or less united. The word '*reaction'* describes the way one feels as a consequence of something that happens (Macmillan dictionary, 2007). However, in the context of physics, the word *'disintegrate'* refers to decaying of an unstable nucleus of an atom (Duncan, 2013). This word is used in radioactivity where decaying does not refer to rotting or decomposition of the nucleus (Duncan, 2013; Oyoo, 2017). Likewise, the word '*reaction'* in chemistry demonstrates what happens when two or more substances are mixed (LeMay et al., 2012). Oyoo (2012) writes that "use of (instructional) language in science texts and classrooms can be a major influence on the level of students' understandings and retention of science concepts" (p. 849). It is in this regard that pre-service science teachers who are being prepared to become the knowledgeable others (Vygotsky, 1978) have a role to play in the learners' understanding of science language. This reasoning is clearly supported by the following assertion, which is a description of how science teachers go about attempting to disseminate science knowledge during teaching in classrooms:

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

While teachers should note the difference between the technical and the non-technical components of science classroom language, not all science teachers are aware of this difference or appreciate that the contextual meanings of non-technical words can cause difficulties in understanding science content (Childs et al., 2015; Oyoo, 2017; Oyoo & Semeon, 2015). The current situation provokes many questions on whether issues of language are a focus in training institutions of science teachers. Drawing from observations of classroom interactions, approximately two thirds of classroom talk is teachers (Ned Flanders 1970 cited in Oyoo, 2012). This means that a large part of classroom discussion is dominated by teacher's talk (Oyoo, 2007). Therefore, equipping the pre-service science teachers and practising teachers with science LOLT is tantamount to equipping the learners that they will teach during their teaching practicum during their initial training and even after attaining their individual teaching qualifications. The exploration of pre-service science teachers' understanding the meanings of non-technical words used in the science context in this study is thus in implicit support of the argument that "schools are [can] only [be] as good as their teachers…" (Kahle,1999, p. 2). The underlying aspect is that of long-term improvement of physical science results *via* a focus on the strengthening of the teachers' knowledge in the use of language effectively during teaching.

1.2. The research problem statement

Of the reviewed literature, there is an observation that non-technical words present difficulty to science learners in conceptualizing science knowledge (Gardner, 1972; Ncube, 2014; Oyoo & Semeon, 2015; Oyoo, 2017; Tao, 1994; Van Laere, Aesert & Van Braak, 2014). Hence, one of the possible explanations for the string of poor performances in physical science at national examinations each passing year. It is on record that most science teachers are not aware of the difference between the technical and the non-technical words (Oyoo; 2012). Teachers are not conscious of the difficulty that is caused by the non -technical words of science classroom language (Wellington & Osborne, 2001; Ncube, 2016). This lack of awareness of the difficulties caused by non-technical words raises questions on whether issues of language are a focus in training institutions for science teachers.

Speaking generally, there is dearth of research on pre-service science teachers' understandings of the meaning of non-technical words, used in the science classroom context, of training institutions for science teachers. As a result, little is known of pre-service science teachers' comprehension of these non-technical words, when used in science classroom context.

The paucity of science language research into pre-service science teachers' is regardless of the aforementioned argument (in section 1.1) that language helps in concept formation (Vygotsky, 1978). As such, the research gap on pre-service science teachers' comprehension of these non-technical words during their science teacher education hinders the opportunities to explore empirically the factors that can help to improve the teaching and learning of science at high school and tertiary levels. Furthermore, the existing gap on science language research on pre-service science teachers implies that little is known about the nature of pre-service science teachers' preparation concerning science language issues, especially their understanding and usage of non-technical words of science classroom language. This study therefore, sought to address this research gap by underlining some insights into pre-service science teachers' understanding of the contextual meanings of the non-technical words and the factors shaping such understanding in view of their training.

1.3. The Rationale of the study Research

Generally, there is paucity of research on pre-service science teachers' understandings of the meanings of everyday words used in the science classroom context. In other words, studies on the pre-service science teacher's understandings of everyday words used in the science classrooms context in South Africa is a rare focus. The study by Sibiya (2017) is the only known study in this area on pre-service science teachers understandings the meaning of everyday words when presented in the science context. Sibiya's study however did target only second year students registered for the Physical Science component of the Natural Science Course. The most recent and notable research studies in the area of understanding the meaning of everyday words used in the science context with a focus on South Africa, have concentrated on learners (see Oyoo, 2017; Oyoo & Semeon, 2015) and on in service teachers (Kurwa, 2016; Mupfawa, 2017; Ncube, 2016) at secondary school level. Hence, this study focuses on pre-service science teachers.

The findings from these research studies with South African high schools learners and with second year university student participants have shown that high school learners and second year science students also do encounter difficulties with everyday words used in the physical science context and commonly used words in the science classrooms and texts (Oyoo, 2017; Sibiya, 2017). Childs et al. (2015) maintains that "we cannot improve the language of any science without improving the science itself; neither can we… improve a science without improving the language or nomenclature which belongs to it" (p. 246). The underlying aspect is that science content is deeply embedded in the language, and thus paying special attention to language used in the science classroom, can improve the process of teaching and learning science.

This study is therefore in support of the view that paying more attention to non-technical words is one of the most essential strategies necessary to improve the quality of science performance. The task therefore, should start at the initial preparation of the pre-service science teachers' stage. It can therefore, be expected that the findings of this study may contribute to the knowledge that may be used by the pre-service, in-service science teachers and teacher training institutions to give necessary attention to the issue around the difficulty of non-technical words used in a classroom context. Hence, this study is to contribute to the current education research in science language by improving pre-service science teachers' awareness of difficulty of non-technical words, which may eventually have a positive impact at a grass root level, where teaching takes place. This forms the rationale for this study.

1.4. The objectives/purposes of this study

The issue about language in the science classroom context is not a new area to be explored. Its existence within the deliberation of science education research goes back more than four decades. The fundamental statement on this research area gained momentum around 1971 when the work of Postman and Weingartner initiated the discussion on language. Postman and Weingartner observed, that "a discipline is a way of knowing, and whatever known is inseparable from the symbols (mostly words) in which the knowing is codified" (Postman & Weingartner, 1971, p.103). This means that failure to understand the words that form the language of a certain subject result in misunderstanding of that subject or discipline. This observation in particular pioneered the attention on language as an issue of learners' difficulties in understanding science content in a science classroom context.

As already indicated here but discussed in more detail in Chapter 2, science classroom language is composed of technical and non-technical words. Studies conducted elsewhere in the world (Farrell and Ventura, 1998; Pickergill and Lock, 1991; Prophet and Towse, 1999) and in South Africa (Oyoo, 2017; Oyoo & Semeon, 2015) have disclosed that it is these everyday (non-technical) words that cause problems when used in a science classroom context. Although studies in the area of language in science in this country are rather scarce, international literature that explores the issue of learners' difficulties with the science classroom language have revealed that there is poor understanding of non-technical words used in the science context (Oyoo, 2017, Oyoo & Semeon 2015). In South Africa, research on non-technical words used in the science classroom has been done in schools and among the second year students registered for the Physical Science component of the Natural Science Course. It is within these parameters that this study deals with pre-service science teachers doing Natural Sciences (second years) and Physical Sciences (third and fourth years) Methodology Courses at university level. Although findings at school level reported learners’ difficulties with non-technical words, some authors (Dlodlo, 1999; Djite, 2008; Mji & Makgato, 2006) have deduced such difficulties to lack of proficiency in the LOLT.

From the established literature (Oyoo, 2017; Oyoo & Semeon, 2015; Van Laere, Aesert & Van Braak, 2014) in the science education research, it is evident that science language is one of the pressing issues that need to be addressed so that there is a good understanding of the science content. However, this message has not reached all the corners of the science teaching profession. As such, if appropriate measures are not taken to address this barrier to learning and teaching of science, unsatisfactory results will always be with us. Studies focusing on pre-service teachers’ meanings of non-technical words when used in the science context are rare. Therefore, this study has the potential to unearth possible difficulties that pre-service science teachers meet in interpreting the meanings of non-technical words when used in a science classroom. Generally, it is observed that teachers are mostly in a hurry to finish the prescribed syllabi; and as a result, they tend to use science classroom language with an assumption that learners understand this language (Cassels & Johnstone, 1985). Moreover, some science teachers often consider science classroom language to be of minimal relevance to the learning of science (Wellington & Osborne, 2001). The objectives/purposes of this study were therefore threefold as follows:

- To explore pre-service science teachers' understandings of meanings of non-technical words used in science classroom context.
- To examine the sources of difficulty of these non-technical words across the second year, third year and fourth year pre-service science teachers.
- To identify the possible messages, from the encountered difficulties with non-technical words used, in the light of their initial teacher training.

Research questions

The research questions that the research in this dissertation focused on as a means to satisfy the objectives listed above were the following:

- To what extent do pre-service science teachers encounter difficulties with non-technical words used in a classroom context?
- Which non-technical words are difficult for the pre-service science teachers?
- What are the sources of the difficulty of these words as encountered by pre-service science teachers?
- What possible messages can be drawn from the encountered difficulties with non-technical words used, in the light of their initial teacher training?

1.5. Significance of the study

The significance of this study in the context of South Africa is now argued on the premise that in South Africa, teacher education is governed by a revised policy on Minimum Requirements for Teacher Education Qualification (MRTEQ) of 2011. Among other things, the policy emphasises that teacher education must address poor content and conceptual knowledge of teachers and make relevant interconnections betweenDu toit

different types of knowledge and practice (DHET, 2011). In addition, the MRTEQ policy requires all new teachers to be proficient in the use of at least one official language. In line with these prescribed requirements, this study recognises the fact that apart from being proficient in the LOLT, science teachers in particular need to be proficient in science classroom language.

The findings of this study (as detailed later in this dissertation in Chapter 5) suggested that pre-service science teachers struggle with non-technical words when used in a science context just as been reported with South African high school learners (Oyoo, 2017). The findings of this study, reveals whether participant pre-service science teachers taught science at school level, have been or are being taught science at university and therefore, what kind of science teachers are being produced. The fact that pre-service science teacher participants in this study have encountered difficulties with everyday words in similar ways as has been reported by high school learners, is one basis that shows that more emphasis is put on the science content than on the place of language in the teaching of science (Childs et al.,2015; Wellington & Osborne, 2001). The fact that science content is embedded in the language of science, it is to bring a better understanding of the nature of the language of the science classroom in order to embrace the science content better. I now discuss briefly the theoretical and conceptual frameworks (detailed later in this dissertation in Chapter 2) adopted in this study.

1.6. Theoretical and Conceptual frameworks

This study advanced socio-cultural theory (Vygotsky, 1978) as it adopts contextual meanings of words and the link between words, language, and knowledge as the conceptual framework (Postman & Weingartner, 1971). The reason for using both theoretical and conceptual frameworks was their ability to complement each other. This study focused on two tenets from Vygotsky's socio-cultural theory namely mediation and internalisation as necessary constructs for learning. The conceptual framework views words as a language and knowledge (Postman & Weingartner, 1971). As such, there is a requirement for the teacher to mediate contextual meanings of the non-technical words at a social plane in order to bring understanding of non-technical words to an individual level.

1.7. Chapter summary and dissertation plan

This chapter was an introduction to the study. It highlighted the following: the purpose of this study, the research questions that guided this study, a brief on the conceptual and theoretical frameworks adopted in this study. The rest of this dissertation is structured as follows:

Chapter Two examines the performance in physical science at national level as means to lay out the extent of the problem of science learning in South Africa based on physical sciences outcomes at matric level. How this study on language relates to pre-service science teachers is also discussed including a review of literature on the role of science classroom language in view of teaching and learning of science.

Chapter Three discusses the research methodology and unfolds different concepts encapsulated in research methodology such as research paradigm, research approaches, research design, research methods, and the data collecting instruments and data analysis procedures used in this study. Issues regarding the population and study sample of the research, reliability and trustworthiness are explicated. Infused in the discussions are ethical issues in the implementation of the study.

Chapter Four presents and discusses the data and findings in this study in line with the research questions and the data analysis framework.

Chapter Five examines the trends that have been found during the analysis of both the quantitative and qualitative data.

Chapter Six provides conclusions, findings of this study and recommendations for future research.

CHAPTER TWO: Literature review

2.1. I**ntroduction**

The main motivation of this study is based on the fact that learners do not perform well in physical science. As such, this chapter will examine factors for poor performance in physical science as reported at matric level, and how this study on value of language, relating to pre-service science teachers, can be a solution. This chapter also examines the literature on the role of science classroom language in view of teaching and learning of science, at both a theoretical and a conceptual basis. However, discussed first is the Trends in Mathematics and Sciences Study (TIMSS) and the status of outcome in physical science in South African schools.

2.2. The state of Trends in Mathematics and Science Study

The Trends in Mathematics and Sciences Study (TIMSS) is an international benchmark, which measures learners' performance in science and mathematics. In the years 2001 and 2003, South African Grade 8 and 9 learners participated in the TIMSS assessment. The results showed that of the 38 countries that took part in the year 2001 and 50 countries that participated in 2003, South Africa came last in mathematics and science in both years (Howie, 2001, 2003). In the TIMSS of 2011 and 2015, the assessment was administered to Grade 9 learners (Reddy et al., 2016).

For the sake of brevity, in 2015, 12 years after the last TIMSS in which South Africa participated, 36 countries participated in TIMSS including South African learners. The outcome for this recent assessment in mathematics disclosed that out of the five lowest performing countries, South Africa trailed second from last with results as follows: Botswana (391), Jordan (386), Morocco (384), South Africa (372) and Saudi Arabia (368) respectively (Reddy et al., 2016). As seen from the scores per country, from the Southern African region, Botswana was the only country with a statistically good score compared to that of South Africa. In science, out of the five lowest performing countries, South Africa trailed last in results as follows: Saudi Arabia (396), Morocco (393), Botswana (392), Egypt (371) and South Africa (358) respectively (Reddy et al., 2016). The poor performance of South African learners both at international and within Southern Africa regions provoked a storm of questions and debates regarding how physical science is taught at national level. The next section therefore, discusses how students performed in physical science in the National Examinations in South Africa.

2.3. Poor performance in the physical science examinations

The spark that ignited this study originates from the poor performance at matriculation level in the subject of physical science. As recorded in the 2016 National Senior Certificate Diagnostic Report, physical science and mathematics continue to be the subjects that high school learners are struggling with, each passing year.

The following Table 2.1 shows the National Senior Certificate Examination 2016 Diagnostic Report on physical science pass rate from 2012 to 2016.

Table 2.1 Summary of percentage results from 2012-2016

YEAR	No. wrote	% achieved at 30% and above	% achieved at 40% & above
2012	179194	61.3	39.1
2013	184383	67.4	42.7
2014	167997	61.5	36.9
2015	193189	58.5	36.1
2016	192618	62.0	39.5

Source: Diagnostic Report 2016

While this observation is not only unique to South Africa, the subjects in question are the basic requirements for students intending to study engineering, architecture, medicine and other related science career paths (Du Toit & Roodt, 2008; Mji & Makgato, 2006). These career paths created by mathematics and physical science are crucial in the growth of the infrastructure and economy of the country. Therefore, enhancing learners' access to these career paths is likely to reduce the scarcity of skilled engineers and scientists in the country, as a means to counter the challenges of the 21st century (Zeidler, Walker, Ackett & Simmons, 2002).

Research shows that South Africa has a ratio of one engineer for every 3100 citizens, one for every 200 in Germany and Japan, while Korea and the United States of America have one to 310 citizens respectively (Du Toit & Roodt, 2008; Gotthardt, 2014). As the Diagnostic Report below shows, there is no dramatic improvement on the South African side to improve this undesirable ratio. A close look at the year 2016, for instance, shows that the percentage pass rate over 30% and above was 62.0 and over 40% and above was 39.5 respectively.

This is regardless of the government intervention through teaching training programs and extra classes on Saturdays (Ncube, 2014). The implication of these results is that fewer people will be enrolled into career paths of medicine, engineering, architecture etc. As a result, the country will experience poor economic growth and infrastructure development.

Du Toit and Roodt (2008) advised that in South Africa, for students to follow a career path such as engineering for example, two important issues must be considered: The issue of the number of matriculants who qualify for engineering, and the quality of mathematics and physical Science knowledge that those students have. While the position of physical science as one of the deciding factors for students to enter particular trades automatically as variously argued vindicates its importance at a national or global level. Du Toit and Roodt (2008) have observed that high-quality engineering students are likely to come from schools with good quality mathematics and physical Science teachers.

The performance in physical science as in Table 2.1 reveals that learners are not achieving the required science results to gain access to universities. Perhaps, the message these statistics are communicating is that the country is in dire need of science teachers who can improve the teaching of science at high school level. In this regard, universities and teacher training institutions play a pivotal role in producing teachers whose subject matter and pedagogical knowledge matters count, hence this study. I now discuss how this study relates to pre-service science teachers.

2.4. How this study relate to pre-service science teachers

This study investigated pre-service science teachers' meaning of non-technical words used in the science context. The main reason for this study was that science teachers use non-technical words to teach science hence, the non-technical words act as waters in which the technical words are swimming. This study on science language therefore, relates to pre-service science teachers, because the lack of understanding of these words (non-technical) is likely to affect both the comprehension and teaching of the science content. Being the case, the relationship between pre-service science teachers and the study on language is seen in the very role of language in the learning of science, especially the quality of the teachers' science required to improve the performance at school level (Ncube, 2016).

Oyoo (2007) defines language as a "system of sounds, meanings and structures with which we make sense of the world around us" (p. 103). In other words, language is a tool that facilitates communication among the human population as well as their surroundings. Chin (2006) mentions that in a classroom setting the “primary source of information input comes from teacher talk and teacher–student interactions, as the processes and transactions involved in the construction of meanings are mediated through language” (p. 1317). Although, some teacher talk is grounded in what is written in science texts, language whether “written (as in science texts) or oral (as in the form of teacher and student talk)—is unavoidable in effective teaching and learning of science” (Oyoo, 2011, p. 849). It is in this context that Oyoo (2012) identifies three relevant issues regarding the relationship between the language of instruction and the teachers. The first issue as already discussed in section 1.1, regards the role of language in facilitating the formation and development of concepts (Vygosky, 1978 in Oyoo, 2012). To this well recognised role of language, Gleitman & Papafragou, (2013) emphasised that “new concepts can arise as a result of experience with language rather than experience with world of objects and events” (p. 504). The second issue views language as an important tool in the intervention process. This is pertinent to language when used by teachers to guide and shape learners conceptions of the science discourse (Oyoo, 2012). The third aspect characterises the teacher as the one who dominates most of the classroom talking as she/he explains the content to be learnt within the classroom context. While these three issues have given a vivid explanation on how this study on language relates to pre-service science teachers, it has simultaneously underlined its relevance to students learning of science concepts (Oyoo, 2012).

2.4.1. Teacher education and pre-service science teachers

The primary role of teacher training institutions is to train pre-service science teachers on how to teach and award relevant qualifications regarding their training achievements. Ostensibly, these are institutions where student science-teachers have an opportunity to learn science content (becoming learners of science content) how to teach science (becoming teachers of science) and becoming proficient users of science language. However, a plethora of criticisms that most teacher education institutions the world over endures include “lack of practicum; separation of theory and practice; lack of accountability; fragmentation of coursework and; lack of collaboration and consultation between university, schools and in-service teachers” (Naylor, Campbell- Evans & Maloney 2015, p. 120). Darling-Hammond and Youngs (2002, p. 13) have observed the following:

> “That teacher’s education and certification do not guarantee teacher effectiveness rather verbal ability and subject matter knowledge are the most important components of teacher effectiveness and teachers who have finished their teacher training programmes are academically weak and under prepared for the jobs…” (p. 13).

While such claims cannot be generalised to each teacher finishing the teacher training programme, probably the argument is that low subject matter knowledge leads to low pedagogical content knowledge (Pitjeng, 2014). While strong content knowledge can also be accompanied by low pedagogical content knowledge, it is often argued that learning to teach is a developmental process; hence good teaching comes with experience (Kennedy, 1999; Naylor, Campbell- Evans & Maloney, 2015; Pitjeng, 2014). In this sense, teacher training does not necessarily warrant good teaching. Some authors (e.g. Kennedy, 1999) subscribed to the view that teaching is a self - evident practice. As such the pre-service science teachers can learn how to teach through “apprenticeship observation” (Lortie, 1975), learn their subject matter through their tertiary training and eventually decide to develop their own teaching style through their own experience (Kennedy, 1999).

This study stands to argue that the initial teacher training still remain central as it lays a foundation for teaching and professionalism. Moreover, training a science teacher entails exposing pre-service science teachers both to content and practical activities. For example, it is through practical activities that students appreciate that information in science is also obtained through observations obtained from use of instruments such as thermometer and triple beam balances in order to record some measurements. As Lederman et al. (2002) describes it:

> Observations of nature are always filtered through our perceptual apparatus and/or intricate instrumentation, interpreted from within theoretical frameworks, and almost always mediated by a host of assumptions that underlie the functioning of scientific instruments (p.449).

Relevant to this study, the importance of language cannot be reduced to content learning alone but has to include practical work as well. This is because at the centre of the process of describing a concept is the correct use of the language as conceived by the practicing science community (Driver et al., 1994). For example, a *sensitive* instrument is the one that measures/weighs very small things. The word *sensitive* is one of the non-technical words used to explain the function of a beam balance as a scientific instrument (Lederman, 2002). This study therefore, posits that knowledge of non-technical words, whether in written or spoken discourses (discussed in section 1.1), and in learning of content and in practical activities have great value in the learning of science. Being the case, such knowledge can be mediated and assimilated, during initial teacher training. The presence of a science language component, in the pre-service science curriculum can therefore bring such required awareness and knowledge about the importance of using science language even in practical activities.

The apprenticeship observation discussed above (Lortie, 1975) presents a limitation as it suggests that school classroom situations are never changing. It entails that whatever the pre-service science teachers observed during their primary and secondary schooling years remain the same. It is seen that in addition to subject matter and verbal ability, (Darling-Hammond & Young, 2002,) one of the roles of the teacher training institutions is to facilitate the way pre-service science teachers would interpret particular situations. Another role is to devise appropriate decisions regarding how to respond to changing events such as curriculum, diversity of students, epistemological beliefs etc. (Kennedy, 1999; p. 56; Maloney & Barblett, 2003).

Some researchers argue that learning to teach is regarded as a complex, dynamic and idiosyncratic enterprise (Naylor, Campbell- Evans & Maloney, 2015). It is viewed as complex because of the realities that teachers encounter such as the nature of schools and classrooms and the diversity of the students in those classrooms (Maloney & Barblett; 2003; Taylor, Van der Berg & Mabogoane, 2013). Learning to teach is dynamic since teachers are faced with different forces such as curriculum policy, school atmosphere, pre-service personal beliefs and pre-conceptions about teaching and learning. Lastly, it is idiosyncratic because student teachers attend science education courses with different dispositions, educational experiences, cultural beliefs and values (Naylor, Campbell- Evans & Maloney, 2015). It is within this observation that Bloomfield (2010) added that the pre-service teachers' prior knowledge, beliefs and experiences can influence what is taken from the courses that are being offered during their initial training. Moreover, this study posits that learning school science requires learning its language, as it appears in science texts and in teachers talk. Considering all these issues Bloomfield made a synoptic inference that "there is no single road to becoming a teacher, nor a single story to learning to teach" (Bloomfield, 2010, p. 221).

This is an acceptable assertion, given that the pre-service teachers do not start teacher training as blank slates, but rather that they possess a wide range of educational experiences, epistemological beliefs and self- efficacy (Naylor, Campbell- Evans & Maloney, 2015). The teacher educators can use such experience to inform their tertiary teaching, differentiate instruction and evaluate teaching which leads to becoming teacher professionals (Trier, 2006; Wideen, Mayer-Smith & Moon, 1998). While prior knowledge about teaching can be used as a fertile ground where learning to teach lays its foundation, it can be a hindrances to learning how to teach as well. For instance, some pre-service science teachers treasure their 'observational apprenticeship' more than what is taught in their training. As such, these very experiences and beliefs can obstruct the conception of the content of teacher education (Brouwer & Korthagen, 2005).

It is therefore suggested that, among other things, teacher education must take into account student teachers' pre-conceived ideas about teaching, and as what is to be brought to the surface so that they can be scrutinised, and if necessary, be challenged. By challenging the irrelevant conceptions about teaching, a new viewpoint may develop, which can create and foster proper attitudes and thinking that are informed by current research work. In short, the teacher education has an obligation to challenge pre-service science teachers, so that a relevant scientific approach to teaching such as emphasis on science language emerges, which will directly influence the students' achievement (Naylor, Campbell- Evans & Maloney, 2015, p. 129).

2.4.2. Pre-service science teachers and rationale for learning science

Generally, in an attempt to improve the school examination outcomes, there is a growing focus on the quality of teachers, which the countries produce (Chingos & Peterson, 2010). As discussed in section 1.1, the quality of teachers to some extent, is a reflection of their own actual training (Kahle, 1999). The rationale for science education in South Africa including the entire Sub-Sahara Africa region is geared towards science education for socio-economic development (Vhurumuku, Holtman, Milkalsen & Kolsto, 2008) and science education for scientific literacy (Abell & Smith 1994; Holbrook & Rannikmae, 2007). Although these two strands seem to be different, they are inter-related.

Globally, science education is seen as a "sort of panacea to problems of poverty, development, sustainability, participatory democracy and good health" (Vhurumuku et al., 2008, p. 233). This view is mainly promoted in developing countries. As such, science education in schools is geared towards promoting technology related careers such as doctors, engineers, science teachers etc. (DuToit & Roodt, 2008). Scientific literacy, on the other hand, is expected to bring an "empowerment of society's citizens in decision-making/

democratic citizenry (e.g. participation in debating socio-scientific issues), producing citizens who can adapt to an increasingly complex scientific and technological world" (Vhurumuku et al., 2008, p. 226). This approach to science education is popular mainly in developed countries, as argued here that science education for scientific literacy is not viable in developing countries "when malnutrition, unemployment, poverty and disease persist with stubbornness and continue to demand larger chunks of the fisccus" (Vhurumuku et al., 2008, p. 242). Concisely, socio-economic and scientific literacy issues cannot be completely be divorced from each other, since they are complementing one another.

Irrespective of the issues of poor performance outlined in sections 2.2 and 2.3, most pre-service science teachers spend a period of three years or more learning their subjects of specialisation. The question of great importance is therefore not whether the duration is sufficient or not. That point has been addressed when reflecting on teaching career as an on-going process of learning. In section 2.4.1. Phelps & Spitzer (2015) argue that the potential teachers cannot simply be prepared to become expert teachers within the teacher education program. There is an emphasis that even upon obtaining their qualifications, pre-service science teachers must be encouraged to learn from and improve on their own teaching so that they can possess 'practitioner knowledge' relevant to their context of practice (Phelps & Spitzer, 2015). It is argued that when teachers learn from their own teaching, they improve both their own content knowledge and awareness of students' ways of thinking. The process of learning from their own teaching is conceived as an on-going teacher formation. Relevant to this study is that teachers must be able to appreciate science language, as it appears in classroom talk and textbooks.

2.4.3. Pre-service teachers' understanding of nature of science classroom language and of science texts

In order for pre-service science teachers to implement the skills of doing and applying science, various aspects within the science domain have to be examined. It is important to appreciate that, not only does science literacy involves understanding of science knowledge (Norris & Phillips, 2003), but also involves understanding the nature of science (Abell & Smith, 1994). By appreciating the nature of science, pre-service teachers and in-service teachers will embrace "knowledge of why science believes what it does and how science has come to think that way" (Abell & Smith, 1994, p. 475). Although some teacher training institutions are located in urban areas, most of the teachers produced are likely to work in the rural areas where they are far from training institutions or expert others (Tytler, Summington, Darby, Malcom & Kirkwood, 2011). As such knowledge about nature of science is very essential in teachers' activities; moreover if students are to become scientifically literate through understanding the nature of science; it is imperative that their teachers must know how science works. In this sense, the pre-service science teachers and teachers in practice have the mandate to shape students' attitudes and manners towards learning a science discipline (Abell & Smith, 1994)

2.4.5. Science language as presented in science texts

Childs et al., (2015) write that there are two components required for a person to read and understand a science text, namely numeracy and literacy. Mathematics is one of the pillars that is readily available and make up part of the science language used in text. It is in the interest of specialised language (technical words) that science has to use other semiotic modes from mathematics such as symbols, equations, graphs (Yore & Treagust, 2006; Lemke, 1998). For the sake of brevity, going through English language scientific journals, physics journals, advanced science textbooks on topics ranging from molecular biology to field ecology, from particle physics to cosmology, what can be seen in the pages of these books and journals are not specialised words only (Lemke, 1998). These textbooks and journals are full of pictures, graphs, mathematical equations, tables and many other visual diagrams. It is clear that the language of science involves the integration of both literacy and numeracy components in its operations.

However, crucial to this study is the recognition that school science also uses common words from everyday life in a special way to say what it means (Lemke, 1998; Wellington & Osborne, 2001). Thus, the study and use of everyday words in science education has gained momentum in recent times (Childs et al., 2015). The presence of ordinary words in the science language and texts is essential, because they form part of the literacy component. This being the case, understanding school science requires understanding the distinct meanings that everyday words embody when used in the science context. Pre-service science teachers are therefore expected to be literate in using both specialised science language (technical words) and everyday words (non-technical) as they explain themselves in teachers talk. According to English language, literacy can be conceived in two ways: the ability to read and write or in another sense it would simply mean knowledge, learned and educated (Macmillan dictionary, 2007). Being literate in science, refers to the ability to understand a disciplined body of knowledge, such as western science, which is text based (Norris & Phillips, 2003). As already mentioned briefly in section 1.6, (as detailed later in this dissertation in section 2.10) the conceptual frame work recognises words as a language and knowledge (Postman & Weingartner, 1971) hence the ability to understand a body of knowledge entails understanding the meanings of words that constitutes a text. Included in these words are the non-technical words that have distinctive meanings when used in the science context. Since Western science is mainly dependent on text, it is hard for a person who cannot write and read to acquire scientific knowledge in depth (Childs et al., 2015; Norris & Phillips, 2003).

As such, Norris & Phillips (2003) argued for a fundamental and derived sense of scientific literacies. Fundamental science literacy regards writing and reading the science content (Norris & Phillips, 2003) while derived scientific literacy refers to “conventional conception of scientific literacy with a focus on the substantive content and nature of science” (Seah, 2016, p. 1061). The fundamental part comprises the knowledge that lies behind science and the thinking required to understand, interpret, analyse, and criticise any text (Norris & Phillips, 2003). The derived part is “constituted by text and the resources that text makes available, and that the primary access to scientific knowledge is through the reading of text” (Norris & Phillips, 2003, p. 237). Therefore, scientific literacy comprises the concepts, skills, understandings, and values generalizable to all reading, and knowledge of the substantive content of science.

In the words of Norris and Phillips (2003) and as argued in this study “literacy in the fundamental sense is central to scientific literacy” (p. 237). Being the case, language is very crucial to scientific literacy, because it involves the ability to write and read scientific text. Considering the language issue, it can be said that a person is scientifically literate when he/she is proficient in science language and understand basic concepts of science (Oyoo, 2017). The power of language and how it is used when teaching (science classroom talk) and written in textbooks requires a good understanding of it in order to draw relevant meanings from both written and spoken discourses. Following this reasoning, it is therefore valid to argue that becoming scientifically literate is essential in interpreting the meanings of everyday words, rich in meaning, which can easily change due to their context of use (Lemke, 1998). It is within this observation that Lemke writes persuasively regarding the fluidity of science language, especially non-technical words:

> Language itself is the most pervasive system of semiotic resources, and the ways in which scientists use specialized languages and use common languages in specialized ways index the discourses of the communities of scientific disciplines. Every word is rich with meanings, meanings that accumulate as we encounter it in many different contexts. Every word is an intersection of many statements, many discourses that make use of it (Lemke, 1998, p.4).

The above quote stands to testify the pivotal role that language plays in science. Yet for science to say what it means, its yoke cannot rest on the shoulders of specialised language alone. The use of everyday words in the science classroom context is very important in the process of teaching and learning. Thus for pre-service science teachers to have a good understanding of these everyday words, teacher explanation is not only important but also crucial.

2.5. Pre-service science teachers' understanding of nature of school science

Literature shows that there is no one acceptable meaning of science. Ziman in Ncube (2016) conceived science as a body of knowledge geared towards solving problems. Feynman (1998) regarded science as a special method of looking at the world, a body of knowledge resulting from investigations, or that science is used interchangeably with technology. Fortje in Oyoo (2014) perceived science as a discourse that encompasses what the society and a body of scientists have come to recognise as being valuable, irrespective of being traditional or modern. From these different conceptions of science, three features regarding science are brought to the surface: a body of knowledge, a special method of looking at the world and application of the knowledge itself in technological developments. This simply means that science is a way of life that has a particular body of knowledge that is recognised by scientists and society (Fortje cited in Oyoo, 2014). It is reasonable therefore to regard science as a culture, since it has a particular way of looking at reality. I now discuss what learning science may entail.

2.5.1. What is learning of science?

In general, learning involves the acquisition of knowledge through study, experience or instruction (Macmillan dictionary, 2007). In other words, the processes of learning may add to one's body of knowledge or change how one understands realities such as beliefs, ideas, or ways of thinking. When deliberating on learning science, or rather what it means to learn science, three features come to the fore: learning science is learning a new language (Wellington and Osborne 2001; Childs, 2006); learning science entails cultural border crossing (Hodson 2009; Yore & Treagust, 2006,) and learning science as akin to undergoing conceptual change (Duit & Treagust, 2003; Oyoo, 2007). Since this study investigates the pre-service science teachers' understanding of the meaning of non-technical words in the science classroom, the three features are now examined in more detail.

2.5.2. Learning the new language

According to Childs (2006, p. 17), "to study Science is to learn a foreign language and unless one masters the language one cannot properly understand the Science". Hence, Wellington and Osborne (2001) posited that learning science is in many ways similar to learning a new language. The authors argue on the premise that science presents "more difficulty in that many of the hard, conceptual words of science – such as energy, work, power – have a precise meaning in science and sometimes an exact definition, but a very different meaning in everyday life" (Wellington & Osborne 2001, p. 5). Therefore learning science "involves internalizing the social language and genres of science and becoming able to use them appropriately in various situations" (Leach & Scott, 2003, p. 100).

Altmann (1997) understands the meaning of the word as the "knowledge that one has of the situations or contexts in which it would be appropriate to use that word" (p. 120). In this respect, it is the meaning of the word as used in a situation that constitutes the feature of the new language. It is argued that knowing the word in everyday use is one thing, and knowing the meaning of the same word in scientific context is another thing (Du Plooy-Cilliers, 2014). It is the connotative meaning of words which compares learning science to learning a new language. This is true with everyday words which students encounter at university level, in text books or lectures; for example the words *sensitive* and *spontaneous.* When these every day words are used in the science context, their meanings change either just slightly or totally. Learning science is conceived as learning a new language because; even when these everyday words are used in the science context; they acquire a different meaning from the known in everyday life. (Oyoo, 2017). In summary, both everyday words used as science words (mixed technical words e.g. *mass*) and every day words used in the science context for example the word *reaction* represent a new language when used in the science classroom context.

2.5.3. Cultural border crossing

Phelan, Davidson, and Cao (1991) give an anthropological definition of culture, which constitutes the norms, values, beliefs, expectations, and conventional actions of a particular group of people. Aikenhead (1996) argues that the science community is composed of scientists who share a set of “norms, values, beliefs expectations and conventional actions” (p.9). Of course, these values, norms etc. might differ between individual scientists and the situation in which he/she find himself/herself. In general, it is appropriate to consider science as having its own culture, due to these anthropological characteristics that it possesses. Pre-service science teachers who come to learn science are from different communities, which have their own understanding of the world phenomena and are different from what is promoted by the science community. As a result, cultural clashes are likely to be experienced between students’ life world and that perpetuated by the science community (Aikenhead & Jegede, 1999; Driver etal. 1994).

Mammino, Mathibeli & Mutambala (2000) indicated that pre-service science teachers might experience border crossing as they move from high school to tertiary institutions such as universities. The transition involves ~~a~~ “substantial differences, both in the depth of the content and in the overall teaching and learning approach” (Mammino, Mathibeli & Mutambala 2000, p.78). For instance , in the field of science, the differences are felt and are evident due to the limited scope of secondary school science. In addition, school science is often constricted to the mere acquisition of some isolated pieces of information, which is presented as dogmatic treaties. Interesting though is the revelation that both Western students and non-Western students experience science as something foreign to them. To this Aikenhead (1996) contends,

> Non-Western students have acquired a traditional culture of their community, which interferes with learning Western science. In the same vein, Western students have their common sense understanding of their physical world; that is, their "traditional" science -- their preconceptions -- that makes sense within their life-world subcultures. Thus, Western students also have difficulty acquiring the culture of Western science (p. 21)

This study argues that one of the things, which make learning science difficult, is science language. Yore & Treagust (2006) argue that most students experience that the language used in the science classroom is different from their home and instructional languages. As already discussed in section 1.3.2, Wa Thiong'o (1994) argued that language is both a means of communication and a carrier of culture. This means that, to experience cultural border crossing among pre-service science teachers, an understanding of how science classroom language operates is of paramount importance. To this, Lemke (1990) adds that, “the mastery of science is mainly a matter of learning how to talk science” (p. 153). This then means that, “every science lesson is a language lesson” (Wellington & Osborne, 2001, p. 2). Several studies have indicated that most science students encounter a three-language problem namely: home language, instructional language and science language (Hodson, 2009; Yore & Treagust, 2006). Students are required to cross the boundaries of home language and instruction language in order to acquire science language. It has transpired that the difficulties are acute among students who "parallels English language learning and involves moving across discourse communities of their family, school, and science" (Yore & Treagust, 2006. p. 296).

2.5.4. Learning science as a conceptual change

Posner, Strike, Hewson, & Gertzog, (1982), observed that the process of learning deals mainly with ideas, their structure and the evidence surrounding these ideas. It is argued that learning cannot be reduced to "simply the acquisition of a set of correct responses, a verbal repertoire or a set of behaviours" (Posner et al., p. 12). The process of learning, like that of inquiry, is described best as the process of conceptual change. According to Duit and Treagust (2003), the concept conceptual change denotes "learning pathways from students' pre-instruction conceptions to the science concepts to be learned" (p. 673). It has been unveiled that students do not come to class as empty slates, but rather have their own pre-conceptions and epistemological beliefs about science. These conceptions are based on students' experiences, their informal observations and apprenticeship observations (Lortie, 1975). These conceptions can be viewed as misconceptions, naïve beliefs or alternative frameworks, if they do not conform to the cultural norms and beliefs surrounding what it means to learn science (Duit & Treagust, 2003). Being the case, it is essential to guard against the misunderstanding which can arise regarding the word *change* in conceptual change.

Most often the word *change* has been understood as an exchange of pre-constructional conceptions for science concepts acquired (Duit & Treagust, 2003). Conceptual change, regarding learning applies in situations where the learners' pre-conceptual structures have to be restructured, in order to accept the intended knowledge (Duit & Treagust, 2003, p.673); in our case the science concepts and explanations to be acquired. However, it is important to explore how students' conceptions change when confronted with new phenomena or the meaning of a phenomenon. For example, the common conception in most of Southern Africa is that lightning is caused by some mystical powers such as witch craft. Some learners, who share this sentiment, will find it difficult to embrace the scientific explanation about lightning. Further, Leach and Scott (2003) give an example of everyday acceptable understanding of energy being used up after a walk or some type of intensive exercise. This way of talking and thinking is not appropriate in science, due to the scientific principle of conservation of energy (Leach & Scott, 2003)

Posner et al. (1982) propose two possible phases to confront such difficulty, namely assimilation and accommodation. In the assimilation phase, the student deals with the new phenomena using already existing concepts. The accommodation phase, on the contrary, entails replacement and reorganization of central concepts (Posner et al., 1982). Therefore, the accommodation phase comes into play when the existing concepts are not sufficient enough to allow the student to comprehend the new phenomena effectively. As such this phase is not only important in conceptual change theory but crucial, since it supports radical change in conceptions, so that new learning may take place.

There are four conditions to be put in place for the radical process of accommodation to take place. The first fundamental step is dissatisfaction with the existing conceptions (Posner et al., 1982). The authors (Posner et al., 1982) believed that students would avoid making major changes in their concepts until they are convinced that "less radical changes will not work" (p. 214). The authors claim that "before an accommodation will occur, it is reasonable to suppose that an individual must have collected a store of unsolved puzzles or anomalies and lost faith in the capacity of his current concepts to solve these problems" (Posner et al.,1982, p. 214). In this regard, the new conception is expected to be intelligible, plausible and fruitful in order to be fully embraced in the accommodation phase. The lucidity of the new conception is seen through its ability to structure the prior experiences of the students. The new conception will be regarded plausible when it is able to solve the problems produced by its precursors and is conformed to other forms of knowledge (Duit &Treagust, 2003). Lastly, the new conception is deemed fruitful and reliable when it displays the likelihood of being extended, and available to incorporate new insights and discoveries (Duit &Treagust, 2003; Posner et al., 1982).

2.6. Relevance of the nature of science and science language

The nature of science is one of the constructs that is heavily debated in the science community. Dekkers and Mnisi (2003) employed the construct nature of science to respond to issues regarding ontology and epistemology; in order to deal with questions such as the origins of science (where does scientific knowledge come from?) and the authenticity of science knowledge (what is the status of the scientific knowledge?). Lederman (1992) explains that nature of science involves "science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (p.331). Vhurumuku & Mokeleche (2009) regard the nature of science as:

> An individual's understandings, conceptions, perceptions, images, ideas, views, beliefs and values about the products of science (laws, theories, principles, models, facts and explanations making up the body of knowledge called science), the processes of science (the process of inquiry including the methods of science) and the scientific enterprise, which includes the social, ethical, political, religious, philosophical contexts and paradigms guiding the work of scientists (p. 97).

Despite these discrepancies incurred in defining this construct, one thing that stands out is that a good understanding of the construct contributes tremendously in developing scientific literacy (Abell & Smith, 1994). I have discussed in section 1.1, how language informs thought and *vice versa* (Vygotsky, 1978). It should therefore be established that the relevance of nature of science in this study on language, lies in the conviction that pre-service science teachers' thoughts and understanding of science can influence the way they are able to teach science in schools. The fact that language is "a vehicle through which knowledge is acquired and organised" (Child et al., 2015, p. 428), it is a powerful tool that can influence either positive or negative perceptions of science. Literature suggest that pre-service science teachers' views on the nature of science are meticulously linked to their beliefs about teaching and learning, as experienced during their years of schooling (Abell & Smith, 1994). To some extent, the way pre-service science teachers understand the teaching and learning of science, is partly (if not all) espoused by science lessons and science teaching they have witnessed. Since we have recognised that science literacy fosters the understanding of scientific knowledge, the inclusion of nature of science in this study is considered relevant on the premise that "language is an integral part of science and science literacy" (Childs et al., 2015, p.428). Hence, the correct interpretation of non-technical words is required, in order to bring intended meanings in the context of use.

Generally, there is a consensus that the nature of science is tentative (subject to change), empirically based (based on and derived from the observations of the natural world), subjective and has a human inference, imagination and creativity (Taber, 2008). This understanding of the nature of science gives guidance to the fact that the use of the everyday words in the science context is subjected to the same human construct. In other words, although non-technical words such as *reaction, spontaneous, disintegrate* embody distinct meanings when used in the science context, they can still retain their everyday meanings if and when used in an everyday context. Krippendorff (2013) argued that context is “always someone’s construction, the conceptual environment of a text, the situation in which it plays a role” (p. 38), and should be treated as such. Since nature of science results (among other reasons) from human imagination and logical reasoning (Taber, 2008), it is the flexibility of some of the everyday words that makes them easy to use both in science and everyday contexts.

2.7. **Anatomy and functional value of school science**

The language of science, as reflected in both textbooks and teachers’ talk, can be divided into two components, namely the *technical component* and the *non-technical component* (Oyoo, 2017; Oyoo & Semeon, 2015). A closer look at these components in their respective capacities may unfold the role they play in science learning in the classrooms.

2.7.1. The technical component

According to Oyoo (2017), the technical component is made of words specific to a science subject or discipline and gives a particular science subject its identity. For example, words like photosynthesis, respiration and genes are words generally associated with biology; momentum, capacitance and voltage are associated with physics, while cations, anions, atoms and moles are mostly used in chemistry (Oyoo & Semeon, 2015, p. 44). Since these technical words give identity to a particular subject or science discipline, they are sometimes called science terms or simply science words or terminologies (Oyoo, 2017). On the same point of identity, it is observed that by listening to the language used in a science classroom, one can automatically know that it is either life science, chemistry or physics components being taught. It is the uniqueness of these technical words that makes their meanings known in the international science community (Oyoo, 2012).

Further, Lowe (2009, p. 3) reasons that science words or technical words can be further subdivided into two categories namely specialized technical words and mixed words (sub technical and semi-technical). The specialized technical words are used only in science and have no meanings outside science itself e.g. bacterium, proton, ultraviolet rays, calorie etc. (Lowe 2009). The second category (Mixed words) reflects everyday words deliberately used as science words e.g., mass, energy, force and cell (Miller as cited in Oyoo 2009). These science words possess new science meanings in addition to their everyday meanings (Oyoo, 2017; Wellington, 1994; Oyoo 2009; Oyoo & Semeon, 2015). The new and different meanings these words acquire when they become science words make them resemble words in a new, different or foreign language, though with fixed meanings (Oyoo 2012, 2017).

2.7.2. The non-technical component

The non-technical component comprises of words that are found in everyday language, but have specific meaning when used in the science context (Oyoo, 2017). Oyoo (2011) asserts that it is this "part of the science teachers' classroom language that may be referred to as the medium of classroom instruction or interaction, as separate from the technical terms" (p. 852). To be less general, this component of the science teachers' classroom is the one in which a science text book is written (Oyoo, 2011) and what teachers' talk emanates from. The bold words in the following assertion show how non-technical words are used in science textbooks:

> "Gas *molecules* display **random** motion; we may **predict** their behaviour from **theoretical** considerations: the actual volume of the molecules may be **neglected"** (Gardner 1972, cited in Oyoo, 2011, p. 852; bold emphasis added).

In the assertion above, the italicised word "molecule" is a technical word in chemistry. The words: **random, predict, theoretical** and **neglect** are referred to as non-technical words, when used as science words in the science context (Oyoo 2011). These words help in the understanding of the behaviour of gas molecules. The non-technical component is further categorized into three subdivisions: namely everyday words used in the science context, meta-representational terms and logical connectives (Oyoo & Semeon 2015).

To begin with, the everyday words used in the science classroom context, is a better known category in research literature. The words in this category have different meanings when used in a science context, in comparison to their everyday use e.g. disintegrates and reaction. Such a difference makes contextual proficiency an element, which fosters learning to take place effectively in any language (Oyoo & Semeon, 2015). For instance, in the Macmillan dictionary (2007);

> The word '*disintegrates*' means to break into small pieces or to become much less strong or united and be gradually destroyed. The word '*reaction*' describes the way one feels as a consequence of something that happens (Macmillan dictionary, 2007, p. 421-1232)

When these words are used in the science context they undergo a complete change (metamorphosis). As already discussed in section 1.1, in the physics context, the word *'disintegrate'* refers to decaying of the unstable nucleus of an atom (Duncan, 2013). This is used in radioactivity where decaying does not refer to rotting or decomposition of the nucleus. It essentially refers to evolution of a new nucleus which has properties very different from the original nucleus (Oyoo, 2017). In physics, the product of nucleus decay process results in 'daughter' nuclei (Duncan, 2013). The word '*reaction'* in chemistry illustrates what happen when two or more substances are mixed (LeMay et al., 2012). Thus, non-technical words, when used in the context of science, carry new meaning important for learning a particular subject.

The second category is *Meta-representational* terms. These refer to the non-technical words that signify thinking, including metalinguistic- and metacognitive verbs (Oyoo, 2012). Metalinguistic verbs are words which take the place of the verb to say such as *define, describe, explain, argue* and *suggest* (Oyoo, 2017, p.786). On the other hand, metacognitive verbs are words which take the place of the verb to think such as *infer, calculate, deduce analyze, observe, hypothesize, assume* and *predict* (Oyoo, 2017, p.786). Overall, the usefulness of these meta-representational (metalinguistic and metacognitive) verbs is that they set up the same words, which are associated with learning and 'talking science' such *as observe, hypothesize, experiment, classify, analyse, conclude, deduce* etc. (Lemke, 1990 cited in Oyoo, 2012). While these words are often used in examinations to indicate the content, structure and emphasis required by the examination questions, students' understanding of the words entails understanding key features of the questions (Oyoo, 2009). As such, the function value of these words is that;

> "… knowledge of their meanings may enhance students' understanding of the demands of the examination questions, so as to accordingly design the correct responses also…understanding of the meanings of these words may enhance their classroom participation" (Oyoo 2012, p. 853).

The *logical connectives* make up the third category. These are words or phrases that operate as links between sentences or between a concept and a proposition (Oyoo, 2017, Oyoo & Semeon, 2015). Typical examples of these words are *since; because; conversely* and *therefore* (Oyoo, 2017; Oyoo & Semeon, 2015). The functional value of these logical connectives is that they are "words that are commonly used in the oral or written discourses of science, to link observation to inference, theory to explanation, hypothesis to experiment,

experiment to findings …" (Fensham cited in Oyoo, 2012, p. 853). Moreover, understanding of their meanings improves "students' classroom participation and understanding of the processes of learning science, including science teachers' classroom language" (Oyoo, 2012, p. 853). Figure 2.1 below, adapted from Simelane (2014, p. 7) represents the summary of the components of the science classroom language based on the literature examined above.

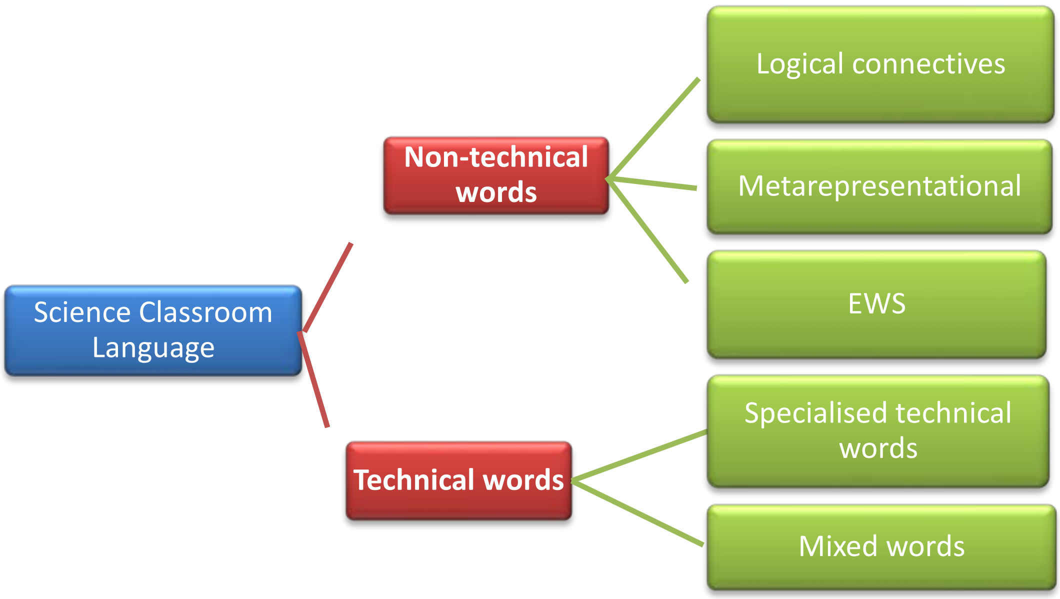

Figure 2.1: Summary of components of science classroom language

Key: EWS =Everyday words used in science, Mixed words= Words found in everyday and science language but are used as science words

2.8. Studies on pre-service science teachers' understandings of the science language

For the past few decades, many of the studies in science education are moving towards addressing issues regarding pre-service teachers (Chingos & Peterson, 2010; Darling-Hammond & Sykes, 2003). It seems that not only South Africa experiences problems with teaching and learning of science. There is a general feeling that improving the quality of teachers produced from teacher training institutions will result in improving students' performance in science related subjects at school level. In the United States of America for example, there is a growing concern that teacher training need to be reformed. Instead of using the teaching industry for survival, teachers are cautioned to direct their efforts towards teaching students (Kennedy, 1999). Moreover, the training geared towards generating adaptive experts, especially in societies where academic standards are constantly changing, is of paramount importance (Darling-Hammond & Bransford, 2005). In this regard, studies suggest that prospective teachers need to learn from their own teaching over time, since teacher-training programmes are seen to be too short to produce life expert teachers (Phelps & Spitzer, 2013).

In Australia, another study established that some pre-service teachers tend to cling to the art of teaching as held by their primary or high school teachers (observational apprenticeship). As such, they cannot accommodate new approaches to teaching encouraged by the teacher educators (Campbell-Evans, Maloney & Naylor, 2015). Some literature emphasises on training high quality teachers (Chingos & Peterson, 2010, Darling-Hammond & Sykes, 2003) by encouraging pre-service science teachers to use different modes of instruction across content areas (Miller, 2009). Some researchers' emphasis is on Pedagogical Content Knowledge (PCK) as an academic construct and conceptual tool (Nilsson & Loughran, 2012). The implication is that PCK can help pre-service science teachers to achieve professional knowledge and practice.

However, even with this, very little is researched about how pre-service science teachers relate to language of learning and teaching science. To be more precise, this research seeks to investigate pre-service science teachers' understanding of meaning of every day words when used in the science classroom context. More recent researchers in Singapore showed that several studies have addressed elementary teachers' perception of language in science school classrooms (Seah, 2015) and the importance of elementary teachers' talk in science classrooms (Seah &Yore, 2017). In these two studies, the issue about the language has been identified to be crucial in the teaching and learning of science subjects.

It has become clear that learners encounter difficulties with words of the instructional language, used in science at elementary level (Seah &Yore, 2017; Seah, 2015). In South Africa, recent studies on language in learning and teaching science have concentrated on high school (Grades 10-12) learners' difficulties with language of learning and teaching science (Oyoo, 2017; Oyoo & Semeon, 2015). Overall, these recent findings resonate with previous outcomes from a body of researchers regarding learners' difficulties with science language in a classroom context. It is noteworthy that most of these studies were investigating difficulties that learners have with everyday words when used in a science classroom at secondary/high school level. However, published studies focusing on pre-service teachers difficulties with everyday words in classroom language is somewhat scarce. Therefore, the existing gap regarding pre-service teachers' understanding the meaning of non-technical words used in the science classroom is the principal focus of this study. It is recognised that one study on pre-service science teachers recently completed (Sibiya, 2017) had focused on only one segment of pre-service teachers namely second year BEd. students.

The key impetus of this study was therefore to close this gap and make a significant contribution to science education. In fact, this study can be considered the first of its kind in South Africa, which investigated pre-service science teachers' understanding of the meanings of everyday words used in the science context. Bearing in mind that participants were from an English medium university, the findings of this study timely counteract "the myths regarding the place of general proficiency in the instructional language in the successful learning of science" by pre-service science teachers (Oyoo & Semeon, 2015, p.40). The ambitious aim of this study is to build a foundation for science literate teachers who are aware of complexities of language in the science subjects they teach and will in turn produce learners who are "scientifically literate not scientifically indifferent" (Aikenhead, 2011, p. 10).

2.8.1. Difficulty with science classroom language

Generally, the outstanding challenge on science classroom language, which the pre-service science teachers are going to use, is that it is different from both teachers' and learners' language as experienced in everyday use. Ncube (2016) explains that the experience of *difference* is more often than not the cause of difficulty, which the students come across when learning science. This being the case, the role of the science teacher in using language as a tool to intervene in learning processes (discussed in more detail section 2.8.4) is more than applicable. The teachers' use of language to guide and shape learners' understanding of the science concepts is thus critical (Oyoo, 2012).

Furthermore, Oyoo and Semeon (2015) reviewed the difficulty of science classroom language residing in science words being unfamiliar to the learners. Learners are very often dismayed and confused when a familiar word, having the same spelling and pronunciation, embraces a different meaning opposed to the one used in everyday language. This makes the learners feel insecure because there is lack of conformity of reality (new meaning) with thought (pre-existed idea of the word) as conceived in everyday language. To this Lemke (1998) writes persuasively:

> "…every word is rich with meanings, meanings that accumulate as we encounter it in many different contexts. Every word is an intersection of many statements, many discourses that make use of it" (Lemke, 1998, p. 4).

The above quote recognises the fluidity of some words, as they are used in different discourses such as science classroom language. While learners experience such difficulty, teachers can encounter problems as well, if they are not encultured in science classroom language.

2.8.2. Difficulty with the technical component

In the discussion of the technical words in section 2.7.2, it emerged that technical words exists in two categories: specialized technical words (e.g. proton) and mixed words (e.g. mass). The problem with specialized technical words lies in their unfamiliarity because some of the words are unique to science, as they are not used in everyday language (Oyoo, 2009; Ncube, 2016). These words have very precise meanings, such as bacterium, and are abstract in nature (Bulman, 1986, p. 21) so that learners may not fully understand or feel confident in using them; for example terms like "thermal conductivity, enthalpy change", and "heterogeneous alloy" (LeMay et al., 2015). Moreover, some of these specialized technical words are polysyllabic, difficult to spell and to pronounce as well e.g. radioactivity, protactinium-234, deceleration etc.

The challenge with the second category (mixed words) is polysemous, because these words acquire new scientific meanings in addition to their everyday meanings (Oyoo, 2017). For instance, using the word *mass* to illustrate how mixed words can embody double meanings. In this respect, I am reminded of my own teaching experience when I asked the learners if they knew that nucleons have ***mass,*** and one of the learners then asked if nucleons go to church. A learner may encounter the word *mass* in everyday language as a religious ritual, which takes place in designated places of worship. In science the same word *mass* is used to mean the amount of matter in an object (Giancoli, 2014). In the science context, the word *mass* signifies the measurement of a particular quantity and it has particular standard or unit. Giancoli (2014) writes that "the standard unit of **mass** is the **kilogram** (kg)" (p.9). This element of changeability in some science mixed words causes them to represent a foreign language and culture. To this observation, Oyoo (2007) writes that:

> Science word has a meaning different to that in everyday language is one reason such words can be viewed as representations of a different, new or foreign language. The use of these words therefore comes with a way of speaking very uncharacteristic of

> the common/dominant culture; the science words/language therefore also represents a different culture – the (foreign) science subculture (p. 4)

These characteristics that have been described in the assertion above, render these words to have triple identity namely conceptual, cultural and linguistic respectively (Oyoo 2007). In short, mixed words pose a big challenge because of the double meanings they embody. Comparing the level of difficulty between mixed words and specialized words, the specialized words, even though difficult due to their foreignness, are relatively easy to comprehend because they hold one meaning which learners can embrace. Moreover, when these specialized words are used in social situations, the implication of their original meanings is still maintained. For instance the word 'entropy' within the theoretical framework of thermodynamics is largely related to "the extent of randomness in the system or with the extent to which energy is distributed among the various motions of the molecules of the system" (LeMay et al., 2015, p. 856). Likewise in social situations the concept 'social entropy' is commonly used referring to systems such as companies becoming chaotic or being in a state of uncertainty if certain measures are not put in place (Davis, 2014, p.113).

2.8.3. Difficulty with the non-technical component

The literature reported on in section 2.7.2 has shown that the non-technical component consists of three categories of the non-technical words, namely Everyday words used in science classroom context, Meta-representational terms and Logical connectives respectively (Oyoo 2017; Oyoo & Semeon, 2015). Starting with everyday words used in the science context, it was Paul Leslie Gardner who pioneered the study of the student difficulties with everyday words, used in the science context (Oyoo, 2017). Gardner conducted his studies in this area in three countries. In Papua New Guinea, the sample comprised of secondary school students doing Forms 1-4 but English was not their first language. In Australia, the sample comprised of science students from Class I, II, II and IIV for who English was their first language. In the Philippines, the sample was science students doing Forms 1-4 for who English was not their first language (Oyoo, 2009). These studies revealed that students have difficulties with the everyday words used in the science context.

Other subsequent studies in this area included Farrell and Ventura (1998) who focused on non-technical words as used in school subject-physics; Prophet and Towse (1999) who focused on the developing country, Botswana with English second language learners and a developed country, the United Kingdom with English first language learners (Oyoo, 2009).

Oyoo's (2000) study was also conducted with both first and second English language learners in Kenya and in the United Kingdom. The trends in all these studies have disclosed that learners have difficulties with everyday words used in the science context, regardless of their linguistic orientations, gender (Oyoo, 2009) and whether learners were English first language (EFLs) or English second language speakers (EFLs).

The findings of these studies can be summarized as follows: Firstly, students confuse words which are graphological or phonetically similar for example *instinct* with *instant, insist* and *resist* with *persist*, and *generalise* with *generate*, *accumulate* with *accommodate* (Tao 1994, p.18). Secondly, students selecting words which meanings are the opposite to the intended meaning, for example *fill* with *evacuate*, *take in* with *emit*, *initial* and *final*. Lastly, students often confuse words in the same semantic field, for example: *detect* with *project*, *isolate* with *insulate*, *theory* with *fact* or *belief* (Tao, 1994). Likewise, Pickersgill and Lock's (1991) study, which focused on first language learners, reported no difference between the understanding of non –technical words in the science context by male and female learners. In fact, the findings of Marshall, Gilmour and Lewis' (1991) study showed that English second language learners in Papua New Guinea indicated that these everyday words were easier when presented in the science context. This was contrary to the findings in the case of learners in the United Kingdom studies of 1980/1985 by Cassels and Johnstone whose participants were English first language speakers. It is through research findings like these that Oyoo & Semeon, (2015) concluded:

> " …proficiency is a necessary (as a prerequisite for any learning in a language) but not sufficient factor of successful learning (ability to tell context); contextual proficiency is a necessary additional for successful learning in science, given the way in which meanings of everyday words change when used in science context " (p. 47).

Ali and Ismail's (2006) study may deem the above assertion correct where students in science and engineering classes performed better on the everyday words used in science context than students in arts classes. Following the trends of how learners performed with everyday words in various studies stipulated in the previous paragraph, it is reasonable to attribute the engineering and science classes' good performance to proficiency in science language (Ncube, 2016). This is because understanding of everyday words becomes difficult due to the multiple meanings it harbours or if words sound or look alike, such as the words power and energy (Wellington & Osborne, 2001).

The recent studies, Oyoo (2017); Oyoo and Semeon (2015) and Ncube (2014) *on learners' interpretation of everyday words when used in physics context* confirms that South African learners struggle with these words. Meta-representational words (metalinguistic and metacognitive) are the second category of the non-technical words used in the science context. The difficulty with these words used in the science context, is more evident in examinations (Oyoo, 2012). This category contains words such as "define" or "explain" (metalinguistic) and "deduce" or "analyze" (metacognitive), which demand a specific way of how questions should be answered. Failure to recognize the functional value in terms of how responses may be constructed may be tantamount to poor performance in the examinations.

The logical connectives, which is the third category of the non-technical words in the science context can also pose a challenge, if suitable processes by teachers are not taken to support learners to apprehend them (Oyoo, 2008). Gardner 1977 (cited in Oyoo, 2008) highlighted that logical connectives, often used in textbooks and in teachers talk, emerged as difficulties as follows: First are those connectives that indicate inference such as *consequently, hence, it follows, therefore* etc. which are seen to be difficult to the learners. The other groups of connectives are the ones that entail generalizations such as *in general, frequently, commonly, occasionally* which are often observed to cause difficulties. Moreover, those that indicate similarities, comparisons and contrasts such as *conversely, at the same time, nevertheless, in contrast* and *similarly* pose a challenge as well. Some difficulties were also detected with additive terms which include words such as *further, furthermore, in addition* and *moreover*. Generally, three connectives have been identified to be extremely difficult namely; *conversely, if* and *moreover* (Oyoo, 2008). It is argued that problems with non-technical words in science can be attributed to teachers' lack of awareness of the difficulties associated with these words in the LOLT, or the failure to tell between technical and non-technical words (Oyoo, 2017). Therefore, it is important to examine the role of the science teacher in teaching and learning of science language.

2.8.4. The possible role of the science teacher in the difficulty of science classroom language

Vygotsky (1978) defines Zone of Proximal Development (ZDP) as the "distance between the actual developmental level as determined by independent problem solving and the level of potential development, as determined through problem solving under the guidance or in collaboration with more capable peers" (p. 86). The ZPD is applicable in this section because it places the teacher in the role of the mediator of the learning process. In accordance with the ZPD, the teacher mediates learning processes by helping learners to understand and solve problems that they could not manage on their own. The role of the teacher in this study is relevant based on the following reasons: a) teachers are the mediators of the science language as presented in science textbooks, b) teachers are needed for the intervention process as the knowledgeable others and c) most of the classroom talking (two thirds) is dominated by the teachers' talk (Oyoo, 2012).

Research has shown that one of the difficulties of learning science is learning its language irrespective of whether the learners are first or second language speakers of the LOLT (Oyoo, 2017; Oyoo & Semeon, 2015). It is therefore imperative that teachers mediate both science content and science language for effective learning to take place. As discussed in Section 1.1, Vygotsky (1978) claimed that a dynamic relationship exists between language and thought and therefore, concepts that teachers teach cannot be fully understood if they are not represented in words (Vygotsky, 1978). It is important that learners must know and understand the words that are used in the science classroom. It is therefore essential for the teachers to explain the words, which constitute science classroom language, namely technical or non-technical words. In addition, the teachers need to emphasize the relationship between words and their context of use, and that everyday words used as science words becomes science concepts (Oyoo, 2012; Oyoo & Semeon, 2015).

Oyoo (2009) highlights some of the steps; such as talking speed, pronunciation, audibility and language level; have to be checked so that difficulties with words in science language can be reduced,. He argues that there is a correlation between talking fast and not pronouncing words clearly. This might lead to some students not understanding. Oyoo (2009) cites words such as *consistent and constituent, perimeter* and *parameter, spontaneous* and *simultaneous* as some of the words that cannot be grasped, if the pronunciation is not articulated well. Audibility is one of the aspects that need to be checked by science teachers. For instance, some classes are large, (a characteristic of South African classes); therefore voice projection is necessary for the learners to access the words that are being used. This issue can be very acute in secondary schools, where the learners are not acquainted and proficient in the science language. Furthermore, the vocabulary (language level) used, can hinder the learners to grasp the science. The process of learning science is cumulative in nature where current concepts build on the previous ones. This means that if the learners are bombarded by language that is beyond their level of understanding, learners will have problems to access the science content.

2.8.5. Language policy in South Africa and relevance of this study

In South Africa, English and Afrikaans are used as languages of learning and teaching (LOLT). South Africa has eleven official languages. The majority of learners are taught in their mother languages from Grade 1 and 3, after which learning takes place in either English or Afrikaans (DBE 2010). The shocking reality is that the background of most of the learners is not English or Afrikaans. Statistically, the student population that speak English as their home language comprises only 7% and yet almost 81.5% of the learners use it as their LOLT (Department of Education, 2010). This stimulates us to reflect on the validity of using foreign languages as medium of instruction in South Africa.

A study conducted by the Department of Education in 2007 on the use of languages in schools revealed that English is a highly preferred language with 81.5% of the learners in the FET band studying in English. Afrikaans has 12.5% of learners while 6% of learners use African languages (Department of Education, 2010). It is observed that English is the top language of choice for teaching and learning (LOLT). English is associated with economic growth (DBE; 2010) and most of the developed countries use it in their daily economic endeavours. Lee (2012) argued that "it is widely accepted that majority of new knowledge is created by developed countries in which English has enjoyed a special status" (p.3). In these countries, the level of English proficiency is regarded as part of the human capital since it guarantees a person access to an employment. Generally, English is gaining a special status as a global language since its influence infiltrate countries that were regarded previously as non-English areas (DBE, 2010; Lee, 2012; Airey, 2009). For instance, the official publication of the German Economic Association and the Spanish Economic Review, the official publication of the Spanish Economic Association, manuals for machinery, all are published using English language (Lee, 2012).

Moreover, the global influence of English language is seen through the potential it has for people to study across borders. People interested to pursue further studies in countries other than South Africa have a great opportunity because most countries use English as a medium of instruction. Therefore, learning English language prepares the person to access studies both at national and international level. To this end, Lee (2012) adds that people are more likely to be connected with new knowledge and development if they possess a good level of

English proficiency. One of the challenges that most African countries are facing is human capital flight (brain drain). It is apparent that most of the skilled African people are constantly in search for greener pastures in highly industrialized continents, such as Europe and America (Vhurumuku et al., 2008). The proficiency in English is one of the key factors to this human capital flight since it allows these skilled African people to cross borders to seek career opportunities. As such, the status of English as *lingua franca* has influenced the Department of education and other relevant stakeholders such as parents and teachers to accept and believe that it is to the advantage of learners to be taught in English (Wildsmith-Cromatory & Gordon, 2009).

The discussions on proficiency in the language of instruction paved a way to contemplate its impact on pre-service science teachers in this study. Therefore, the question that assumes priority is whether high level of proficiency in the LOLT alone account for good performance in physical science. Perhaps to put the question in context is to investigate whether pre-service science teachers encounter difficulties with non-technical words used in the science classroom, given the level of their general proficiency in LOLT?. This study examines pre-service science teacher's understandings of meanings of everyday day words when used in science classroom context. As already discussed in this chapter (section 2.8.3), proficiency in LOLT is indispensable but not adequate enough for successful learning of science. This is because given the way in which the meanings of everyday words change due to the influence of context; contextual proficiency therefore is required for successful learning in science (Oyoo & Semeon, 2015). The need for contextual proficiency is to support the premise that "everyday words cease to be mere English words when used in science context" (Marshall &Gilmour 1991, p.334). In addition, Chinua Achebe (1990, p.162) cited in Oyoo and Semeon, 2015, p. 43) argued that learning science in a particular language needs more than mere proficiency in that language as he questions: "What kind of science can a child learn in the absence, for example of basic language competence and attendant inability to handle concepts?"

2.9. The theoretical framework: Socio-cultural theory

As briefly discussed in section 1.6, socio-cultural theory is deemed relevant as theoretical framework to this study because of its inclination towards how knowledge is constructed in a classroom context. This theory posits that "knowledge is constructed in the social context of the classroom through language and other semiotic means" (Chin, 2006, p.1317). Moreover, the theory considers learning as something that happens between people (inter-psychological) and within the mind of an individual student (intra-psychological). On an inter-psychological plane people use words as language to mediate knowledge and on an intra-psychological plane, language is used as a psychological tool to internalize knowledge. Vygotsky (1978) argues for a tangled web that is woven between language and thought. He argues for a dynamic relationship that exists between language and thought such that the concepts that teachers communicate and teach cannot be fully understood if not represented in words (Vygotsky, 1978). There is an emphasis on social mediation through language which leads to thought formation in the mind of the pre-service science teachers.

Wertsch (1994), argues that a socio-cultural approach "concerns the ways in which human action, including mental action (e.g., reasoning, remembering), is inherently linked to the cultural, institutional, and historical settings in which it occurs" (p. 203). It is not possible to give an account of human action without considering their cultural, institutional, and historical setting or context behind the action. Yet, of interest is that such contexts are produced and reproduced through human action (Wertsch, 1994). Context (discussed in detail in Section 3.6) is conceived as "always someone's construction, the conceptual environment of a text, the situation in which it plays a role" (Krippendorff, 2013, p. 38). Such analysis shows how important context is in understanding a particular phenomenon such as meanings of non-technical words when used in the science classrooms. Flanders (cited in Oyoo, 2012, p. 851) posited that at least two thirds of all the science classroom talk is teachers' talk, hence teacher mediation and explanations are crucial to bring contextual word comprehension to the non-technical words. Therefore, in this study pre-service science teachers' understanding the meanings of non-technical science words were influenced by their experiences to which they were first exposed. More importantly, failure to give the correct meanings of non-technical science words could be attributed to lack of teacher explanation during the two thirds science classroom talk. Leach & Scott (2003) posited that the processes leading to learning and development of the higher mental functions in the individual come from the social environment. It is in this social milieu that language and other semiotic resources facilitate means where ideas are discussed between people on an inter-psychological plane.

2.9.1. Learning process and concept of mediation

The diverse bodies of literature recognise the distinctive role of mediation in Vygotsky's cognitive psychology (Fernyhough, 2008; John-Steiner & Mahn, 1996; Karpov & Haywood, 1998; Wertsch, 1994). In particular, Karpov and Haywood (1998) argue that the higher mental processes are mediated by psychological tools such as language, signs and symbols through classroom deliberations (social mediation). In case of teachers/lecturers, they impart knowledge to learners or the pre-service science teachers, using language and other semiotic modes such as graphs, equations etc. The pre-service science teachers in turn internalize them and with time these tools become the mediators of the individual's advanced psychological processes. The point is that what pre-service teachers have acquired in social settings is being assimilated and internalized at an individual level and this gives birth to the formation of new knowledge. Social mediation involves the acquisition of knowledge and skills through an individual's interaction with knowledgeable others. Wertsch, (1994) posits that;

> social mediation helps in understanding how human mental functioning is tied to cultural, institutional, and historical settings since these settings shape and provides the cultural tools that are mastered by individuals to form this functioning (p. 204).

In this approach, the mediational means are what might be termed the "carriers" (Wertsch 1994) of socio-cultural patterns and knowledge. It has been mentioned that consciousness is constructed through a person's interactions with the world, therefore, cognitive development cannot be divorced from its social and cultural context" (Wertsch 1994). The importance of culture is that it ensures that learning is context based and that the new generations learn from its pioneers (Vygotky, 1978). Relevant to this study is that the science community in practice recognizes everyday words to have scientific meanings when used in the science context. Karpov & Haywood (1998) subscribed to the idea that learning is tied to the culture and situation where it was learned. Hence, it is thought that culture provides a lens through which individuals perceive and make sense of the world phenomena from a social level to an individual level. Wa Thiong'o (1994) argued that language is both a means of communication and a carrier of culture. As such, culture is cocooned in a language hence language has an indispensable role in the learning processes.

Thus, Vygotsky (1978) conceived individual development as the transformation of socially shared activities into internalized processes. John-Steiner and Mahn (1996, p. 193) wrote that personal development such as higher mental functioning originates from social sources and the action of human beings on both the social and the individual aspects are mediated by tools and signs. Language acquisition in this sense is part of the social source development. Vygotsky's (1978) socio-cultural constructivism explains that learning is dependent on the ability of people to construct their meanings of the world around them. In this construction process, language is seen as an essential tool facilitating meaning making. Largely, it can be said that the socio-cultural approach therefore, appreciates how the "knowledge is internalized, appropriated, transmitted, or transformed in formal and informal learning settings" (John-Steiner & Mahn, 1996, p. 196).

2.9.2. Internalisation and the non-technical words

We have discussed in section 2.9, that the learning process occurs first at a social plane. However, it is observed that the whole learning process transcends this inter-psychological plane through the process called internalization (Karpov & Haywood, 1998; Leach & Scott, 2003; John-Steiner & Mahn, 1996; Vygotsky, 1978). The concept of internalization is conceived as a process where "individuals appropriate and become able to use the conceptual tool first encountered at the social plane" (Leach & Scott, 2003, p. 99). Fernyhough (2008) viewed the notion of internalization as "the process whereby the individual, through interaction with others, actively reconstructs external, shared operations on the internal plane" (p. 227). The unique feature in both explanations is that internalization involves an individual's capacity to perform complex mental functions with increasingly less dependence on externally provided mediation (Lantolf &Thorne, 2006). In this regard, language and physical signs are vital to transform social learning into psychological functions.

The non-technical science words are words that are known to the pre-service science teachers. However, when used in the science context, their meaning change. It is in this respect that mediation that leads to internalization is required so that as individual pre-service teachers are able to explain the meanings of these non-technical words with less help from the knowledgeable other. The intra-psychological plane learning takes place at an individual level through the use of psychological tools such as language. The process of learning at this level is tool /instrument mediated (Doolitle, 1997). These tools include:

> language; various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes; diagrams, maps, and mechanical drawings; all sorts of conventional signs; and so on (Vygotsky, 1981, p.137 cited in Wertsch 1994, p. 204).

The above assertion, confirms that the concept mediation is important in the learning process as it surfaces both at inter-psychological and intra-psychological levels. While mediation was very crucial in Vygotsky's contribution to the psychology of learning, it is also crucial in this study because pre-service science teachers require mediation to understand the contextual meanings of the non-technical words used in the science classroom language. Literature has shown that the success in science cannot be attributed to the proficiency of LOLT alone, but that pre-service science teachers should therefore be taught to interpret science classroom language (Oyoo & Semeon, 2015). As a result Vygotsky remained resolute that the “central fact of psychology is the fact of mediation” (Vygotsky, 1978, p. 116). The conceptual framework appreciates words as language and knowledge, and therefore understanding the meaning of words as used in the science classroom is crucial.

2.10. Conceptual framework

This study adopted contextual meanings of words and the link between words, language and knowledge as the conceptual framework (Oyoo, 2017; Oyoo & Semeon, 2015). This framework suggests that words have meanings according to their context of use. Therefore understanding pre-service teachers’ difficulties within this framework is crucial in order to transform knowledge effectively. Research has shown that failure to differentiate and correctly apply the meanings of words in context is the main reason for science being poorly understood by learners (Oyoo, 2017; Oyoo & Semeon, 2015). This framework therefore fits well with the interrelationship between words, language and knowledge as reflected in the following statement:

> 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 knowing is codified (Postman & Weingartner, 1971, p.103)

In this study, the link between words, knowledge and language (Postman & Weingartner 1971) was adopted and served as a data analysis framework on language. The framework was implemented as a pragmatic perspective (Gyllenpalm, et al., 2010 cited in Oyoo, 2017) regarding how words that form a language can possess different meanings depending on the context of use. The link between science words, science knowledge and the meaning of non-technical words in the language of instruction is recognized on the pretext that whatever science content is known “is inseparable from the words in which the knowing is codified” (Hodson, 2009, p. 242). This reaffirms the fact that contextual proficiency and general proficiency in the language of instruction are crucial to the understanding of the words used in the language (Oyoo, 2017; Oyoo & Semeon, 2015). Failure to understand the contextual meaning of the words in the science classroom context may lead to mistakes in grasping the meanings of the words in their context of use.

The use of language cannot be avoided if effective learning is to take place (Oyoo, 2011). This highlights pre-service teacher's unawareness of the need to learn, amongst other things, how to communicate effectively in the classroom (Oyoo, 2011). However, how can pre-service teachers be conscious of language issues if their own training does not put much emphasis on this aspect? The learning of science therefore calls for intervention of the knowledgeable others (science teacher educators) to socialize pre-service teachers on what it means to learn and teach science. It is apparent that learning science involves three learning domains: learning a new language, cultural border crossing and conceptual change. There is always a need for teachers to explain the meanings of these everyday words used in the science classroom because these "words cease to be mere words" in the context of science (Marshall & Gilmour, 1991, p.334).

In order to negotiate and enculture these three domains into the mind-set of the pre-service science teachers, Vygotsky (1978) proposes employing the concept of Zone of proximal development (ZPD). Relevant to teacher education is the thinking that learning is a process by which pre-service science teachers grow into intellectual life of more capable teacher educators. In this case, science teachers educators are indeed knowledgeable others who make decisions about how much time to allocate to a particular course, what relevant courses to be covered, when and in what order, to what standards of achievement, and to which students (Schwille et al., 1983, in Oyoo, 2012). More important is the role of the teachers in explaining words whether technical or non-technical, so that the students can understand the science content. There are growing literature that shows that ZPD encompasses research and pedagogical innovations that include parent-child interactions, and teacher-students interactions (Lantolf & Thorne, 2006). Moreover, ZPD is orientated both present (development achieved) and forward looking (developmental potential) (Lantolf & Thorne, 2006). In particular, it is the forward looking, which makes ZPD relevant to this study. It is through assisted performance that the need for different kinds of assistance is required for different individuals in order to accomplish particular skills.

The guiding principle is that the process of development is not the same among all student teachers. It differs across individuals, across time and the kinds of curriculum offered during such training (Lantolf & Thorne, 2006, p. 263). The findings from this study were not linear. This explains why one of the purposes of this study was to investigate pre-service science teachers' understanding the meaning of non-technical words across different years of studies.

2.11. Summary of the chapter

This chapter deliberated on the performance in physical science at national level based on physical science outcomes on matric level. How this study on language relates to pre-service science teachers was also discussed, including a review of the literature on the role of science classroom language in view of teaching and learning of science. The difficulties of the components of science classroom language and theoretical and conceptual frameworks adopted in this study have been explicated.

CHAPTER THREE: Research design and methodology

3.1. Introduction

This chapter examines the research methodology that was used to establish pre-service science teachers' meaning of non-technical words used in the science context. It unfolds descriptions of different concepts encapsulated in research methodology such as research paradigm, research approaches, research design, research methods, data collecting instruments and data analysis procedures that were used in this study. The chapter has ponders on the determination of the population and sample of the research, issues about reliability and trustworthiness are also explained. Lastly, matters pertaining to ethical issues such as ethics clearance, participant information, confidentiality and anonymity are equally considered in this methodology chapter.

3.2. Research methodology

Educational research is understood as systematic activity that is directed towards providing knowledge or adding to the understanding of existing knowledge, which is of relevance for improving the effectiveness of education (Stenhouse, 1984). Merriam and Tisdell, (2016) indicated that research can either be classified as basic or applied research studies. Basic research studies are inspired by intellectual curiosity to know more about a particular phenomenon, hence, such research studies are geared towards the general extension of knowledge (Merriam & Tisdell, 2016). Applied research studies, on the other hand, take interest in improving the quality of practice of a particular discipline such as science (Merriam & Tisdell, 2016). Hence, the findings of such research are geared towards influencing how a certain practice should operate. For examples, the findings might influence administrators or policy makers to improve how things are done (Merriam & Tisdell, 2016). This study deliberates on pre-service science teachers' meanings of non-technical words used in the classroom context in view of improving the way universities prepare science teachers for future endevours. As such, the study is considered an applied social science research project.

Steinhouse (1984) argues that research is a systematic enterprise, meaning that it has a certain pattern or ways of going about it. The pattern or strategy by which "researchers go about their work of collecting data, analysing and describing, and explaining phenomena" is referred to as methodology (Nieuwenhuis, 2016, p. 51). More often than not, methodology includes the research methods, which are considered most suitable for collecting and analyzing data, in order to generate knowledge about a particular phenomenon in question. Research methods are understood as "range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation, for explanation and prediction" (Cohen, Manion & Morrison et.al., 2003, p. 44). Traditionally, research methods refer to qualitative, quantitative and Mixed Methods (MM) research. The authors (Cohen et al., 2003, p. 73) argue that the "purpose of the study" determine the methodology and the design of the research. This study in particular, adopts a case study design and a MM approach. The reasons for such choices are explained in the subsequent sections. In addition to the purpose is the argument that the selection and use of methodology depends on where the researcher is coming from regarding his/her fundamental epistemological and ontological assumptions.

Punch (2009) explains the concept assumption as follows: The assumptions about the "nature of the reality being studied, assumptions about what constitutes knowledge of that reality, assumptions about what therefore are appropriate ways of building knowledge of that reality" (p. 15). As already discussed, this study on pre-service science teachers' meanings of the non-technical words used in the science classroom is educational research and is traditionally situated within the social sciences (De Vos, Delport, Fouché & Strydom, 2011). In social sciences, facts are not objective and neutral, since they depend heavily on the context and people's understanding of the information. In light of the discussion above, this study therefore adopts an interpretivist paradigm which posits that reality depend on the person perceiving it. I now turn to explain the concept paradigm and interpretivists positions of looking at reality as is relevant to this study.

3.2.1. The research paradigm of this study

Punch (2009) asserts that the concept 'paradigm' is very broad encompassing the ontological assumptions (social reality) and epistemological assumptions (the nature of knowledge). Punch define paradigm as a "set of assumptions about the world, and about what constitutes proper techniques and topics for inquiring into that world" (2009, p. 16). Central to understanding the concept paradigm are the following components: ontology and epistemology (Crotty, 1998; Scotland, 2012).

Ontology is regarded in this case as the point of departure for this study, because the curiosity or interest to do an investigation is stimulated by a certain situation in a particular context.

For instance, poor performance at matric level and perpetual unsatisfactory performance in the Trends in Mathematics and Sciences Study (TIMSS) assessments are just some of the reasons that stimulated this research in science language. Epistemology, on the other hand, deals with the "nature of knowledge and different ways of knowing" (Du Plooy-Cilliers, 2014, p. 23). In the context of this study, the knowledge of non-technical words is crucial in understanding science content. This is because the conceptual framework that guides this research recognizes words as a language and knowledge. In other words, the knowledge of the non-technical words facilitated the relationship between the knower (pre-service science teachers) and the known that is the science content itself (Crotty, 1998).

I had chosen interpretive paradigm as a guide as to how the findings from this study should be interpreted. This paradigm holds a view that reality depends on the person perceiving it hence the desire to understand the subjective world of human experience as central to this paradigm (Cohen, Manion & Morrison, 2011, p. 16). This paradigm concentrates on individuals' understanding and interpretation of the phenomena around them. The interpretivist approach resonates well with this study since it seeks to investigate pre-service science teachers' contextual meanings of non-technical words. Following the guidelines of this paradigm, pre-service science teachers therefore, assigned meanings to these words depending on their own experiences and encounters they had with these non-technical words (Du Plooy-Cilliers, 2014).

As such, the epistemological position grounding pre-service science teachers' conceptual meanings to these words cannot result in one objective understanding. The reason resides in difference in experiences, cultural backgrounds and circumstances (ontology) that might influence their conceptions of these words. The ontological position of interpretivists therefore, rests on the assumption that reality is experienced based on one's circumstances and experiences. Hence, this paradigm concurs with the socio-cultural theoretical framework adopted in this study, which emphasises social and tool mediation as paramount to learning. Through mediation, the pre-service science teachers would be exposed to the contextual meanings of these non-technical words. From such an analysis, it can be deduced that the concepts ontology and epistemology are the basis of any research. It is the researcher's ontological and epistemological analyses which determine which methodology and research methods to be used.

3.2.2. Research design-case study

This study employed a case study as a research design. Creswell (2012) defines a case study as an "in-depth exploration of a bounded system (e.g., an activity, event, process or individuals) based on extensive data collection" (p. 465). The word *bounded* in the immediate definition means, "being unique according to place, time and participant characteristics" (McMillan & Schumacher, 2010, p. 344). The reason for choosing this case study design was based on the advantages this approach offers that were congruent with the goals of this study such as the ability to allow the use of MM (Bryman, Bell, Hirschsohn, Dos Santos, Du Toit, Masenge, Van Aardt & Wagner, 2014). The analysis using a case study involves statistical findings and descriptions of specific cases of the social phenomenon (Tashakkori & Teddlie, 2010). It is argued that those exemplifying findings were to add value to understanding pre-service science teachers' meanings of non-technical words used in the science classroom.

Further, a case study recognises that context is a "powerful determinant of both causes and effects and that in-depth understanding is required to do justice to the case" (Cohen et al., 2011, p. 289). Germane to this study on non-technical words was the aspect of context in which these words were used. The participants in this case study were expected to give meanings to these non-technical words used in the science classroom context and possible factors influencing those meanings. It is established that a case study is an in-depth exploration of a bounded system; therefore, the issue about numbers is therefore meaningless, it could involve one person, a group of individuals, a whole class, and a department within a school or the whole school itself (Opie, 2004).

This study therefore, was a case study of 184 pre-service science teachers at an English medium university studying towards becoming teachers at high school level. Their common features or characteristics were that they were studying at an English medium university, located in Johannesburg, South Africa. These pre-service science teachers were also from English Medium Schools (EMS) and as such, their schooling therefore took place in English. The academic activities at this university took place, using English as LOLT. Hurst (2016) observed that, in an English medium university, English acts as a kind of gatekeeper. This is because a pass in English is required in the National Senior Certificate (NSC), in order to access entry into many of the higher education programmes and institutions in this country. Another feature was therefore that these pre-service science teachers had a pass in English, which allowed them to have access to this university.

Yin 2009 (in Cohen et al., 2011) identified four types of case studies: single case design, embedded single case design, multiple case designs and embedded multiple case designs. This research used multiple case designs, since it examined, among other things, pre-service teachers' meanings of non-technical words, according to different levels of study. The questionnaire used was the same across all levels. The results were compared and contrasted regarding words which had posed a challenge to those pre-service science teachers. This was followed by semi-structured interviews. Furthermore, using the case study allowed the results to be easily understood by lay people. The use of a case study in this research study exposed some distinctive features that may otherwise be lost in larger scale data. These distinctive and unique features contributed to the understanding of the research.

The advantage of a case study is that it presents a real situation that enables readers to have a holistic view, rather than simply presenting them with abstract theories or principles (Opie, 2004). In this regard, it helps the researchers to understand how ideas and abstract principles fit together (Cohen, et al., 2011). When conducting research through case study approach, it is crucial to acknowledge that there are many variables operating in a single case. Therefore, to employ more than one tool for data collection was of paramount importance in this study. This case study therefore blended numerical and qualitative data and this resulted in MM approach.

Generally, case studies have limitations such as limited generalising of the findings, due to the perception that it produces soft data (narrative) among others things. The issues of lack of generalisation in this study was minimised by using all pre-service science teachers in all the three methodology classes, which included second year participants of the Natural Science Methodology Course (n=106), as well as third year- (n=40) and fourth year (n=38) participants of Physical Science Methodology Courses. Moreover, on the argument regarding production of soft data, this study used a mixed methods approach to analyse the data (Tashakkori & Teddlie, 2009). The use of MM produces narrative (soft data) and numeric (hard data). The analysis on narrative and numeric data introduces the research approach of this study: Mixed Methods.

3.2.3. Research approach - mixed methods (MM)

Mixed methods are pragmatic in nature involving narrative (qualitative) and numerical (quantitative) approaches in responding to the research questions (Tashakkori &Teddlie, 2009). The quantitative component stemmed from the structured questionnaires while the qualitative component emanated from the semi-structured interviews. Creswell (2009) reflects on MM as both a methodology and a method. As a methodology, it "involves collecting, analysing, and mixing qualitative and quantitative approaches at many phases in the research process, from the philosophical assumptions to the drawing of conclusions" (p.8). On the other hand, as a method, it "focuses on collecting, analysing and mixing quantitative and qualitative data in a single study or series of studies" (Creswell, 2009, p. 8). Perhaps, a more detailed definition of mixed method (MM) is the one provided by Creswell and Plano Clark. The aforementioned authors defined MM research as:

> Research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process. As a method, it focuses on collecting and analysing, mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone (Creswell & Plano Clark, 2007, p. 5)

The fundamental philosophical assumption that guides MM research is the pragmatist paradigm, which assumes a worldview and interest in both narrative and numerical data and their analyses (Tashakkori & Teddlie, 2009). Many researchers such as (Punch, 2009) highlighted the benefits of employing MM approaches in research. For example, Punch (2009) asserts that "we can learn more about our topic if we combine the strengths of qualitative research with the strength of quantitative research while compensating at the same time for the weaknesses of each method" (p. 290). The authors (Creswell, 2012; Punch, 2009) indicate that mixed method provides accurate and increased levels of confidence in research findings. Since it is a combination of two methods, the weakness of one method can be improved by the strength of the other. As such MM, provided sufficient knowledge required to inform theory and practice (Johnson & Onwuegbuzie, 2004). The weakness of this method is that it is time-consuming since it requires the researchers to engage with both qualitative and quantitative revelations.

Mixed methods are classified into four designs namely: triangulation design, embedded design, explanatory design and exploratory design (Creswell & Plano Clark, 2011; De Vos, et al., 2011). ~~However,~~ This study used the explanatory design, which favours the collection of quantitative data first, followed by the qualitative data.

3.2.3.1. The sequential explanatory design

This study employed the sequential explanatory design, which is a two-phase design in which the quantitative data is collected first and the qualitative data followed at a later stage (De Vos, et al., 2011; McMillan & Schumacher, 2010; Merriam & Tisdell, 2016). In this study, the first phase involved the collection and marking of the structured questionnaires. The marking process helped to respond to the first research question namely; to what extent do pre-service science teachers encounter difficulties with non-technical words used in science classroom context? The questionnaire was then analysed and scrutinised to establish which non-technical words were answered correctly or incorrectly. This was to respond to the second question: Which non-technical words emerged as difficult to the pre-service science teachers?

The second phase of this explanatory design was geared towards explaining the possible reasons why pre-service science teachers performed well on some particular word items and not on others. In order to explain such quantitative findings, the collection of the qualitative data was deemed relevant. As such, the collection of the qualitative data was guided by the third and fourth research questions: What are the sources of the difficulty of these words as encountered by pre-service science teachers, and what possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training? In order to respond to these questions, semi-structured interviews were organised with some of the participants. These interviews were meant to help explain the results or findings from the first phase considering the participants' performances (De Vos, et al., 2011; McMillan & Schumacher, 2010). In short, in this explanatory design priority was unequal and given to the collection of the quantitative data. Cohen et al. (2011) report that, since the numerical data set the scene for in-depth interviewing, the qualitative data analysis emerged as a follow up to what had transpired in the quantitative data analysis.

The advantages of this two-phase design method approach were that it was straightforward to implement and to present the results (McMillan &Schumacher, 2010). Further, the process of data collection involves collecting only one data at a time, which made for conducive and good analysis. The only encountered and observed challenge regarding this explanatory design was that it was time consuming to collect quantitative and qualitative data separately (De Vos, et al., 2011; McMillan & Schumacher, 2010).

3.3. The study and data collection approaches

In Section 3.2.3, it was indicated that due to the nature of this study, in order to increase the confidence of its findings, both quantitative and qualitative methods were required. The pre-service science teachers' meanings of non-technical words were therefore examined using both statistical and narrative analysis of data. This being the case, the collection of data included participants answering multiple choice questionnaires and interviews. The interviews were used to follow up on specific items that were either performed well or not within the confines of the study as a means to understand the possible reasons for such response options. The questionnaire / word test was therefore the main source of data.

3.3.1. The questionnaire: Design and Features

The questionnaire was the main tool used to collect the quantitative data for this study. Babbie in De Vos, Strydom, Fouché and Delport (2011) conceive a questionnaire as a "document containing questions and or other types of items, designed to solicit information appropriate for analysis" (p. 186). Questionnaires are grouped into three categories namely: unstructured, semi-structured and structured questionnaires (Creswell, 2012).

Unstructured (open) questionnaires

The first type of questionnaires is called an unstructured questionnaire. Cohen et al. (2011) devise that the term *unstructured* is not appropriate since the purpose of a questionnaire is to allow the participants to follow, to some extent, some form of given structure. As such, unstructured questionnaires can be referred to as open questionnaires. In this study, the preference to open questionnaire is adopted on the basis that, the word *open* is convincingly akin to an open invitation for the participants to write any response they choose (Cohen, et al., 2011). This kind of questionnaire is applicable in situations where the possible answers are not known or the questionnaire is exploratory.

Semi-structured questionnaires

The semi-structured questionnaires contain open-ended questions. Cohen et al. (2011) contend that semi-structured questionnaires have clear structure, sequence and focus but the "format is open –ended, enabling respondents to reply in their own terms" (p. 382). , in other words, the semi-structured questionnaire set the tone of the agenda but does not presume the nature of the answers (Cohen et al., 2011). It is mainly employed in a qualitative method of inquiry that combines a pre-determined set of questions (closed) that are used to facilitate or prompt discussion for further questions (open) in order for the researcher to further explore the responses that were given.

Structured questionnaires

The structured questionnaires are sometimes referred to as closed questionnaires. This is because there are close-ended questions where researchers have very little involvement and are suitable when a high number of people are responding to the questions (Creswell, 2012). Most of these questionnaires follow a multiple choice format, where the participants choses from the predetermined given responses (MacMillan & Schumacher, 2010). This study used structured questionnaires to collect the quantitative data, as it was easy to deal with a large group of participants (second - fourth year students). The structured questionnaires were suitable for high numbers of people (184 participants) who were responding to the questions; and the questionnaires were useful in generating occurrences of response, essential for statistical treatment and analysis (Cohen et al., 2011). These questionnaires allowed comparisons to be made across the participants' responses on the particular item (Cohen et al., 2011). Generally, questionnaires reduce the chances for researcher's involvement in the process of answering questions. In this study, the questionnaires were used to unearth the quantitative dimension based on the first two research questions: *To what extent do pre-service science teachers encounter difficulties with non-technical words used in a science classroom context, and which non-technical words emerged as being difficult amongst the pre-service science teachers*?

3.3.2. The questionnaire design

With permission, this study adopted the structured questionnaire, which was used in Oyoo's (2017) study, as seen in the attached Appendix A. The questionnaire had 30 multiple choice questions, each with the target word underlined, and with four options to choose from (options A, B, C and D) as the possible contextual meanings of the non-technical word; with only one option being correct regarding the use of an everyday word in a science context (Oyoo & Semeon, 2015). The non-technical words used in this questionnaire are part of and are relevant to science content at Grades 10-12 respectively; which are levels the participants mainly teach. The participant pre-service science teachers therefore, were expected to know the meanings of these non-technical words as used in a science context. The pre-service science teachers were to make their choices by circling one of the four options that had a meaning closest to that underlined non-technical word (Oyoo, 2017). The word “spontaneous” is a typical example from the questionnaire of the non-technical words used in the science classroom.

The two chemicals seemed to combine in a spontaneous reaction. This means the reaction

A. was very quick
B. happened by itself
C. once started increased vigorously
D. was explosive

The structure of the questionnaire was that it had some structured space for the participant’s name and student number. The presence of the student number and names was considered not to potentially jeopardise issues about confidentiality and anonymity, since I was the only person handling the questionnaires and hence I had controlled access to them. The spaces for student numbers and names of the participants were meant to help to identify participants for interviews. Since the analysis of the questionnaires, was to be followed by interviews, the names and student numbers allowed me an opportunity to trace those easily who indicated willingness to participate in the interviews; in order to follow up on issues identified in the questionnaire data.

3.3.3. The interviews

This study used the interview method to collect qualitative data to follow up on issues identified in the questionnaire. Creswell (2012) defines an interview as a “process whereby a researcher asks questions from an interview guide, listens for answers or observes behavior and records responses accordingly” (p. 382). Cohen, Manion & Morrison (2011) refer to interviewing as the gathering of data through direct verbal interaction between the researcher and the participant. Overall, an interview is understood as a meeting for obtaining information through questioning one or more persons. This can be face to face or using electronic devices such as cellphones or telephones respectively. Denscombe (2010) proposes three types of interviews, namely structured, semi-structured and unstructured interviews, depending on the data to be collected and the phenomenon investigated. The three different kinds of interviews are now discussed in the following sequence: unstructured, structured and semi-structured.

Unstructured interviews

The unstructured interviews are more flexible than the other two kinds of interviews: structured and semi-structured. The researcher's role is to introduce the topic under investigation and then allow the participant to deliberate and engage with the issues. As a result, there is no order or sequence in terms of how questions are asked. It allows the participant to use their own words in trying to express themselves and the direction of the interview can be very unpredictable (Cohen, Manion & Morrison, 2011). This kind of interview gives a large amount of information for analysis, especially in cases, where the participant's responses are unknown (Opie, 2004).Therefore, it is likely to be more difficult to analyze such a data. Moreover, the researcher's bias and prejudices are likely to influence the unstructured interviews.

Structured interviews

The structured interviews are regarded as rigid in terms of their format of the questions and answers. All the participants are expected to be asked the same questions, with the same wording and sequence. Opie (2004, p. 17) notes that such "interviews often use large samples and are often organized round a prearranged schedule of questions, which are short, direct and capable of immediate simple answers". The researchers are expected to remain neutral to guard against influencing the responses of the participants. In fact, structured interview is like a questionnaire that is administered face to face with a respondent (Denscombe, 2010; Cohen, Manion & Morrison, 2011). The researcher has a predetermined list of questions, to which the participants are invited to offer limited option responses. It has the advantage that there is standardization; as each participant is faced with the same questions. Structured interviews are therefore associated with collecting data for quantitative purposes.

Semi-structured interviews

In this kind of interview, like in the structured interviews, the researcher still has a clear list of issues to be addressed and questions to be answered. However, with the semi-structured interview, the researcher is flexible and is not bound in terms of the order in which the topics or questions are considered (Opie, 2004). More importantly, it allows the participant an opportunity to develop ideas and speak more widely on the issues raised by the researcher; hence, it provides a deeper understanding of the phenomena under investigation (Cohen, Manion & Morrison, 2011; Denscombe, 2010). The benefit of the semi-structured interview is that the researcher is able to gain the trust and rapport of the participant. The answers are open-ended, and there is more emphasis on the interviewee, elaborating points of interest. Opie (2004) observes that flexibility in asking questions can be a limiting factor because the researcher's prejudices can easily influence the conversation.

This study used semi-structured interviews, considering its strengths and relevance to the study. The semi-structured interview was necessary, to follow up on special issues identified in the questionnaire. It was therefore important that some of the participants were allowed a platform to explain the rationale behind some particular response options. In this regard, semi-structured interviews allowed the researcher to probe in the quest of seeking and clarity (Punch, 2009). The deliberations of this interview were captured using an audio recording machine. The interviews were to establish the reasoning behind pre-service science teachers' responses to certain selected items from the questionnaires. The interviews therefore were to address the third and fourth research questions: What are the sources of the difficulty of these words as encountered by pre-service science teachers and what possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training? In order to achieve desirable responses on these questions, I prepared a semi-structured interview schedule, which was a guiding tool during the interviewing processes. The design, structure and features of the semi-structured interview schedule are presented below.

3.3.4. The interview schedule: design and features

Interview schedules are tools that are used to collect qualitative data in interviews. Opie (2004) argues that if the aim of the interviews is to motivate participants to say what they think with greater richness and spontaneity, then appropriate questions must be asked to stimulate such responses. The interviews were meant to follow up on issues identified in the marked and analyzed questionnaire, thus the interview schedule was prepared to address such peculiar issues. To put it simply, the purpose of the interview schedule was to highlight word items which required the participants to further explain their understanding and choices of particular words on the questionnaire. The elaboration was based of the non-technical words that appeared challenging to the pre-service science teachers, and also on those non-technical words that participants achieved a total score of 100 %.

As already discussed in section 3.2.2, this study had three participating groups: second year participants of the Natural Science Methodology Course, and third year and fourth year participants of Physical Science Methodology Courses. Therefore, the preparation of this interview schedule was done based on the performance of each participating group. For instance, the second year group had difficulties with the words: *sensitive, effect, trace* and *retard* but performed well on words such as *characteristics, constant, linear, system and negligible*. The third year group experienced difficulties with the words such as *sensitive, trace* and *retard* but did well with words such as *conserve, system, linear* and *constant.* The fourth year group struggled with the following words: *retard* and *trace* but performed well on words such as *dehydrate* and *factors*. Although, the interview schedule was designed as one standardized entity some items were not applicable to other participating groups. This means that some of the actual questions and probing questions were not always the same. Opie (2004) writes that the critical role of an interview schedule is to make sure that interviews become a success. Hence, in general the interview schedule consisted of these example questions:

1. *Have you ever heard about words e.g. sensitive, disintegrate in your studying whether at high school or at university levels?*
2. *Are these words important in the learning and teaching of science? If so explain in what way?*
3. *Do your science lecturers use these words, if so do they provide their meanings in science context? (**Whether in content or methodology classes).***
4. *I have the following words: **TRACE, RETARD, EFFECT** and **SENSITIVE***
   *(a) TRACE: Majority answered: **Used to have some Potassium. Why?***
   (b)** RETARD: Some answered: **Speed up the reaction** or **make the reaction go the other way. Would you explain?
   (c)** EFFECT**: The reason for adding the acid?
   (d)** SENSITIVE: **Gets spoilt VERY easily** or **can be used only by sensible people.
5. *How can students be helped to know the meanings of these words?*
   - *There are some words that the participants got almost 100% what do you think is the reason for that e.g. second Years:(characteristics, constant, linear, system* and *negligible); third Years: (Conserve, System, Linear* and *Constant) and fourth Years (Dehydrate* and *factors).*

Reflecting on the structure of the interview schedule immediately above, it becomes clear that the questions embraced a mixture of issues about context of use, teachers' non-explanation and students' previous experiences and encounters with these words. Further, the interview contemplated on non-technical words that were exceptionally performed. A semi-structured interview with these questions was influential in stimulating the participants to explain with greater richness and spontaneity why they opted for certain meanings on the questionnaire (Opie, 2004). The interview schedule contained open-ended questions so that the researcher could probe deeper about participants' ideas, beliefs, views and opinions on these non- technical words, during their schooling experiences and their university teacher preparation. The analyses of the interviews schedule lead us to the issues regarding the context of study and sampling methods as now discussed.

3.4. The study context and sampling

3.4.1. Teacher science education curriculum

The teacher education methodology-curriculum is one of the issues that is important to be explored. By examining the curriculum of these pre-service science teachers, one tends to appreciate what these prospective science teachers achieve at the end of their initial teacher education (ITE). Taylor (2016) writes that:

> ITE serves as a bridge between prospective teachers exiting the school system to enrol in teacher education faculties, on one hand, and newly qualified teachers (NQTs) who are embarking on a career in schooling, on the other…To what extent are the universities providing the teachers required by the school system? (p.11)

In this respect, the teacher training institutions have the obligation therefore, to make sure that pre-service science teachers are well equipped before exiting their respective training institutions. This study reiterates its position that equipping the pre-service science teachers with language of science education among other things, has a likelihood of improving the understanding of science content. Of course included in this language of science education, is the understanding of the meanings of the non-technical words used in a science context, which is the focus area of this study

Looking across the teacher education curriculum for pre-service science teachers (1st - fourth year methodology courses) in this English medium university, the following observations were made: first and second year students do Natural Science Methodology Courses while third year and fourth year students do Physical Science Methodology Courses. In Natural Science I Methodology Courses, the pre-service science teachers deal with topics such as identifying central concepts in natural sciences, classroom management, misconceptions on topics such as: energy transfer and preparation for the teaching experience (Wits Education **S**yllabuses, 2016). Those students doing Natural Science II Methodology Courses in addition to what is done in Natural Science I methodology, examine the following topics: application of theories of learning in Natural Sciences, quantitative and qualitative evaluation of summative and formative assessment, creation of teaching and learning resource materials etc.

The third year Physical Science Methodology Course emphasises among other things: introduction to the Physical Science FET Curriculum, big ideas of physical sciences, Physical Science and laboratory management, development of the professional identity of a physical science teacher and teaching experience preparations (Wits Education Syllabuses, 2016). In the fourth year Physical Science Methodology Courses, the pre-service science teachers are exposed to pedagogical and professional issues in relation to the learning and teaching of physical science, examination of FET school science content and skills germane to teaching and learning of physical science.

From the above reviewed curriculum in this English medium university, it appears that language in science education is not taken into consideration. The deficiency of language in science education implies that non-technical words used in the science classroom are not given full attention. In short, the absence of the language component means that there are no formal teacher explanations on these everyday words, used in the science classroom context. I have argued in the introduction (Section 1.1) that science content is embedded in language hence teacher explanation on language is likely to improve the complexity of teaching and learning science. I now present pre-service science teachers background information

Pre-service science teachers background information

The schools in South Africa are grouped into five categories known as quantile for the purposes of the allocation of financial resources (Wits, 2016). The classification is based on the poverty of the community and infrastructural factors. The schools in quantile 1 to 3 are no-fee paying schools, while those in quantile four and five are fee-paying schools. This being the case, schools in quantile one are those that are most under-resourced (poorest) while those in quantile 5 are the most highly resourced. There is also a quantile 6, according to the Wits classification. Largely, the students that go to South African institutions of higher learning come from these varied quantile schools.

The recent study conducted at the University of Witwatersrand among the students registering for first year in 2016, revealed that most students who are enrolled at this institution comes from well-resourced schools (quantile 4 and 5). While most of these students are African, they are still regarded academically strong since Wits University is one of the institutions that enroll top achieving students (Wits, 2016). The findings also revealed that the majority of the students who had an Admission Point Score (APS) between 35 and 40 were enrolled in the faculty of humanities. This is the faculty in which the participants of this present study fall under.

Speaking generally, it was observed that the majority (50.54%) of students who enrolled at this English medium university was from quantile 5 and 6, in other words highly and extremely well resourced schools (Wits, 2016). Those from adequately resourced schools (quantile 4) constituted 13.79% of participants and relatively resourced schools (quantiles 1-3) constituted 33.79 % of participants. In addition, the international students constituted 22.25% of participants. From these statistics, it can be concluded that the majority (64.24%) of students who enroll in this English medium university are from schools with good learning materials, infrastructure and resources. It is only 33.37% of the student's population that come from under resourced school and underprivileged backgrounds.

Overall, the university is a home for students from all walks of life both nationals and international students. However, a large percentage of these students are from four provinces: Gauteng (63.99%), KwaZulu Natal (9.95%), Limpopo (9.65%), Mpumalanga (6.10%), international students (1.59%) and other 5 provinces (8.75%) respectively. These students are coming from either semi-urban or urban areas such as major towns, cities, established suburbs and townships (Wits 2016). Interestingly, there are some students who come from farm schools (1.94%), isolated rural villages (15.52%) and informal settlements (0.98%). The table below is a summary of Wits students' background demographics regarding LOLT and home language.

Table 3.1: Summary background demographics of the students who enrol at the English medium university

Province	Percentages	School Language	Home language
Gauteng	63.99%	English	Mixed
Kwazulu-Natal	9.95 %	English/Isizulu	English/Isizulu
Limpopo	9.65%	English	Sepedi/Tshivenda
Mpumalanga	6.10%	English/Afrikaans	Siswati/Isizulu
Other 5 provinces	8.75%	Other	Other
International	1.59%	Other	Other

From this Table 3.1 above, it can be seen that English is the main dominating language of learning and teaching (LOLT) in many provinces due its socio-economic role (DBE, 2010). This is followed by Afrikaans especially in provinces such as the Free State, North West and Northern Cape. The use of African languages is very minimal except in the KwaZulu-Natal Province (Wits, 2016). While both English and Afrikaans gained status as official languages during the colonial era, they continued to enjoy the same status as LOLT in primary schools, high schools and even in higher institutions of learning (Hurst, 2016; DBE, 2010). Regarding higher education institutions that use English as medium of instruction, Hurst (2016, p. 219) writes:

> Higher education institutions in South Africa are dominated by English, a result of the colonial history of the country and its education system, a legacy which is intensified by the current dominance of English in higher education worldwide. Within this context, the level of proficiency in English of aspiring students can dictate their access to higher education. English acts as a kind of gatekeeper, with a pass in English in the NSC (National Senior Certificate the school-leaving certificate in South Africa) being a requirement for entry into many of the higher education programmes and institutions in the country which have English as their stated medium of instruction (MoI).

Hurst (2016) argues that the level of proficiency of these LOLT such as English and Afrikaans can dictate the access to higher institutions of learning. Put positively, it means to some extent that students, who are registered at high education institutions in this country such as this English medium university, obtained a good grade in English at matric level. The population of students therefore, from which the sample was drawn had a good proficiency in the language of learning and teaching regardless of the quantile of the schools they came from. In addition, the findings suggest that students at this English medium university come from schools where English (25.28%) and Afrikaans (34.00%) are the leading LOLT. While the majority of students (55.96%) were not taught in their first language, only 43.79% attended schools where the LOLT was their medium of instruction. This means that most of the students who are at this English medium university had to break through the language barrier in order to access and understand subject matter in class (Wits, 2016).

In terms of geographical location it was revealed that the majority of students (79.41%) who took part in the research study came from schools classified as urban (DBE, 2010) and 18.25% came from rural schools. It should be noted that rural schools do not necessarily mean that they are under- resourced since there are some schools under quantiles 4 and 5 that make up part of the rural schools (Wits, 2016). However, it should be noted that the chances of practicing the LOLT after school are higher in urban areas than schools located in rural areas. In this sense, those from urban areas are somehow advantaged. But largely, basing our arguments on these demographics, the participants sampled for this study would not be expected to have many difficulties with English language as LOLT. I now discuss the issues regarding sampling.

3.4.2. Sampling of participants

Punch (2009) argues that every research whether qualitative, quantitative or MM involves sampling for the single reason that we cannot "study everyone everywhere doing everything" (p. 251). Sampling is therefore " the method used to select a given number of people (or things) from a population"(Mertens, 2005, p.307). In accordance with McMillan and Schumacher (2010, p.129), a population is a "group of elements or cases, whether individuals, objects or events, that conform to specific criteria and to which we intend to generalise the resullt of the research". A sample therefore is a subset of the population considered for actual inclusion in the study or that has been selected for investigation (De Vos, et al., 201; Bryman et al., 2011). The findings from the selected sample can be generalised as a representation of the whole population from which the sample was drawn.

There are different kinds of methods of sampling participants for a study. Cohen, et al., (2011) identify two main methods of sampling: probability (random) sampling and non-probability sampling. Probability sampling is a method of sampling where the participants taken from a larger population have a known chance of members being selected for the sample (Cohen et al., 2011; McMillan & Schumacher, 2010). Henry (cited in Mertens, 2005) refers to probability sampling as a method where "probable samples are selected in such a way that every member of the population actually has a possibility of being included in the sample…" (.p. 308). Probability sampling is divided into simple random sampling, systematic sampling, stratified sampling, stage sampling and multi-phase sampling (Cohen et al., 2011).

Non-probability sampling on the other hand, is a method where the sample "derives from the researcher targeting a particular group, in the full knowledge that it does not represent the wider population" (Cohen, et al., 2011, p. 155). In this case, some members of the population have no chance to be selected because the researcher uses the sample that is easily accessible or that meets certain characteristics required by the study in question (McMillan & Schumacher, 2010). Non-probability sampling is divided into convenience sampling, quota sampling, purposive sampling, dimensional sampling, snowball sampling, volunteer sampling and theoretical sampling (Cohen, et al., 2011).

This study in particular used non-probability sampling. Within non-probability sampling, convenience and purposive were seen relevant to be used in selecting the participants. Convenience sampling was seen relevant because it promotes the aspect of using nearest individuals to participate in the study. Cohen, et al.(2011) writes that “captive audiences such as students or student teachers often serve as respondents based on convenience sampling” (p. 156). It is within this thinking that this study opted for pre-service science teachers from an English medium university, who were very accessible to the researcher. The purposive sampling was regarded relevant because of its orientation towards a particular group of individuals who have knowledge about the phenomenon being researched. The pre-service science teachers had the characteristics expected for this study namely; that they were doing Natural Science Methodology and Physical Science Methodology Courses that prepared them to teach in high schools. While they were easily accessible, they had the required knowledge of a science, which involves the use of everyday words in a classroom context. This particular university had been selected on the basis that it is an English medium institution and had a special science division that trains science teachers.

3.4.3. Sample details: Distribution and Features

McMillan and Schumacher (2010) indicate that one of the important aspects to consider when conducting and evaluating research is the size of the sample or number of participants involved in the study. Generally, it is important to have as many participants as possible in order to ensure the credibility of the findings or results. The sample for this study comprised 184 pre-service science teachers studying at an English medium university. The sample was drawn from the population that is mostly African and included second year students of Natural Science Methodology Course, third year and fourth year students of Physical Science Methodological Courses. It is important to note that these three groups had participants who were English first language speakers (EFLs) and English second language speakers (ESLs). What follows now is a discussion of the details of each participant groups that constituted the sample in this study.

Second year pre-service science teachers

The sample of second year pre-service science teachers was drawn from a group of participants registered for the Natural Science Methodology Courses. These were second year students who were either to chose to teach physical science or life sciences as areas of their specialisation (DBE, 2011). In the second year, they were taught both physical science (physics and chemistry) and life science (biology) content. From the population of 156-second year students, 106 students formed the sample and completed the questionnaire in this study. All the participants indicated their interest to participate in the interviews. However, as it turned out, only 9 (4 males and 5 females) students were available for the actual interview proceedings.

Third year Pre-service science teachers

The third year pre-service teachers doing the Physicl Science Methodology Courses, were a group of participants who have made the choice of taking physical science as their subject of specialisation. Physical science is geared towards investigating both physical and chemical phenomena (DBE, 2011, p.7). As such, following the requirements from the CAPS document (2011) physics is not a stand alone subject, it is combined with chemistry to make it physical science. These participants therefore, were being prepared to be teachers of both physics and chemistry components. In accordance with their training, these participants will teach physical science to Grades 10-12 at high school levels. Of the population of 72, third year students, 40 participant students formed the sample and completed the questionnaire in this study. From this participant group, only 11 students honoured the invitation to participate in the semi-structured interviews.

Fourth year Pre-service science teachers

The fourth year pre-service science teachers doing the Physicl Science Methodology Courses, were a group of participants about to exit the university, going to the field where they were to teach physical science as their subject of specialisation. Through the Teaching Experience (TE) programmes, these participants have been exposed to the teaching of Natural Sciences in their 1st and second years and physical science in their third and fourth years of training. This population was composed of 38 students,who formed the sample and completed the questionnaire. From this participant group, only 12 students agreed to the interview, however, on the actual day of the interviews the number increased to 14 because 2 additional students who did not confirm their participation, decided to honour the invitation as well. The discussion on the details of the sample brings us to reflect on the processes involved in the actual data collection.

3.5. Actual Data collection

I have discussed in section 3.2 that research is classified as basic (promote extension of knowledge) or applied (geared towards improving how things are done). Merriam & Tisdell (2016) posit that research studies in areas such as education, health, administration and other related areas of social activity, are categorised as applied social sciences. These fields are considered applied social sciences, because they are orientated towards issues concerning the welfare of human beings (Merriam & Tisdell, 2016). It is observed that conducting research on human beings can be a complicated exercise, since it has “the potential to cause (usually unintentional) damage” (Opie 2004, p. 25). This is due to the fact that some of the methods or questions used in the processes of collecting data might affect the participants’ emotions, values and dignity (Cohen, Manion & Morrison, 2011). As a result, ethical measures were put in place to make sure that the participants were protected against any damage resulting from deliberate or negligent mistakes by the researchers. The processes regarding entry into the research site, implementation of both questionnaire and interview schedule and exiting from the research site are now presented.

3.5.1. Gaining access to the research site (ethical considerations)

Before conducting this educational research, it was important that I obtain an ethical clearance document that allowed me to access the research site. Further, it was imperative that the participants were informed what their participation entailed. Denscombe (2010) emphasizes that there is a need for the participant to understand the aims, methods, and the importance of their participation, in that particular research. The participants therefore had to give formal consent to take part in the study. These consent documents incorporated issues about confidentiality, treatment and security of the data.

It is within these observations that ethical matters were considered of great importance in conducting this educational research. Sieber cited (in Opie, 2004) explains that, “ethics has to do with the application of moral principles to prevent harming or wronging others, to promote the good, to be respectful and to be fair” (p. 25). The explanation confirms that adherence to ethical demands during research is non-negotiable. It is therefore compulsory; that the researcher treats the sample or number of participants with honesty and integrity. The participants are the stakeholders in the research and therefore may not be misled or exploited in any way.

In this study, the first step was to apply for the ethical clearance from Wits University to allow me to conduct the research with the participants of the chosen English medium university. Cohen, Manion and Morrison (2011) have noted, "most institutions of higher education have their own ethics committee, and these usually have their own codes of ethics against which they evaluate research proposal" (p. 99). The pre-service science teachers, who were to participate in this study, were from the school of education of this English medium university, particularly in the science division. I therefore had to apply to the Head of School (HOS) and Head of Science Division (HOD) for permission to conduct the research at this institution. Cohen, et al., (2011, p. 152) note that, "researchers will need to ensure that not only access is permitted, but is in fact practicable". When the ethics application was approved, I was granted the ethical clearance by Wits School of Education's Human Research Ethics Committee and assigned the Protocol Number: 2017ECE028M. The actual Ethical clearance is available as Appendix B attached.

The process of collecting data involved both answering the questionnaire and partaking in the semi-structured interviews. When the ethical clearance was granted, an arrangement was made that students should answer the questionnaire in one of the methodology courses. In all chosen study groups, the invitation to participate was made on my behalf by the methodology course lecturer. The students were given a letter to read through, with an explanation regarding their participation. The content of the letter was an assurance that their participation was voluntary and that they had a right to withdraw from the study at any time without disadvantaging them in any way. While the collected data was accessible to my supervisor and me, pseudonyms were used in the writing to ensure the participants' anonymity. When students gave consent to voluntary participation, an arrangement was made when questionnaires would be completed.

One important section in the questionnaire was provided where the participants were to express their wish to continue with a follow up interview (See the attached questionnaire in Appendix A). This information was available on the last page of the questionnaires. Hence, when each questionnaire was marked, it was scrutinized in terms of whether the participant consented for follow up interviews or not.

During the follow up interviews, the confidentiality and anonymity of the participants were assured, by the use of pseudo names. In this way the participants' details were concealed. All information was kept on my personal computer and was password protected. The raw data will be destroyed after a period of 3-5 years, after completion of the project.

3.5.2. Administration of the questionnaire.

McMillan and Schumacher (2010) reiterate that a questionnaire serves as a quantitative data-collecting tool in quantitative research. With the second year students, the administrations of the questionnaires took place at the beginning of the lecture with the help of the course lecturer. The participants were asked to be seated and the course lecturer reminded them that partaking in the questionnaire was voluntary. No participant was to be penalized for not taking part in the questionnaire. Although the participants were aware that this questionnaire had no any influence on their course assessments, they were asked to respond to it with a sense of seriousness, as though it was a class test or any kind of assessment that demanded an individual effort. The whole exercise lasted about 40 minutes. When all the participants had completed the questionnaires, I collected them to be marked. As discussed in 3.6.1, the questionnaires counted 30. The questionnaire was further examined in order to identify those participants who consented to follow up interviews.

With the third year students, the administration of the questionnaires was done at the end of the lecture. The lecture finished at least 20 minutes earlier to allow participants to respond to the questionnaires. Once again, the participants were reminded that answering the questionnaire was voluntary and therefore no one was to be penalized in any way for not participating in the study. The participants were asked to answer the questionnaire as individuals. Like with the second year students, these participants were aware that this questionnaire was not for marks, but were requested to take it seriously. It was observed that some participants took almost 45 minutes to complete the questionnaires and submitted it to the researcher and the course lecturer. Upon collection, the questionnaires were marked and checked for those individuals who expressed interest and willingness to be part of the follow up interviews.

With the fourth year students, the questionnaires were administered by the course lecturer at the beginning of the methodology lecture course. All the participants present accepted to answer the questionnaire. All the ethical considerations were highlighted to them. When they completed responding to the questionnaire, I collected the questionnaires for marking. The participants took almost 35 minutes to complete the questionnaire. The questionnaires were marked, scrutinized and checked to identify those participants who indicated to be involved in the interview.

3.5.3. Study implementation through interviews

It is important to mention that the administration of the questionnaires to all participants took place in the month of June before their winter examinations, after which the students were to leave for the winter holidays. The winter holidays were followed by teaching experience (TE). Since the students only returned from the teaching experience in the month of September, I was only able to conduct the interviews in the month of October. The follow up interviews therefore took place three months after the completion of the questionnaires.

3.5.3.1. How the interviews were conducted

The semi-structured interviews were conducted as follows: The interviews were in the form of focus group interviews. These interviews were conducted in a boardroom.. The best time for participants was during lunch break to make sure that the participants were free from any academic activities and had plenty of time for meaningful participation in the interviews. Merriam and Tisdell (2016, p.47) posit that in mixed methods research, the interviews form the qualitative data and are used to explain in depth a particular finding emerged from the quantitative data. In this study, the particular findings were from the questionnaire which constituted the quantitative data, since the participants were asked to indicate whether they would be available for follow up interviews.

When the questionnaires were marked, it was scrutinized in terms of whether the participant consented for interviews. In each group of the participant pre-service science teachers, the questionnaires were categorized into two sets: those that consented for interviews and those that did not. Obviously at this stage, the interest was on the questionnaires of those participants who gave a positive response to the interviews. As already discussed in section 3.3.3, the interviews were meant to follow up on issues identified in the marked and analyzed questionnaire. The proceeds from these interviews therefore constituted the qualitative part of this MM study. The quantitative data provided the non-technical words which were difficult for the participants, and the qualitative data provided reasons for such difficulties.

Upon the quantitative data collection, the participants had to leave for the winter holidays and teaching experiences. It was therefore difficult to access the participants for interviews.

Further, when the participants returned from their teaching experiences, they were pre-occupied with formal assessment tests and revisions in preparation for their year-end examinations. This meant that the idea to use all those who had indicated their intention to participate in the interviews was not realized. This resulted in resorting to non-probability sampling methods. At this stage one of the non-probability sampling methods, which were considered relevant to this study, was the snowball sampling method. Following is the snowball sampling method and the reasons for choosing it for the semi-structured interviews.

3.5.3.2. The snowball sampling method

This qualitative dimension of data collection for this study used snowballing, in order to get participants for the semi-structured interviews method (Bryman, et al., 2011; Cohen et al., 2011, De Vos et al., 2011; Mertens, 2005). This method takes its name from the snowball which accumulates more snow and becomes bigger and bigger as it rolls. Alston and Bowles (in De Vos et al., 2011) devise that snowball sampling is convenient when there is "limited access to appropriate participants for the intended study" (p. 223). I have explained in section 3.5.3.1, that it was difficult to get my intended sample for interviews, hence the snowballing method was found to be appropriate.

Using the snowball method, my initial task was therefore to get three participants representing each sample group (Second year Natural Science Methodology group, and the third and fourth year Physical Science Methodology groups) who indicated their intentions and willingness to take part in the interviews. Pascoe (cited in Du Plooy-Cilliers, Eds., 2014) argue that the initially selected participants should match the sample considerations of the study. In this study, the sample considerations were as follows: participant should be doing methodology course in either Natural Science (second year students) or Physical Sciences (third- and fourth year students), and will be interviewed voluntary and without any remuneration . This being the case, the initial trio of participants was to suggest or recommend other participants who still had an interest in the interviews and had indicated willingness to take part.

In order to maintain constant communication with the first three participants, I had requested to have their cell phone numbers. It followed then that I established three chat groups through WhatsApp (social media) namely: second year's interview group, third year's interview group and fourth year's interview group. Thus through these first three selected participants representing each group, I was able to be "connected to their friends, friends of their friends, and friends of friends of their friends” (Cohen at al., 2011). Although I had begun with a relatively short list of participants, the list (like a snowball) grew, as the names were added through the referral of the first three participants (Mertens, 2005). Eventually, I had “accumulated contacts, contacts of contacts, contacts of contacts of contacts*”* (Cohen et al., 2011) and these contacts were placed in their respective interview groups.

It was through these WhatsApp interview groups that venues, dates and times for interviews were scheduled or rescheduled to establish a time when all participants could be available. Noy cited in Cohen et al. (2011) observes that the snowball sampling method is essentially social in nature, since the researcher relies on sound interpersonal relations, known contacts, friends and acquaintances in order to organize the participants. The advantage of this sampling method is that a researcher is able to gather participants in a short period of time. A possible challenge, according to my experience using WhatsApp, was that a researcher must always have enough airtime and/ or data bundles to acknowledge receipt of new contacts and welcome new members to the interview groups.

With this discussion on the snowballing sampling method I now turn to deliberate on how interviews were conducted in each of the interview groups. The group interviews were conducted in the following order: First the fourth year’s interview group, followed by the third year’s interview group and lastly the second year’s interview group.

The fourth year’s interview group

While the collection of the quantitative data started with the second year participants, the interviews started with the fourth year participants. The fourth year students were prioritized because obtaining the qualitative data from them was crucial, since they were exiting the institution upon completion of their examinations. It would have been very difficult to make any arrangement for interviews once the students had left. There were fourteen fourth year participants, who turned up for interviews of which one was an English first language speaker (EFLs) and the rest were English Second Language Speakers (ESLs). One of the participants in this group was interviewed alone because she could not attend the group interview, due to other academic commitments. It was important to have such an interview as the participant indicated willingness to be interviewed and any additional participant meant an increase in the sample size, which increased the credibility of the findings qualitatively. It should be noted that even though the participant was alone, the same questions and approaches were used for comparability purposes (Paton in Palaiologou, Needham and Male, 2016).

The interview took place in one of the board rooms during the lunch hour break. All the proceedings in this interview were audio recorded. The boardroom was selected because it was conducive to audio recording and was easily accessed by the participants. The lunch hour break was ideal to ensure that participants would not fail to attend due to other commitments such as academic activities. I waited for all the participants who had confirmed attendance so that all would be in attendance at the same place and time. As already pointed out in section 3.3.4, the semi-structured schedule contained open-ended questions and aimed at probing the participants on why some non-technical words were performed on poorly. The participants were therefore advised to answer any questions freely, or add their views to any given response by someone else. When all open-ended questions and probing questions (e.g. When you enter into the teaching field next year, what are you going to do differently as a science teacher?) were exhausted, the researcher brought the interview to an end. The time distribution for the fourth year interview was as follows: 55 minutes and 20 seconds for the group interview (13 participants) and 15 minutes and 40 seconds for the participant who was interviewed alone.

The third year's interview group

The third year participants were the second group to be interviewed. As with the first group interviewed, in this interview, the venue (boardroom), time (lunch hour break) and audio recording machine were maintained, echoing to the reasons explicated in the previous paragraph above. Before starting the interviews, I waited for all the participants to arrive so that no participant was left behind. This allowed the participants to contribute without one feeling that he/she is missing some information. Twelve third year participants were expected to come for the semi-structured interview, however, one could not attend and left me with a total of 11 participants in this group. All the participants present were ESLs. When everyone had arrived, I introduced myself and welcomed the participants.

The same semi-structured schedule was used and contained the same open-ended questions and aimed at addressing specific findings that emanated from the questionnaires. Paton (in Palaiologou, Needham and Male, 2016) stipulates that "depending on the research objectives and questions, the same interview topics and sequence could be used for different groups of interviewees to increase the comparability of responses" (p. 161). Therefore, the questions asked were similar; such as why some non-technical words were performed on poorly and factors which lead to participants' particular responses, resonating with meanings as used in the science classroom context. Likewise, particular interest was vested on some non-technical words, such as *conserve, system, linear* and *constant,* which particular participants performed well on. (See attached semi-structured interview schedule as Appendix C). When all open-ended questions (in the semi-structured schedule) and probing questions (e.g. Knowing the difficulties of these everyday words, what would you do differently in your future career as a science teacher?) were exhausted, the researcher brought the interview to a close. The interview took 45 minutes and 8 seconds.

The second year participants' interviews

The second year participants were the last group to be interviewed. The interview failed to take place on the day it was scheduled for, namely Friday, the 13th of October 2017. I had sent the message on the WhatsApp groups on Tuesday the 10th of October 2017, indicating that the interview will take place on Friday the 12th of October 2017. However, the 12th of October 2017 was not the Friday but the Thursday. When I re-circulated the message indicating the correct scheduled date, some members did not favor Friday, being a weekend (especially those who did not have to attend any academic activities on Thursday after the lunch break). Some participants, on the other hand, indicated to have changed their Friday commitments to Thursday for the sake of the Friday interview. Being the case, I had found myself in a very awkward position of choosing either Thursday or Friday.

Cohen et al.(2011) write that the participants cannot be forced or pressurized to participate in the study, they can only be encouraged to do so, however, the decision whether to take part or not is ultimately, entirely their own decision. Knowing that it was not possible for me to conduct the interviews on two consecutive days, I consciously decided to stay with my proposed date of the 13th of October 2017, but I thanked all who were willing to participate on Thursday. The consequence of this confusion was that the turn-out participant numbers for this particular interview totaled 9 individuals. While the second year students had the highest number of people who consented to be interviewed, the actual turn-out number was less as compared to the other two group interviews conducted. As with the other two groups, the second year participants used the same facility (boardroom), the same time (lunch hour break) and the same recording machine. The reasons for preferring the boardroom and the lunch hour break have been already explained above.

The interview started with the researcher introducing himself and explaining the purpose of the interview. The participants were assured to be free and open to answer any question. The questions asked were similar to the ones encountered in the previous two interviews conducted with the third- and fourth year participants. Special interest was vested on some non-technical words such as *characteristics, constant, linear, system* and *negligible, on* which the participants performed a score of 100%. At the beginning of the interview the participants were somehow reserved. They were not comfortable to elaborate on their responses. Hence I had to probe further until they had opened up. Some of the probing questions were: *So do you think you guys got all answers correct on this questionnaire? Are you going to teach science during your TE, the same way you are taught here or at school, just copy and paste?* The former probing question was asked at the beginning of the interview when the participants were still tongue-tied and the latter when they could not respond to the 5th question: *How can you help the students/learners to know the meanings of these words?* It was through questions such as these that the participants were motivated to engage with the issues under discussion. Nevertheless, the interview went well and lasted for 24 minutes and 15 seconds.

3.5.4. Exiting from the research site: Reflection on the data collection stage

The three interviews were conducted in three days, but not consecutively. The days were not consecutive because each group had its own logistical issues to be sorted out before finalizing the day for the interview. One of the main pressing issues were arranging days for attending the interviews. Since the participants were approaching the end of the year examinations, they were not attending lectures on a daily basis. Some would only come for revisions and collection of their tests scripts etc. Each interview was therefore arranged in a way that it could accommodate the availability of the participants who indicated willingness to take part.

Largely, the site could be excited when all the questions have been exhausted; when the participants continue giving the same responses or kept on repeating themselves. For instance, one of the last questions was: *There were some non-technical words (constant, linear, system etc.) that the participants got almost 100% what do you think could be the reason for that?* The participants' responses were*: their everyday meanings and science meanings are the same.* Another participant would say: *yes their meanings do not change with context.* When the participants started with these types of repetitious responses, it was regarded as a signal that the participants had exhausted their responses.

It is worthwhile to mention that the time for semi-structured interviews varied per group. Lin (in Palaiologou, Needham and Male, 2016) posits that "the length of interview varies depending on the availability of individual respondents' time or interactions between interviewees and interviewers" (p.161). As it has transpired in this research; the fourth year interview was the longest (55: 20 minutes); the third year's interview was 45:08 minutes; the second year's interview took 24:15 minutes and the single participant interview lasted 15:40 minutes.

It is also vital to acknowledge the successes and challenges incurred during this data collection process. The obvious success was that I managed to collect both quantitative and qualitative data from all three participating groups. Further, I valued the cooperation and support I received from the students who participated, even though it was time for them to study for exams. The possible challenges included: waiting for some participants to arrive as they were not on the campus, having to reschedule some interview dates and days of the interviews and lastly but not the least, the anxiety or fear of whether the students would turn up for interviews or not.

Evaluation of the data collection process

The collection of the data for this study happened in two phases: collection of quantitative data and collection of qualitative data. The quantitative data was collected using the structured questionnaire and the qualitative data was done using semi-structured interviews. Generally, the whole data collection process has been a learning experience for me as researcher. To begin with, my first application for ethical clearance was rejected; because it did not meet the prescribed requirements by Wits School of Education's Human Research Ethics Committee. After making several amendments to my application, as suggested by the ethics committee, I then re-applied. As already mentioned in section 3.5.1, my second application was successful and I was granted ethics clearance with the assigned Protocol Number: 2017ECE028M. The positive response from the Wits School of Education's Human Research Ethics Committee opened the doors for me to access the research site. Gaining access to the site was very easy, because I was assisted by the lecturer of the course. As explained in section 3.5.3.2, quantitative data was collected first using the questionnaires followed by the qualitative data.

Basically, it was very difficult to use all the people who consented on the questionnaires as samples for the interview. It was within this context that I used snowball sampling to include some of the participants who indicated willingness to participate. The snowball sampling had proven to be effective because it could accommodate the use of social media (WhatsApp) for access to participants (Cohen et al., 2011). It was through the snowballed participants that qualitative data collection became a reality. One remarkable thing about snowball sampling, as observed in this study, was that all the participants (except one third year student who excused herself) honoured the interviews. In review of the experiences incurred in the process of both qualitative data and quantitative data lead us to examine how this data could be analyzed.

3.6. Data analysis and strategies

De Vos et al. (2011) define data analysis as the "process of bringing order, structure and meaning to the mass of collected data" (p.397). Schwandt (2007) argues, "Data analysis is an activity of making sense of, interpreting and theorising data" (p.6). By the kinds of data collected, descriptive analysis and content analysis were deemed suitable approaches used to analyse the data. De Vos, et al. (2011) refers to descriptive statistics as "procedures that describe numerical data in that they assist in organizing, summarizing and interpreting sample data" (p.251). Since descriptive statistics reduces large data sets in its analysis, it is sometimes called summary statistics (McMillan & Schumacher, 2010).

Descriptive Analysis

The use of descriptive analysis in analysing the quantitative data of this study involved the following steps: The analysis of the questionnaires contained 30 word items. These word items were subjected to descriptive analysis where they were marked against correct responses and then recorded in terms of their frequency and meaning, and later converted to percentages in terms of correct responses and incorrect responses respectively. Through this analysis, the word items that turned out to be well performed and poorly performed in were chosen for qualitative data analysis, through semi-structured interviews. The scores per participant group (per item) were tabulated into charts such as tables and graphs. In this way, the items with high scores (correct or incorrect) were considered during the participants' interviews.

Content Analysis

Content analysis is a "strict and systematic set of procedures for the rigorous analysis, examination and verification of the contents of the written data" (Cohen, et al., 2011, p. 563). Krippendorff (2013) posits that "content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the context of their use" (p. 24). The word 'text' in this regard, refers to any written document, which is meant to be read, interpreted and understood. In this study, the process of creating the text was through transcribing the interview questions and responses that were recorded. Creswell (2003) defines transcription as the "process of converting videotape, audio tape recordings or field notes into text data" (p. 239).

Krippendorff (2013) indicates that the use of content analysis as a research technique should be able to produce findings, which are replicable. The replication of findings is seen when a different researcher, working at a different time and circumstances, is able to get the same result using the same analysis technique applied to the same phenomena in question (Krippendorff, 2013). Fahy (2001) argues that when using content analysis, a researcher must indicate which part of the text or unit of analysis or data segment is she or he investigating. This is because it has an impact on the kind of information to be extracted from the text in order to respond to the research questions (Fahy 2001). An unit of study or data segment is a "text that is comprehensible by itself and contains one idea, episode or piece of relevant information" (McMillan &Schumacher, 2010, p. 370).

In this study, content analysis was used for interpreting the contextual meanings of the non-technical words used in the questionnaire. The unit of analysis therefore, was the patterns in the pre-service science teachers' responses, resulting from the follow up interview conducted in order to answer the research questions 3 and 4. My units of analysis were therefore not uniform. They differed from a single word, a sentence, a few lines of text depending on what provided a meaningful response (McMillan & Schumacher, 2010). Since data enter a content analysis from outside, they become texts to the researcher within the context that the researcher choose to read them (Krippendorff, 2013). As already presented in section 2.6, a context is conceived as "always someone's construction, the conceptual environment of a text, the situation in which it plays a role" (Krippendorff, 2013, p. 38). In this study, therefore, the units of analysis were read with a science context in mind.

3.6.1. Analysis strategy of the questionnaire

The journey towards data analysis was started by numbering all questionnaires that were collected from the participants. The questionnaires were numbered from the first one to the last in all respective three classes. Each questionnaire had 30 items to be answered, each item having four optional answers marked A, B, C, and D as the meanings of non-technical words presented in the science context. In these questionnaires, all the possible meanings provided as an option were correct, but there was only one meaning that was applicable within the science context. In a similar study, Oyoo, (2017) explained that the criteria in this regard was that the items selected were “considered correct only if the meanings selected on the questionnaire or referred to in the interviews applied in the context of science” (p. 794).

The process of marking the questionnaires was the next step and of interest was to look at the number of participants who had selected either A, B, C, D or N/R (no response) as their response options per item. These numbers were recorded and converted to percentages. The focus therefore, was not only on the number of correct responses provided by each questionnaire item, but the occurrence of the selections as answers as either correct or wrong (quantitative) across the pre-service science teachers’ study level. In short, the responses were statistically analyzed for score patterns and trends to arrive at conclusions to the first two research questions: To what extent do pre-service science teachers encounter difficulties with non-technical words used in a classroom context and which non-technical words emerged as difficult to these pre-service science teachers?

The data analysis of the quantitative data was done in two stages: On distribution of the score (quantitative) and alternative meanings from the participants’ responses. On the quantitative level, the responses from the questionnaire were analyzed statistically for score patterns to determine if pre-service teachers had difficulties with everyday words when used in the science context. The criterion for difficulty was that scores of items below 100% were regarded as very difficult. In this English medium university, 50% is the pass mark in any subject from 1st year up to fourth year. In this study however, our pass mark was deliberately set at 100%. The reason was that since the participants were from an English speaking university, pre-service science teachers are expected to embrace a good command of English. Moreover, as highlighted in section 3.4.1, the schools these pre-service science students came from were also English medium schools.

3.6.2. Analysis of interview data

The distribution of the difficult and well performed words in tables provided an avenue by which these words could be followed up through the semi-structured interview process. This was to generate an understanding of the meaning of these difficult everyday words used by pre-service science teachers, in the science context. The link between words, knowledge and language was adopted and served as a data analysis framework on language (Postman &

Weingartner, 1971). The framework was operationalised as a pragmatic perspective, (Gyllenpalm, et al., 2010 cited in Oyoo, 2017) regarding how words that form a language can possess different meanings depending on the context.

3.7. Summary of the chapter

The chapter examined the research methodology that was used to establish pre-service science teachers' meanings of non-technical words used in the science context. It has highlighted relevant concepts pertaining to research methodology. The chapter has pondered on matters concerning ethical issues, such as ethics clearance, participant information, confidentiality and anonymity.

CHAPTER FOUR: Findings and discussions

4.1 Introduction

This study was on the understanding of the meaning of the non-technical words used by pre-service science teachers in science classroom context. This chapter presents and discusses the data analysis and findings in this study. Details of design and implementation have been provided in sections 3.2.2 and 3.5.4, as well the data analysis framework and strategies have been provided in sections 3.6, 3.6.1 and 3.6.2. This study sought to address the following research questions:

- To what extent do pre-service science teachers encounter difficulties with non-technical words used in science classroom context?
- Which non-technical words emerged as difficult to the pre-service science teachers?
- What are the sources of the difficulty of these words as encountered by pre-service science teachers?
- What possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training?

In addressing these questions, participants answered the questionnaires, which were the main data gathering tool for the quantitative data of this study. Data from the questionnaires were analyzed through descriptive analysis. The findings from the quantitative data were used to answer questions in bullets 1 and 2 respectively. The data obtained from interviews was used to respond to questions in bullets 3 and 4 by extracting relevant quotes which assisted to answer these questions. These quotes were compared with what is published in journal articles in this area. While I acknowledged many research reports available in literature regarding non-technical words used in the science classroom context, analysis of the interviews were done using only published journal articles. For instance, on learners' performance, the following articles were deemed relevant in South Africa: Oyoo & Semeon, (2015); Oyoo, (2017); and internationally: transnational articles published in Malaysia, Australia, Malta, UK, Papua New Guinea and Philippines. Furthermore, on teachers' lack of awareness of the non-technical words, the relevant article used for analysis was of Oyoo (2012).

4.2 Discussion of the research questions

Schumacher and McMillan (2010) assert that it is practically impossible to analyse and interpret the data unless it is organised. The data in this study was organised both quantitatively and qualitatively. The quantitative data collected using questionnaires was first coded, marked, and organised according to the number of scores (correct or incorrect) per item per year of study. This process was meant to respond to the first research question: *To what extent do pre-service science teachers encounter difficulties with non-technical words used in classroom context?* The items with the highest scores of incorrect responses according to the science context were then considered and characterized as difficult words. The pre-service science teachers' response charts where the scores were recorded were given codes according to the year of study. For instance, NSII for second year Natural Science, PSIII for third year Physical Science and PSIV for fourth year Physical Science.

Considering the difference in the years of study, results from these three groups of participants were analysed separately. However, the criterion for difficult across these groups remained the same for comparability purposes so as to establish whether the difficulty of these words vary with the level of study. This was to pave the way to arrive at conclusions so as to answer the second research question: *Which non-technical words emerged as difficult to the pre-service science teachers?* As already discussed in section 3.6.1, in this English medium university, 50% is the pass mark in any subject from 1st year to fourth year. In this study however, our pass mark was deliberately set at 100%. The reason was that since the participants were from an English speaking university, pre-service science teachers were expected to embrace a good command of English. Considering pre-service science teachers' general proficiency in LOLT, this study, however, deliberately took 100% as the pass mark. This means that any score less than 100% would be considered a fail hence rendering the item difficult. The criterion for difficulty was varied as follows: scores of items ranging between 40 and 65% were regarded extremely difficult, those between 66 and 85 % moderately difficult and those between 86 and 99% were considered just difficult. Considering the 50% pass mark at this university, I had operationalized the cut-offs percentages into extremely, moderate and difficult.

Therefore, after the selection of the difficult words using the criterion stated in the previous paragraph, the interviews were arranged with the participants. For the interviews different codes were used in the transcribed text. The letter R represents researcher (interviewer), ST representing Student Teacher. As such ST1 would mean that the response was given by the first respondent and ST2 second respondent and so on. However, it does not necessarily mean that they were the same persons across all interviews groups, as it is just a representation.

The main reason for interviews with the pre-service science teachers was to investigate the reason behind their responses to particular items in the questionnaires that were considered difficult. This process was guided by the third research question: *What are the sources of the difficulty of these words as encountered by pre-service science teachers?* Through this exercise, a qualitative comparison between their questionnaire and the interview data was established regarding the identified difficult items. It was this comparison that made it possible to establish if pre-service science teachers had alternative meanings to these non-technical words that caused them to interpret them wrongly. Probably, the point worthy pondering was why the pre-science teachers gave such interpretation to the non-technical words. This kind of thinking was to establish the answers to the fourth research question*: What possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training?*

4.2.1 The questionnaire findings

I have discussed in section 3.6, the data analysis strategies that were used in this study. The finding from the data analysis based on the questionnaires marked revealed clearly that pre-service science teachers had difficulties with some non-technical words that are used in a science classroom context. It was observed that all the participant pre-service science teachers, regardless the year of their study namely: second year participants of Natural Science Methodology Course (n=106), and third year (n=40) and fourth year (n=38) participants of Physical Science Methodology Course, experienced difficulties in giving the correct meaning to some of these non-technical words as understood in the science classroom. An anlysis of each year of study was required in order to make sure that all the methodology courses' findings were given equal attention. I now present to deliberate on the findings of second year Natural Science Methodology Course particpants.

4.2.2 The second year students' performance on non-technical words

The details on the performance regarding the numbers of the participant pre-service science teachers per optional response and corresponding percentages, is available as Appendix D. However, the simplified version of Appendix D is presented in Table 4.1 immediately below, which shows relative distribution of Natural Science participants' scores on each of the 30 items. Following the established criterion of analysis (section 4.2.) of the non-technical words on the level of their difficulty, the following words emerged to be extremely difficult (scoring 40-65 %) for Natural Science partcicipants: ***sensitive 50%, effect 56%, trace 61%*** and ***retard***

64%. The words such as ***convention 72%, contract 72%, prepare 75%, sponteneous 75%, consistent 76%, evacuate 80%, disintergrate 82%, displace 82%*** and ***generate 83%*** emerged as moderately difficult (scoring 66-85 %). The rest of the words were regarded just difficult (scoring 86-99 %). It is noteworthy, that the following words***: conserve, system, linear*** and ***constant*** did not pose a challenge since the second year participants scored 100% in each of these items.

Table 4.1: Distribution of second year participants' relative scores on each of the 30 items

NSII Pre-service teachers' codes		Correct Answer	OVERALL % PER OPTION SELECTED (n=106)					% of Incorrect Responses	% of Correct Responses
No	**Words**		**A**	**B**	**C**	**D**	**N/R**		
1	**Consecutive**	**C**	0.00	2.83	92.45	4.72	0.00	7.55	92.45
2	**Displaces**	**B**	1.89	82.08	1.87	14.15	0.00	17.92	82.08
3	**Limit**	**D**	0.94	0.94	3.78	94.34	0.00	5.66	94.34
4	**Prepare**	**D**	19.81	1.89	1.89	74.52	1.80	25.47	74.53
5	**Dehydrate**	**A**	98.11	0.94	0.94	0.00	0.00	1.87	98.11
6	**Generate**	**C**	4.72	9.43	83.96	0.00	1.89	16.04	83.96
7	**Sensitive**	**A**	50.00	2.83	2.83	43.40	0.94	50.00	50.00
8	**Characteristic**	**B**	0.00	93.40	5.66	0.00	0.94	6.60	93.40
9	**Trace**	**C**	35.85	2.83	60.38	0.94	0.00	39.62	60.38
10	**Fundamental**	**B**	4.71	87.74	5.66	0.94	0.94	12.26	87.74
11	**Constant**	**A**	100	0.00	0.00	0.00	0.00	0.00	100
12	**Contract**	**C**	9.43	11.32	71.70	6.60	0.94	28.30	71.70
13	**Valid**	**A**	98.11	0.00	1.89	0.00	0.00	1.89	98.11
14	**Spontaneous**	**B**	17.92	74.53	2.83	3.77	0.94	25.47	74.53
15	**Factors**	**D**	3.77	1.87	3.77	90.57	0.00	9.43	90.57
16	**Concept**	**C**	0.00	0.00	97.17	2.83	0.00	2.83	97.17
17	**Diversity**	**B**	0.00	99.06	0.94	0.00	0.00	0.94	99.06
18	**Linear**	**A**	100	0.00	0.00	0.00	0.00	0.00	100
19	**Retard**	**C**	16.04	15.09	64.15	3.77	0.94	35.85	64.15
20	**Effect**	**D**	16.04	26.42	1.89	55.66	0.00	44.34	55.66
21	**Consistent**	**B**	4.71	76.42	15.09	2.83	0.94	23.58	76.42
22	**Function**	**D**	0.94	0.00	0.94	98.11	0.00	1.89	98.11
23	**System**	**D**	0.00	0.00	0.00	100	0.00	0.00	100
24	**Convention**	**A**	71.69	10.38	5.66	6.60	5.66	28.3	71.69
25	**Negligible**	**C**	4.71	3.77	89.62	0.94	0.94	10.38	89.62
26	**Evacuate**	**D**	5.66	3.77	9.43	80.19	0.94	19.81	80.19
27	**Estimate**	**B**	0.94	95.28	1.87	1.87	0.00	4.72	98.28
28	**Conserve**	**C**	0.00	0.00	100	0.00	0.00	0.00	100
29	**Disintegrate**	**A**	82.08	2.83	1.87	12.26	0.94	17.92	82.08
30	**Random**	**B**	0.94	98.11	0.00	0.94	0.00	1.87	98.11

The general expectations from the quantitative data findings were that the second year participants would have scored most of these words at 100%. However, the findings had proven the opposite because only four words: conserve, system, linear and constant had emerged to be well comprehended by second year participants. As such, failure to have words scored at 100% was evidence that the problem with these words transcended the aspect of general proficiency in the LOLT. In other words, the second year participants did not posses a good word comprehension of these everyday words when used in the science classroom context. The table 4.2 below, stands to testify to this observation. Even though the Table 4.2 below presents only very difficult and moderately difficult words, the rest were equally difficult, since the second year pre-service science teachers did not manage to get a full score on these words. According to the conceptual framework governing this research study where words are language and knowledge, lack of understanding these words suggests lack of proficiency in the science language and probably the scientific knowledge itself.

From Table 4.1 above, I have sampled the extremely difficult and moderately difficult words and summarised them in descending order of difficulty in Table 4.2, immediately below as follows: **sensitive, effect, trace** and **retard.** The words with an asterisk (*) indicate that they are extremely difficult. These very words were used for analysis and interviews since they have posed a primary challenge among the second year pre-service science teacher participants.

Table 4.2: Summary of difficult words expressed as percentages

No	Word	% Correct responses	% In correct responses
1	**Sensitive***	50	50
2	**Effect***	56	44
3	**Trace***	61	39
4	**Retard***	64	36
5	Convention	72	28
6	Contract	72	28
7	Prepare	75	25
8	Spontaneous	75	25
9	Consistent	76	24
10	Evacuate	80	20
11	Disintegrate	82	18
12	Displace	82	18
13	Generate	83	17

Table 4.2 and Fig. 4.1 show clearly that the extreme difficult items among the second year natural science methodology participants were *sensitive, effect, trace* and *retard*. From the

literature review examined, it is apparent that the same non-technical words have emerged to be difficult in the previous studies (Cassels & Johnstone, 1980; Tao 1994). Table 4.2 reveals that second year's participants experienced difficulties in understanding the meaning of everyday words used in the science classroom context. Figure 4.1 below shows a graphical distribution of the most diffcult words in descending order of highest incorrect scores on the item to the lowest.

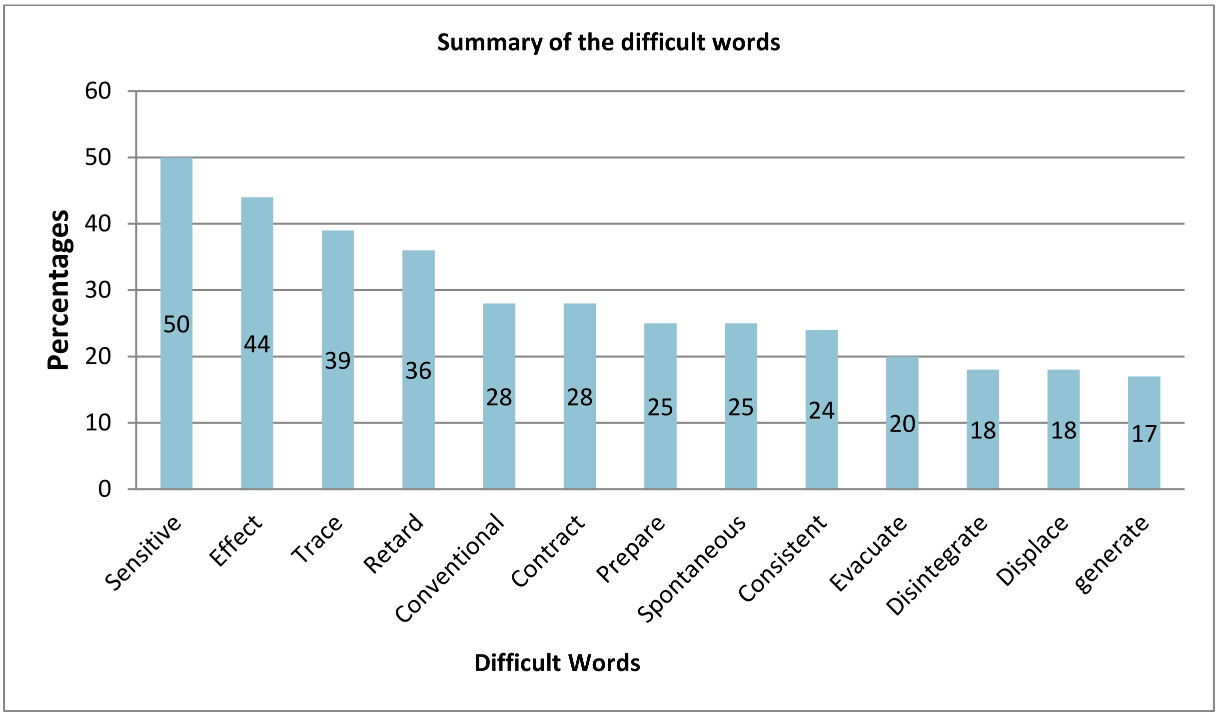

Figure 4.1: Graphical distribution of most difficult words in descending order of incorrect responses

4.3 The analysis of the extremely difficult items

I have selected thirteen items that emerged extremely and moderately difficult to most second year participants in this study. It would be better to analyze all of them but since four of them have emerged to be extremely difficult these items will be selected for systematic analysis on second year pre-service teachers' understanding of these words when used in the science classroom. Following the order of difficulty, the word *sensitive* is therefore discussed first.

4.3.1 Sensitive

From Table 4.2 and Figure 4.1, we find that the most difficult word (scoring 40-65%) was *sensitive*. The pre-service science teachers obtained an overall 50% incorrect responses on this item. The word *sensitive* appeared in the questionnaire as reproduced below:

The beam balance is a very sensitive instrument. This means that

A. can be used to weigh very small things
B. can be only used by sensitive people
C. is hard to understand how it works
D. gets spoilt very easily

The four responses given immediately above were all possible answers in whichever context: science context, everyday context or street jargon. As already mentioned in section 3.6, guided by the scientific tool (content analysis) used to analyse the qualitative data, a context is conceived as "always someone's construction, the conceptual environment of a text, the situation in which it plays a role" (Krippendorff, 2013, p. 38). As such, on this word item, only one constructed option was correct: A –'can be used to weigh very small things' in accordance with the classroom science context. In this study, the answers on this item were distributed between the given options as follows: A- 50%, B- 3%, C- 3%, D- 43% and N/R- 1% did not give any answer. The distribution of the scores suggested that in total at least 50% of the participants did not know the contextual meaning of the word sensitive when used in the science classroom. The optional response worth pondering is D that attracted almost 43% of the participants. Figure 4.2 below is a graphical representation of this distribution expressed in percentages.

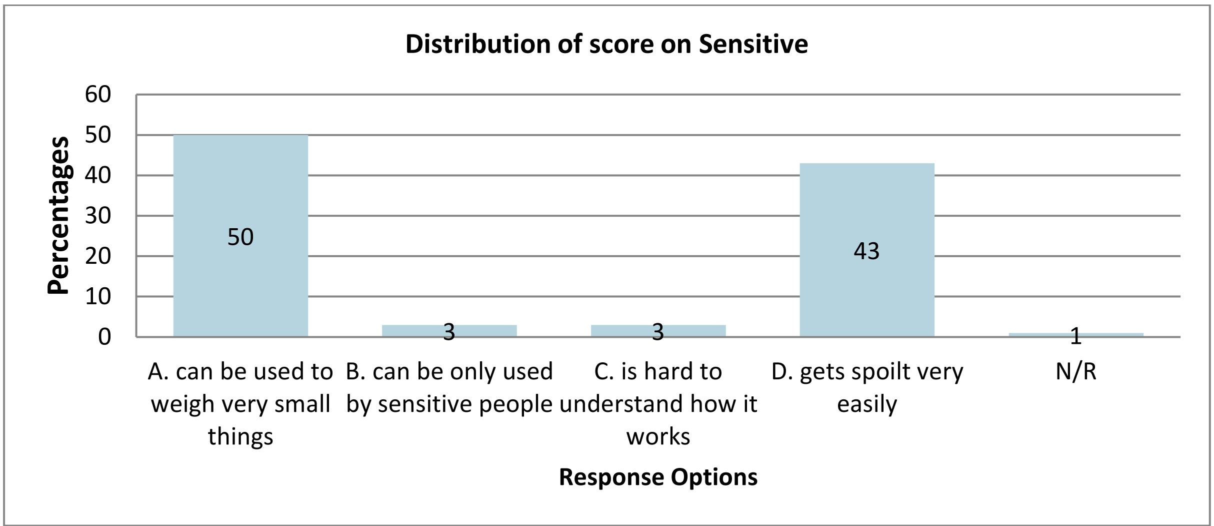

Figure 4.2: Graphical distribution of selections between options of the word 'sensitive'

The word "sensitive" in physical science is used for instruments that can be used to measure very small things. As such pre-service science teachers were likely to have encountered this word during their practical work where instruments such as thermometers (measures small changes in temperature) and beam balances (weighs/measures small things) are regarded as sensitive. As already indicated, the correct optional response to the word 'sensitive' was 'A': *can be used to weigh very small things*. However, as seen from the graphical representation immediate above, the correct response 'A' scored 50% (n= 53/106) participants selecting it. Since half of participants did not get it right, the distribution of this half (50%) was as follows: B- 3 % (n=3), C-3 % (n=3), D- 43 % (n=46) and N/R-1 % (1). The score that excited the greatest interest on this item is that 43 % of the participants chose 'D' which reads 'gets spoilt very easily', an option which was not a correct contextual science response.

The discussion on the difficulties encountered by the word *sensitive* was guided by research question 3, which concerned itself with the sources of the difficulty of the non-technical words as used in the science classroom context. The excerpt below highlights the interview responses that the researcher conducted with the second year participants on the word *sensitive*. I started the interview on this word by asking the participants to choose the correct response from the four given options.

> *ST1: Okay, I would go with the last one.*
> *R: You would go with the last one? It gets spoiled easily?*
> *ST1: Yes; because from everyday knowledge, when you say like, my skin is sensitive to the sun, like the meaning, like, obvious if like the skin can get spoiled easily, or, I don't know which term to use. Something like that, so whoever chose that number (D) I agree with.*
> *R: So you are agreeing with number (D)?*
> *ST1: From the everyday knowledge*
> *R: From everyday knowledge, but is that the same in science context according to this statement the way you look at it?*
> *ST1: Sort of.*

The participant (ST1) chose option (D) as the correct response for item number 7. The reason for such a choice was based on everyday knowledge or context. The participant mentioned twice that she chose option (D) based on everyday knowledge. From the interview responses with the participants, they acknowledged that the option response (D) emanated from their encounter with the everyday meaning of the word *sensitive*. As such many of the participants who selected (D) had the everyday meaning of the word in mind when responding to this item. This finding is not unique to this study. The study conducted by Oyoo (2017) among Grade 12 physical science learners in South Africa on their understanding of non-technical words revealed a similar outcome. The participants were inclined to choose this response option due to the influence of the everyday context (Oyoo, 2017; Oyoo & Semeon, 2015). Since option A, the correct response in the context as in the questionnaire accumulated 50%

(n=53/106) participants, almost half of the study population had therefore chosen option A. The excerpt that follows disclosed their reasons for selecting A.

> *R: You. Your hand was first. Okay, let's start this side*
> *ST2: No, she can talk.*
> *ST3: From Science, I think (A) is the correct one, because, obviously it's an instrument and if it's sensitive it can only weigh other things, smaller things, not things with a larger mass. But from an everyday knowledge, ahh like, of the word (d) is correct.*
> *R: (D) is correct? Aah, okay, so what you are telling me is that there is the same word it has a meaning in the everyday life, but now it comes to this side….*
> *All STs: Science language. It carries a different meaning.*

As transpired from the interview responses, some of the participants subscribed to option D due to the everyday context, others acknowledged option A according to the science classroom context. Such utterances pointed to one thing namely that some words used in science classroom change according to the context of use. Both local literature (Oyoo, 2017; Oyoo & Semeon, 2015) and international literature (Cassels & Johnstone, 1980/1985; Farrell &Ventura, 1998; Marshall & Gilmour, 1990) subscribe to the notion that change of context is one of the reasons non-technical words cannot be easily understood. Since these non-technical words can be associated with more than one distinct contextual meaning, the context in which these words are used is therefore crucial.

MESSAGES FROM DIFFICULTIES ENCOUNTERED

The interview responses on this word 'sensitive' with the selection of option D, was based on the everyday meaning of the word. In everyday context, the word *sensitive* is attributed to things such as skin that can easily get damaged due to heat from the sun. The everyday context is conceived to be realistic within people's experiences. There is an agreement between what the pre-service science teachers' train of thoughts are, with the actual reality. The scientific understanding on the other hand, carries a different meaning, other than the one people are accustomed to. The message from the encountered difficulties is that there is an observed lack of correct explanations of the meaning of these words, such as *sensitive* in practical activities, science text books and classroom teachers' talk.

4.3.2 Effect

The word "effect" emerged as the second most difficult word (40-65%) with second year pre-service science teachers scoring 44% incorrect responses on this item. This word item number 20 appeared in the questionnaire as follows:

If you were asked to find the <u>effect</u> of adding acid to a metal, this means you would try to find:

A. the reason for adding the acid
B. the quantity of acid used
C. how long the reaction took
D. what happened

The correct response for this item was: D –'what happened' according to its usage in the science classroom context. However, as emerged from the responses on this item, the scores were distributed between the options as follows: A- 16 %, B- 26 %, C- 2 %, D- 56 % and N/R-0 % respectively. Figure 4.3 below is a graphical representation of this distribution, expressed in a percentage.

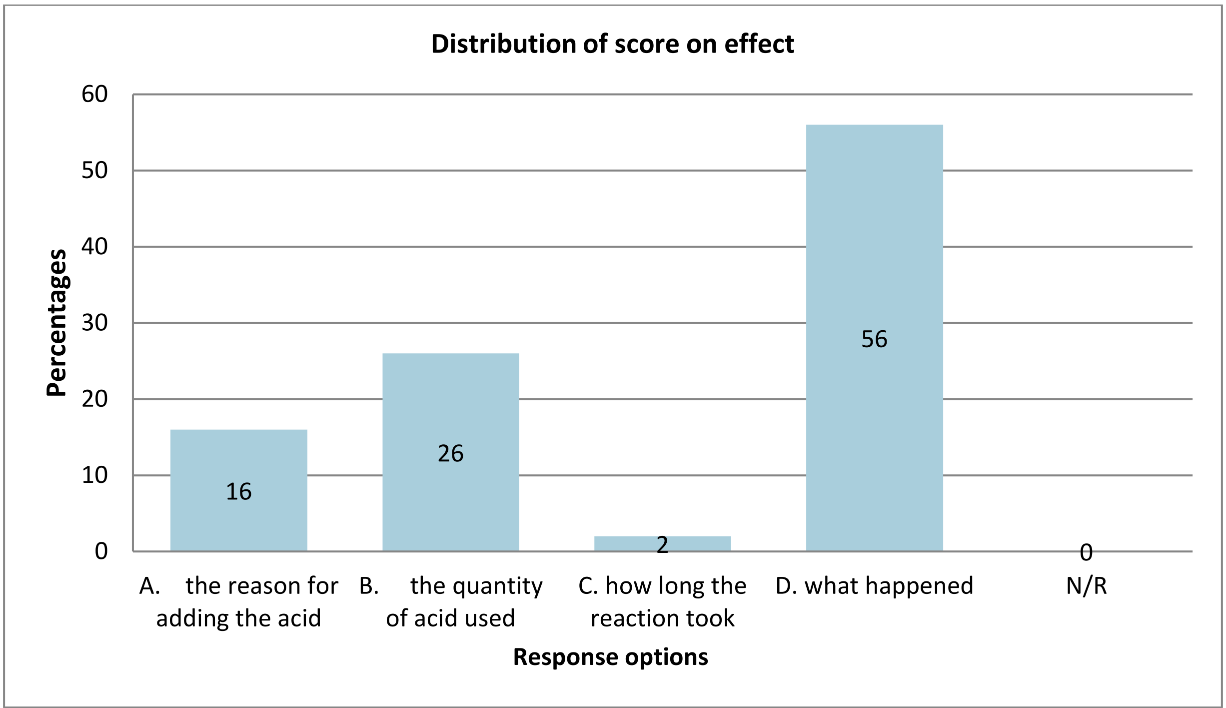

Figure 4.3: Graphical distribution of selections between options of the word 'effect'

The graphical representation Figure 4.3 shows that at least 44 % (n=47/106) of the second year participants harboured an incorrect meaning of the word *effect* as used in the science context. The distributions of the incorrect responses were A-16 % (n=17), B-26 % (n=28), and C-2 % (n=2) respectively. The score options that were worth pondering in this item were that of options A and B. In option A, almost 17 participants (16 %) conceived the word effect to mean 'the reason for adding the acid' while 26 % (n=28) of the participants conceived it as 'the quantity of acid used'. While the word effect was not an unfamiliar word in physical science text books, only 56 % (n = 59/106) of the second year participants gave the correct contextual meaning of the word. Below are excerpts from the interview responses on the incorrect responses A and B.

R: Some people they wrote when you say effect it means the reason for adding the acid. Or in the first place what would be your answers?
ST1: How long the reaction took, I think.
R: The effect would be how long the reaction took, okay. Why?
ST2: Mine the last one.
R: The last one? Errr, what happened?
ST2: Yes
R: What happened, Okay.
ST3: I think it's what; it's what happened because it's a result, the effect, yes

The participants had different understandings of the meaning of the word *effect* as it appeared as item 20 and that was shown through their spontaneous selection of different options. However, two participants (ST2 and ST3) seemed to agree on the last option "what happened" as the correct answer. The consequence was that the first participants (ST1) who chose option C "how long the reaction took" did not explain his/her reason for choosing response option. It was for this purpose that I had to ask a probing question since I was thinking about those participants who chose A "the reason for adding the acid".

R: Okay, but if the person says the reason for adding the acid is.
ST3: Eish, okay. Can you read the question again?
R: If you were asked to find the effect of adding acid to a metal, this means you'd try to find the reason for adding the acid, the quantity of acid used, how long the reaction took and what happened.
ST3: I don't think it's the reason.
R: It's not the reason?
ST3: Yes, because already the effect, they want to find reasons, so we can't say the reasons again.
R: So according to you the answer would be?
ST3: The last one
R: What happened?
ST3: Yes
R: Yes, and you also?
ST4: Aaah, yes. I would say if a person doesn't really know the meaning of effect, then he or she will probably choose the wrong answer.

As the interview continued, probing the participants to hotly debate on some options that were selected, the participant (ST4) added the aspect of general proficiency in the LOLT. The participant point was that if the other participants embrace the correct meaning of the word *effect* (thus according to the English dictionary) then they would have not chosen the wrong answer. In this regard, lack of general proficiency in LOLT was seen as one of the reasons for poor understanding of some non-technical words used in the science classroom context. No sooner had participant (ST4) finished raising her point of view, participant (ST5) brought an argument that suggested knowing the meaning of a word alone was not sufficient to explain the scientific meaning of the everyday word when used in a science classroom context. The following excerpts emphasize the point:

> *ST5: But sometimes I feel like it's not necessarily about knowing the meaning of the word because we come across, like everyday life, we come across different meaning. So I might have a certain meaning, she might have a certain meaning of effect and when we're answering that question, it would probably be different.*
> *R: Oh, depending on your experience with the word?*
> *ST6: Ja, depending on the experience, everyday experience.*

The excerpts above suggest that the source of difficulty of this word *effect* had to do with the individual's knowledge and experience of the word, within a particular context of use. It could not be reduced to its dictionary definitions only, but rather the context in which the word was encountered, whether in everyday experience, school context etc. This argument then brought forward the issues about contextual meaning and use of the non- technical words as one of the difficulties incurred when these words are applied in the science context. It is justified in the sense that when the participant (ST6) was asked by the researcher to choose an option response from the four, the participant chose the option which was scientifically applicable because of the context in which it was used. It is therefore reasonable to posit that context is a valuable part of understanding the meaning of non-technical words.

As discussed, the correct response for the word *effect* was D- 'what happened' which suggested a change as a result of a particular influence or cause namely: an act of adding an acid to a metal. This item abounds both in Grade 10-12 physical science content as well as in practical activities (DHET, 2011). For instance, under the topic 'Matter and Materials' in Grade 10 (DHET, 2011), the item *effect* surfaces as follows: "The *effect* of the different types of chemical bonding are over emphasized here" (DHET, 2011, p. 23). Similarly, in Grade 12, most of the practical activities employ the item to investigate a particular influence of a substance such as determining the "effect of catalyst-hydrogen peroxide and manganese dioxide; burning sugar cube with and without dipping in activated carbon" (DHET, 2011 p. 123). The word *effect* was therefore not unfamiliar to the pre-service science teachers.

MESSAGES FROM DIFFICULTIES ENCOUNTERED

The message from the interview response on the word *effect* points to the issue of context. Some pre-service science teachers argued that knowing the meaning of the word would have led to the correct response. However, some have indicated that one word can have multiple meanings and knowing one meaning, cannot solve the contextual problems of these non-technical words. It is therefore clear that context has a significant influence in explaining the meaning of these words when used in the science classroom.

4.3.3 Trace

According to the marked second year questionnaires, the word *trace* emerged as the third most difficult word (40-65 %) with second year pre-service science teachers scoring 39 % incorrect responses on this item. This word item number 9 appeared in the questionnaire as follows: The soil contained a trace of potassium. This means it

A. used to have some potassium
B. had plants, which use potassium
C. had a very small amount of potassium
D. had a large amount of potassium

The correct response for this item in accordance with the science classroom context was: C – 'had a very small amount of potassium'. However, as emerged from the responses on this item, the scores were distributed between the options as follows: A- 36 % (n=38), B- 3 % (n = 3), C- 60 % (n = 64), D- 1% (n=1) and N/R-0%. In short, it means 60 % of the participants knew the contextual meaning and 40 % of the participants did not know the meaning of the word *trace,* when used in the science classroom context. These quantitative data findings are represented in a graphical form as shown below in Figure 4.4.

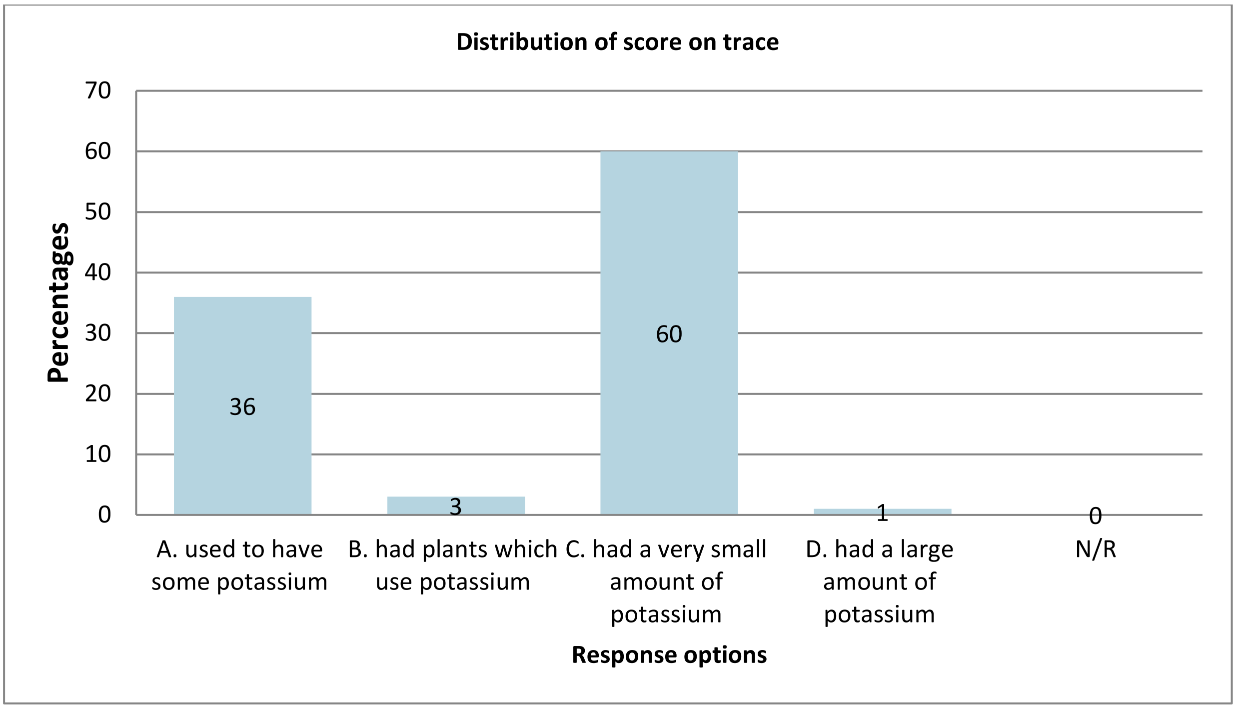

Figure 4.4: Graphical distribution of selections between options of the word 'trace'

From the graphical representation in Figure 4.4, it became evident that most of the participants' responses were oscillating between options A (used to have some potassium) and C (had a very small amount of potassium). The total distributions of the incorrect responses were A- 36 % (n=38), B- 3 % (n=3), C- 60 % (n=64), D- 1 % (n=1). The graphical representation illustrates that 40 % (42/106) of the second year participants chose an incorrect contextual meaning of the word *trace* while 60 % (64/106) chose C, the correct response as used in the science context. While the scores in option A attracted more attention, investigating the source of difficulty in all options, which did not reflect a scientific meaning is of utmost importance. The excerpts below from the interview responses reflect on the possible sources of difficulty regarding the word *trace* as experienced by the participants.

R: The sentence said the soil contained a trace of potassium…So many people they chose, it used to have some potassium, and others they say had a large amount of potassium. What do you think can be the reasoning behind that?
*ST1**:** Biology, Maybe?*
R: Biology, Mmh, What about Biology?
***ST1:** When something has got a trace, like it used to, so I think it's from, maybe it's someone did Biology chose that answer.*
R: Mmh, how is it used in Biology, the word trace?
ST1: Can anyone help me?

The interest to find out why some participants were inclined to select option A (it used to have some potassium), revealed that perhaps the participants option was influenced by a biology context. In South Africa, physical science at high school constitutes physics and chemistry contents. The other science subject at school level is biology commonly known as life sciences. At this English medium university students who chose to take science as their major subject, are required to study natural sciences in the first and second years of study. Natural science constitutes physics, life science (biology) and chemistry. It is within this context that participant (ST1) thought the word *trace* could have been encountered in biology, whether at school level or university level. In the following excerpts, the researcher was curious to know how the word *trace* is used in biology.

R: Mmh, give examples of how the word trace is used in Biology?
Or when does it appear, when we are talking about what in Biology?
***ST1:** When we are doing fossils.*
***ST2:** Ja, fossils.*
R: When talking about the fossils?
STs: Yes, tracing of fossils.
ST2: Fossils

The meaning of the word *trace* in the excerpts above was understood in association with dinosaur fossils. As the participants have articulated, it is based on life sciences (biology) where a trace could possibly entail a visible appearance or marks of something when the actual object/organism does not exist anymore. As argued by the participants in this interview response, the presence of visible marks or remains of something such as potassium signifies that the element was previously abundant in that particular location. The excerpts below confirms this way of thinking.

> *R: Ok, trace, all right. And if a person chose to say it had a large amount of potassium, what do you think can be the reason behind?*
> ***ST2:*** *Another thing we said that, she mentioned Biology where we say trace is used when we talk about fossils. So if they gonna find traces of, let me say, a bone of a dinosaur somewhere here, it means it used to live here. So that person might have that impression that it used to have the large amount of, of, of potassium and then due to time it was depleted. So yeah, that's why they found smaller traces of that so it shows that it used to be there. Ja, so I think*

According to how the word item was structured, the word *trace* meant *minute* or *small quantity* of an element, such as potassium in a given substance such as soil. However, that small quantity did not indicate an initial large amount, as argued by the participants. Even though the meaning of the word *trace, when used in biology,* is perhaps closely related to the participants' everyday experiences, its application in this context was not applicable. The source of difficulty is that even in the very subjects of science (agricultural sciences, biology, chemistry, physics etc.) the meaning of everyday words must be conceived within the confines of its contextual use, applicable to that particular subject.

MESSAGES FROM DIFFICULTIES ENCOUNTERED

The message from the difficulties encountered can be seen from different angles. There is strong evidence that the students are not familiar with the word *trace*. This lack of familiarity could be attributed to the irregular use of the word in science classrooms. This explains the reason the participants thought of the context in which they experience the word (remains of dinosaur) rather than pondering on the meaning as it appeared in the questionnaire. Another possible difficulty would be lack of English exposure on the different meanings of words such as *trace*. One of the meanings of the word *trace* is *small* or *minute* (Oxford dictionary, 2010). Since science use particular or selective meanings of the word to convey its message, lack thereof is a potential cause of the difficulty experienced.

4.3.4 Retard

The last word that was considered most difficult, using the criterion of 40-65 %, for the second year pre-service science teachers was *retard*. In this word the participants scored 36 % incorrect responses on this item. This word appeared in the questionnaire as item number 20. The item was constructed as follows:

The pupil was trying to find a chemical that would retard the reaction. This means the chemical would

A. speed up the reaction
B. makes the reaction go the other way
C. slow down the reaction
D. gives maximum yield from the reaction

The correct response for this item in accordance with the science classroom context was: C – 'slow down the reaction'. However, as emerged from the responses on this item, the scores were distributed between the options as follows: A- 16 % (n=17), B- 15 % (n=16), C- 64 % (n=68), D- 4 % (n=4) and N/R-1 % (1). In short, the total distribution of the incorrect response options chosen was 36 % of which options A (speed up reaction) and B (makes the reaction go the other way) seemed to have attracted participants from this group. While four participants selected option D (gives maximum yield from the reaction), one participant could not figure out the correct response. These quantitative data findings are represented in a graphical form as in Fig. 4.5.

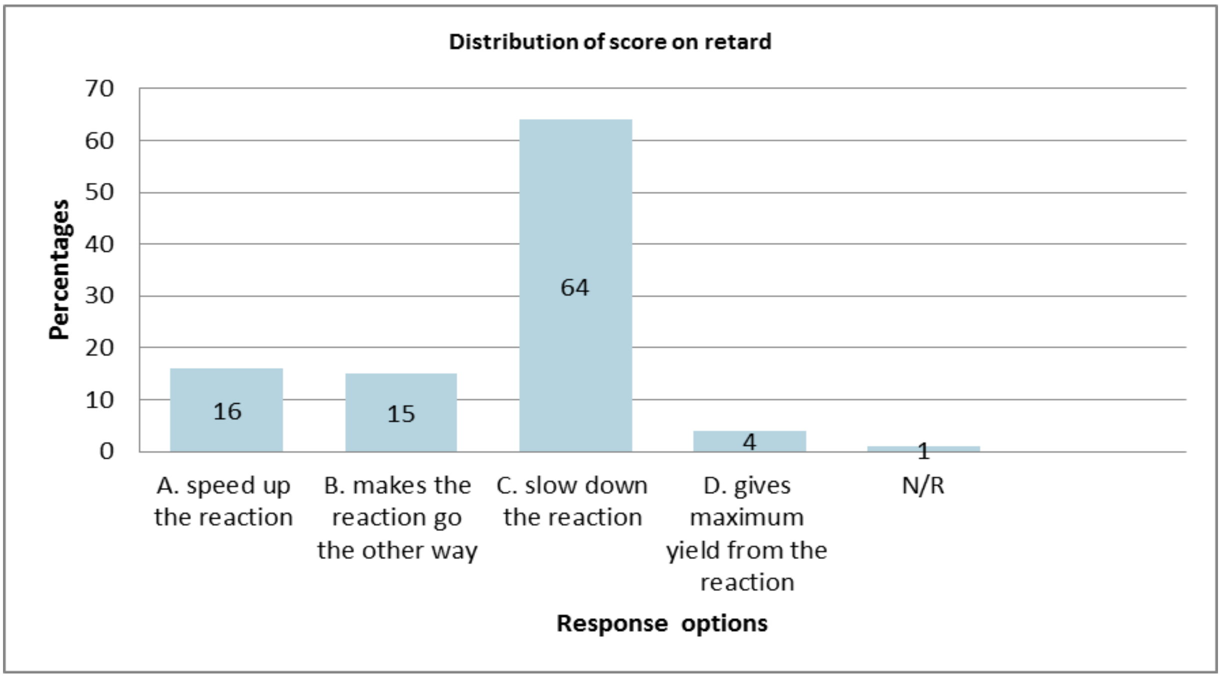

Figure 4.5: Graphical distribution of selections between options on the word 'retard'

Figure.4.5, above illustrates that 36 % (38/106) of the second year participants chose an incorrect contextual meaning of the word *retard* while 64 % (68/106) chose C as the correct response, as used in science context. The scores in options A and B show that a good number of participants were selecting either of these options, which of course were not the correct responses, according to its scientific meaning. These options were the focus in the interviews conducted. The following excerpts from the interview responses disclose possible reasons for choosing these options.

> *R: But, so, some people they wrote that if you do use the word retard in this sentence, it means it will speed up the reaction or it makes the reaction go the other way. So, (Pause)… what is your take on that?*
> *ST1: Okay, I think retard like it makes the reaction go other way, because from what Professor XXXX taught us in Physics, he said we shouldn't say the car decelerates but it retards, if I remember well, so meaning it goes opposite direction.*
> *R: Retard is opposite direction.*
> *ST1: Yes*

The reason for choosing option B (makes the reaction go the other way) is cited from a physics lecture's input, where retardation refers to moving objects that are decreasing in velocity or slowing down. In case of motor vehicles, the decrease in velocity can be caused by application of brakes. In terms of moving objects, if opposing forces acting on an object outweigh the initial forces, the object will move in the opposite direction and hence the logic for choosing opposition B. In this regard response B is a result of applying the understanding of the word from physics into chemistry. One of the participants explained why they thought option B was the right one:

> *ST2: "Okay, so we are a group right, so majority of you are fast learners, and then I'm slow. You guys are doing one thing and then I'm diverting from you guys…" Ja, instead of doing what you guys are doing, I'm doing something else.*

The source of difficulty therefore resides in the change of context of use, which results in change of meaning of the same word. As argued in the excerpt above, the meaning of the word *retard* is derived from a behavior that is opposite to the expected. The findings on this item are not unique to this study. Oyoo (2017) in his study of Grade 12 learners on their understanding of the word also found that learners were attracted by option B. It has to be noted that the participants were not willing to comment on option A (speed up the reaction). Those that spoke on this item commented mainly on option B. At this interview the researcher had to ask a fundamental question as to whether these words play a pivotal role in the teaching and learning of science. The excerpt below discloses the unique characteristics of these non-technical words when used in the science context.

> **ST3:** *I feel like it creates confusion because when we use it in everyday context it carries a different meaning when we use in in scientific context, that's why you find that most learners don't understand the word such as disintegrate when it is used in everyday I think context, it carry a different meaning when used in a scientific context.*

Basing the argument on the participant's (ST3) response, that these words create confusion when used in a different context, the researcher was interested to investigate if at all these words were explained, whether by their teachers at school or lecturers at the university. The excerpt that follows serves as the last response in point.

> *ST2: "Okay, like on a perspective of school, neh, they didn't like explain the difference between the everyday knowledge and the school knowledge. They just introduced… okay there's the cells. Like they won't tell the difference between like the cell that they use as an everyday term and the one that they, we use at school…"*

From the excerpt, participant ST2's experience was that there was no explanations on the words that are used in the science classroom. Of course she gives an example of the technical word *cell*. One would therefore validly argue that if the word cell (technical) cannot be explained, everyday words such as retard and trace cannot be considered explained either.

MESSAGE FOR DIFFICULTY ENCOUNTERED

From the students' responses, these words change in meaning when used in the science classroom context. Moreover, it would appear that these everyday words are not explained in the classroom. The lack of explanations by the teacher, of these words in their contextual meaning, has a detrimental effect on the understanding of science.

4.4 Third year students' performance on non-technical words

Full details on the third year pre-service teachers' performance, regarding the numbers of the participant pre-service teachers per optional response and corresponding percentages, is provided as Appendix B. However, the simplified version of Appendix B is presented in Table 4.3, and it shows the relative distribution of third year participants' scores on each of the 30 items. When the questionaires of these participants were administered, coded, marked and scrutinised, the words that emerged as extermely difficult (scoring 40-65 %) were as follows: ***sensitive 35 %, trace 53 %*** and ***retard* 55 %**. The words that were singled out to be moderately difficult (scoring 66-85%) were: *convention 73 %, effect 75 %, prepare 75 %, displace 76 %, limit 78 %, fundamental 78 %, disintegrate 80 %, contract 80 %, consistent*

83 %, consecutive 83 %, factors 83 %, spontaneous 85 % and *evacuate 85 %.* The rest of the words were regarded as just difficult (scoring 86-99 %).

The expectations from the quantitative data findings were that the third year participants would have scored 100% in each of these words. However, only five words*: characteristic, constant, linear, system* and *negligible* appeared to have been well comprehended amongst these participants, scoring 100% on these words. The third year participants did not know the meaning of these everyday words when used in the science classroom context. Table 4.3, illustrates the relative distribution of third year participants' scores on each of the 30 items.

Table 4.3: Relative distribution of third year participants' scores on each of the 30 items

PSIII Pre-service teachers' codes		Correct Answer	OVERALL % PER OPTION SELECTED (n=40)					% of Incorrect Responses	% of Correct Responses
No	**Words**		**A**	**B**	**C**	**D**	**N/R**		
1	**Consecutive**	**C**	2.5	2.5	82.5	12.5	0.00	17.5	82.5
2	**Displaces**	**B**	5.0	77.5	0.0	17.5	0.00	22.5	77.5
3	**Limit**	**D**	0.0	0.0	22.5	77.5	0.00	22.5	77.5
4	**Prepare**	**D**	17.5	0.0	7.5	75.0	0.00	25.0	75.0
5	**Dehydrate**	**A**	97.5	2.5	0.0	0.0	0.00	2.5	97.5
6	**Generate**	**C**	7.5	5.0	87.5	0.0	0.00	12.5	87.5
7	**Sensitive**	**A**	35.0	5.0	2.5	57.5	0.00	65.0	35.0
8	**Characteristic**	**B**	0.0	100	0.0	0.0	0.00	0.0	100
9	**Trace**	**C**	40.0	5.0	55.0	0.0	0.00	45.0	55.0
10	**Fundamental**	**B**	5.0	77.5	5.0	12.5	0.00	12.5	77.5
11	**Constant**	**A**	100	0.0	0.0	0.0	0.00	0.0	100
12	**Contract**	**C**	2.5	17.5	80.0	0.0	0.00	20.0	80.0
13	**Valid**	**A**	95.0	0.0	5.0	0.0	0.00	5.0	95.0
14	**Spontaneous**	**B**	12.5	85.0	2.5	0.00	0.00	15.0	85.0
15	**Factors**	**D**	7.5	0.0	10.0	82.5	0.00	17.5	82.5
16	**Concept**	**C**	2.5	0.0	95.0	2.5	0.00	5.0	95.0
17	**Diversity**	**B**	2.5	97.5	0.0	0.0	0.00	2.5	97.5
18	**Linear**	**A**	100	0.0	0.0	0.0	0.00	0.0	100
19	**Retard**	**C**	22.5	15.0	52.5	10.0	0.00	47.5	52.5
20	**Effect**	**D**	17.5	7.5	0.0	75.0	0.00	25	75.0
21	**Consistent**	**B**	0.0	82.5	15.0	0.0	2.5	17.5	82.5
22	**Function**	**D**	0.0	0.0	2.5	97.5	0.00	2.5	97.5
23	**System**	**D**	0.0	0.0	0.0	100	0.00	0.0	100
24	**Convention**	**A**	72.5	15.0	7.5	5.0	0.00	27.5	72.5
25	**Negligible**	**C**	0.0	0.0	100	0.0	0.00	0.0	100
26	**Evacuate**	**D**	0.0	7.5	7.5	85.0	0.00	15.0	85.0
27	**Estimate**	**B**	10.0	87.5	2.5	0.0	0.00	12.5	87.5
28	**Conserve**	**C**	2.5	0.0	97.0	0.0	0.00	2.5	97.5
29	**Disintegrate**	**A**	80.0	20.0	0.0	0.0	0.00	20.0	80.0
30	**Random**	**B**	0.0	97.5	2.5	0.0	0.00	2.5	97.5

Table 4.4 and Figure 4.6 below are summaries of these findings showing only very difficult and moderately difficult words. The rest are equally difficult since the third year pre-service science teachers did not manage to get a 100% score on these words. The conceptual framework governing this research study had viewed words as language and as knowledge. The lack of understanding of the contextual meaning of these words suggest lack of proficiency in the science language, and possibly in scientific knowledge itself.

Table 4.4: Summary of relative % score on the very difficult and moderate words

No	Word	% Correct responses	% In correct responses
1	**Sensitive***	35	65
2	**Retard***	53	47
3	**Trace***	55	45
4	Convention	73	27
5	Effect	75	25
6	Prepare	75	25
7	Displace	76	24
8	Limit	78	22
9	Fundamental	78	22
10	Disintegrate	80	20
11	Contract	80	20
12	Consistent	83	17
13	Consecutive	83	17
14	Factors	83	17
15	Spontaneous	85	15
16	Evacuate	85	15

The graphical representation in Fig 4.6 shows the very and moderate words in the descending order of the incorrect responses. Arranging the words in the order of incorrect response serves to highlight the level of difficulty posed by each non-technical word as experienced by the third year participants.

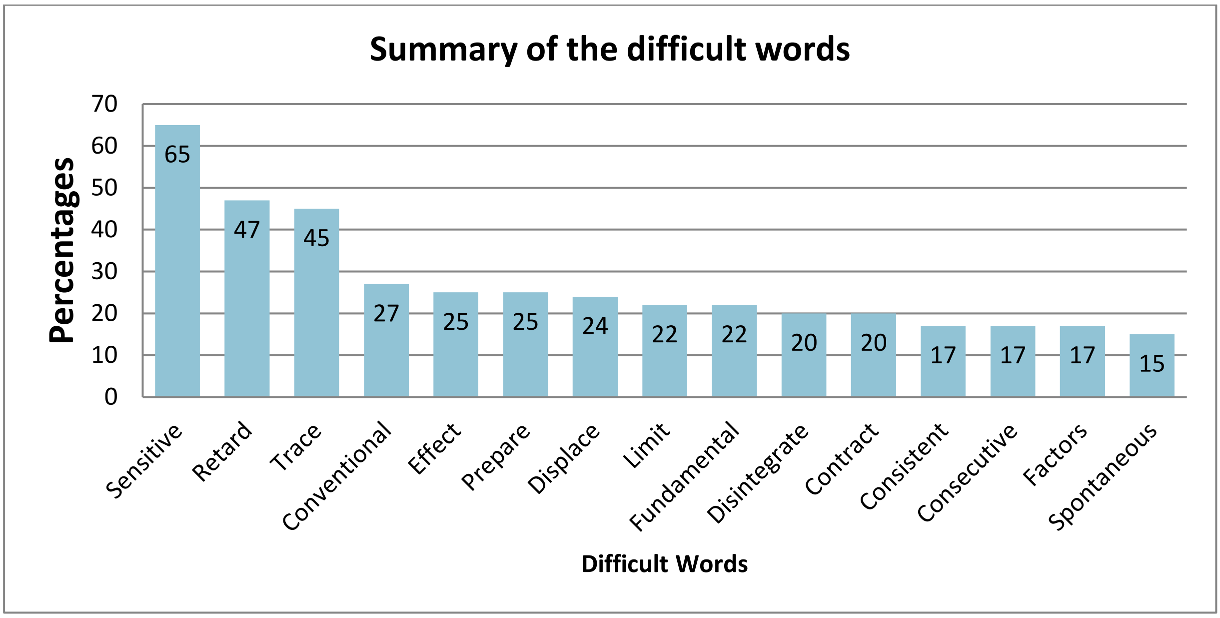

Figure 4.6: Graphical distribution of most- and moderate difficult words of incorrect responses

4.5 The analysis of the extremely difficult items

Evidenced in Table 4.6 and Figure 4.6, 15 items emerged as extremely and moderately difficult to the third year participants in this study. According to the criteria set of 40-65 % incorrect responses for very difficult, three items had emerged to be in this category, namely *sensitive, retard* and *trace*. These items were selected for systematic analysis on the understanding of the meaning of non-technical words by third year pre-service science teachers, when used in the science classroom. With respect to the level of difficulty, the word *sensitive* emerged as most difficult and therefore is discussed first.

4.5.1 Sensitive

The word *sensitive* had also emerged as the most difficult item for the third year participants in this research study. The overall percentage correct was 35 %, meaning that 65 % of the third year participants had recorded incorrect responses on this item. The word *sensitive* appeared in the questionnaire as represented below:

The beam balance is a very sensitive instrument. This means that

A. can be used to weigh very small things
B. can be only used by sensitive people
C. is hard to understand how it works
D. gets spoilt very easily

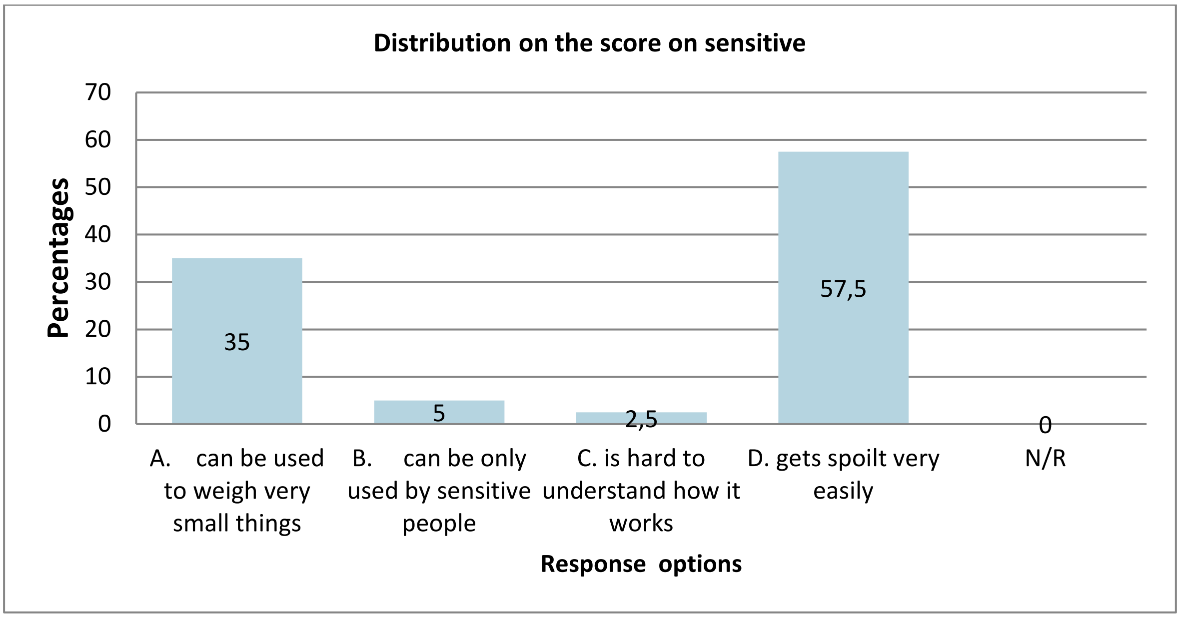

Figure 4.7: Graphical representation of this relative distribution between options

Option A –*'can be used to weigh very small things'* was the correct response. As seen from Figure 4.7, the participants' answers on this item were distributed among the given options as follows: A- 35 % (n=14), B- 5 % (n=2), C- 2.5 % (n=1), D- 57.5 % (n=23) and N/R-0 %. These scores suggest that in total, 65 % (n=26/40) of the participants did not know the contextual meaning of the word *sensitive,* when use in the science classroom. Considering the graphical presentation (see Fig. 4.7), it becomes evident that many third year participants had opted for option D namely: Gets spoilt very easily as a correct response (57.5%). Why option D has emerged as the most preferred option deserved to be followed up in the interview, to unravel the inclination towards this response option in the question.

> *ST1:I think the reasoning behind that, getting it spoilt very easily because if a person is sensitive, right, you can't just joke, they are very fragile, they are easily, you know, taunted and stuff. So, ja that's why people might think that it's sensitive and it can get spoilt easily.*
> *R: So it's from the everyday life.*
> ST1: "everyday life…"
> *ST2: For me I'd go with (D), I'd agree more with (D), because something sensitive is something which is fragile, which is easily damaged, like, which reacts very quickly to slightly changes of the environment or whatever the case.*

The excerpts above are in line with the everyday use of the word as in the Oxford dictionary (2010). In the everyday context, the word *sensitive* refers to the ability to understand other people's feelings, objects that are easily damaged (fragile), especially by the physical character for instance, glass. A sensitive topic or subject therefore needs extra attention to avoid offending or hurting other people. The two excerpts cited above based the word *sensitive* on everyday experiences. The relevant research literature has recorded that everyday context influences how learners/students arrive at incorrect optional responses (Cassels & Johnstone 1980/1985; Marshall, Gilmour & Lewis, 1991). Further, (Oyoo, 2017). In recent research with South African learners on their comprehension of the non-technical words used in the science classroom, noted that participants selected incorrect meanings due to the influence of everyday contexts. However, some participants had different views on the optional response as in the excerpt below:

> *ST3: I choose it can be used by sensible people.*
> *R: Why?*
> *ST3: Because 'sensitive', is near to 'sensible' in English, so the learner just decided it can be used by sensitive people. Sensible, sensible and sensitive they are look-alike yes.*

The participant (ST3) conceived the word *sensitive* as 'look alike' (similar) to sensible. These findings are not only unique to this study. Literature had stated clearly that there exists confusion with words that sound alike or look alike (Farrell & Ventura, 1998; Marshall & Gilmour, 1991; Tao, 1994). In this regard the participants (ST2 and ST3) thought the words ***sensitive*** and ***sensible*** mean the same thing. In trying to probe these participants to reason on the link between a *sensitive instrument* and *sensible people,* other than the look-alike aspect as indicated in the excerpt above, the following interview response highlights the reasoning behind the incorrect interpretation of the word, *sensitive*.

> *R: Because it's sensitive it can be used by sensible people?*
>
> *ST3: Sensible can mean reasoning and it can also mean sensitive, so the fact that it's sensitive it can be used by sensible people.*
> *R: Okay, that's your understanding?*
> *ST3: Yes.*

The participant's thinking was inclining towards relational thinking. They perceived the words *sensitive* and *sensible* as having a logical relationship. The logic behind the participants' train of thoughts is that, since the beam balance is a *sensitive instrument*, it therefore required a sensible person who can make good judgement when using it.

MESSAGES FROM ENCOUNTERED DIFFICULTIES

The responses given to the word *sensitive* as transpired from this interview, is the result of the influence from everyday context where *sensitive* is attributed to materials that are fragile. Another source of difficulty was due to the influence of how the words look alike or sound-alike such as in the case of sensible and *sensitive*. The message from the encountered contextual difficulties is due to the lack of teacher's explanation of these words. The confusion between *sensitive* and *sensible* suggests that science teachers should also be proficient users of LOLT. In this regard, the proficient use of instructional language during teaching is a pre-requisite for effective teaching of science. Otherwise words such as *sensitive* and *sensible* should not be a cause or problem for misunderstanding the non-technical words, especially at this stage of their study.

4.5.2 Retard

The second very difficult word was *retard*. This word item appeared in the questionnaire as item number 19 as follows:

The pupil was trying to find a chemical that would <u>retard</u> the reaction. This means the chemical would

A. speed up the reaction

B. makes the reaction go the other way
C. slow down the reaction
D. gives maximum yield from the reaction

The correct response for this item in accordance with the science classroom context was: C – ‘slow down the reaction’. However, as emerged from the responses on this item, the scores were distributed between the options as follows: A- 22.5 % (n=9), B- 15 % (n=6), C- 52.5 % (n=21), D- 10 % (n=4) and N/R- 0 %. In other words, the total distribution of the incorrect optional responses chosen was 47.5 % (19/40). These quantitative data findings can be represented in a graphical form as shown below in Figure 4.8.

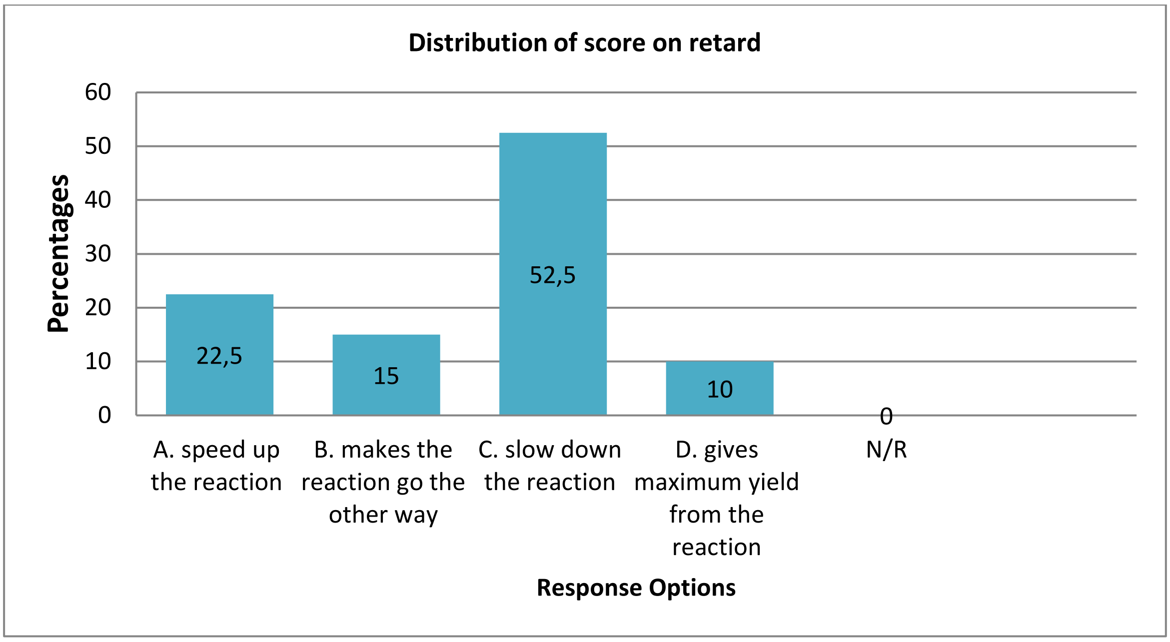

Figure 4.8: Graphical representation of this relative distribution of scores between options

Looking at the bar graph in Figure 4.8, it becomes evident that although half of the participants chose option C (52.5 %) (n=21/40), the rest of the participants were distributed among options A, B and D respectively, totalling 47% of the participants. The following was an excerpt where the researcher wanted to know the correct optional response according to the science classroom context.

ST1: No, no. All of them they are correct
R: All of them are correct?

In the excerpt above, the participant (ST1) was adamant that all the options that have been provided were correct. Since only one item was by design correct in the science context, I then asked the question directing, it specifically to the responses that were not aligned with the science classroom context. The excerpts below are interview questions and responses as witnessed in the interview:

> *R: But in terms of someone who chose to say it will make the reaction go the other way, what would you think they were thinking?*
> *ST2: Arrr, okay. For me I understand that a retarded person is a person who just thinks……*
> ***ST1**: (intercepts**)** Slow.*
> ***ST3:** To me in my understanding, when we talk about retard, we talk normally like older people, or someone who has a disorder. Those who are really struggling and we know when this person is retarded, you can say run and they'll be like….., bala, write something, they don't want or they are doing their own things, that's why you'll be like, aay this one.*

In the excerpts above, the participants deviated from the question as in the questionnaire but instead responded as with regard to a person as a retarded person who is slow and someone who has a disorder. As a result such an individual cannot manage to do things at a normal pace like those who are abled. Following this train of thought, some participants opted for option response B namely: will make the reaction go the other way. Apparent from this perspective, everyday experiences and knowledge of this word item must have influenced these kinds of responses. The next concern is why some participants were attracted to the option: speed up the reaction. Option A had attracted 22.5 % (n=9) who selected this option (speed up the reaction), the exact opposite of the word retard.

> *R: Arrr, the ones that said it speeds up the reaction?*
> *ST2: Aay, aay, I don't understand that one.*

The participants were very quiet about this question. At least one participant acknowledged that it's difficult to make a valid connection between 'retard' and 'speed up'. Yet such responses and findings are not unique to this study. The literature had stated that students sometimes embraced the meaning that was the exact opposite of the correct meaning of a word (Farrell & Ventura, 1998; Marshall & Gilmour, 1990). With regards to why some participants had chosen option B (makes the reaction go the other way), the following excerpt unravels the possible reason some participants endorsed option B.

> ST2: *I think because we are talking in the context of teaching, hence I' m saying as a teacher when you say a child is retarded, you are usually referring to their academic performance.*
> ST2: *"…A retarded person is someone, to us as teachers, is someone who is slow in books, and in reality, those children, they are the sporty ones, you see. They are the gamblers, the tsotsis, you see. They are smart outside, they are very fast".*

The excerpts above pose an argument that a retarded person is associated with the option response B. In terms of academic performance, the retarded person would be slow, suggesting moving in the opposite direction as far as academic progress and performance is concerned. While such utterances seem to reflect everyday context, it is more the influence of connotative meaning as opposed to denotative meaning. Farrell and Ventura's (1998) research study found that some responses to word meanings were based on connotative meaning (variety of mental connection a word may suggest) rather than denotative meaning which entails true meaning of the word (Sutton cited in Farrell and Ventura, 1998). Therefore, the meaning of the word retard suggests a person who does the opposite of the expected.

MESSAGES FROM ENCOUNTERED DIFFICULTIES

From the interview responses, the word retard is associated with the everyday context understanding describing people with some difficulties in doing certain things in life. The connotative meaning however, is the influence of such perceptions. The messages therefore from such encountered difficulties point to a lack of explanation of these words when used in the science context and probably infrequent use of the word in the science classroom could contribute to these incorrect utterances.

4.5.3 Trace

According to the marked third year questionnaires, the word *trace* emerged as the third most difficult word (40-65%) with third year pre-service science teachers scoring 45 % incorrect responses on this item and 55 % of the participants scored correctly. This word item, number 9 appeared in the questionnaire as follows:

The soil contained a <u>trace</u> of potassium. This means it

A. used to have some potassium
B. had plants, which use potassium
C. had a very small amount of potassium
D. had a large amount of potassium

The correct response for this item in accordance with the science classroom context was: C – 'had a very small amount of potassium'. However, as emerged from the responses on this item, the scores were distributed between the options as follows: A- 40 % (n=16), B- 5 % (n=2), C- 55 % (n=22), D- 0 % (n=0) and N/R- 0%. The distribution of responses is also represented in a graphical form as shown in Figure 4.9.

It is clearly presented in the graph in Figure 4.9 that option D and N/R did not attract any of the participants. All the optional responses were distributed between options A, B and C, of which options A and B were incorrect, according to the science classroom context. Responses for A and B totalled 45 %. Thus 45 % of the participants did not know the meaning of the word *trace* when used in the science classroom context. Of interest though, was the observation that 40 % of the participants opted for optional response A namely: *used to have some potassium* as correct while 5 % had chosen option B.

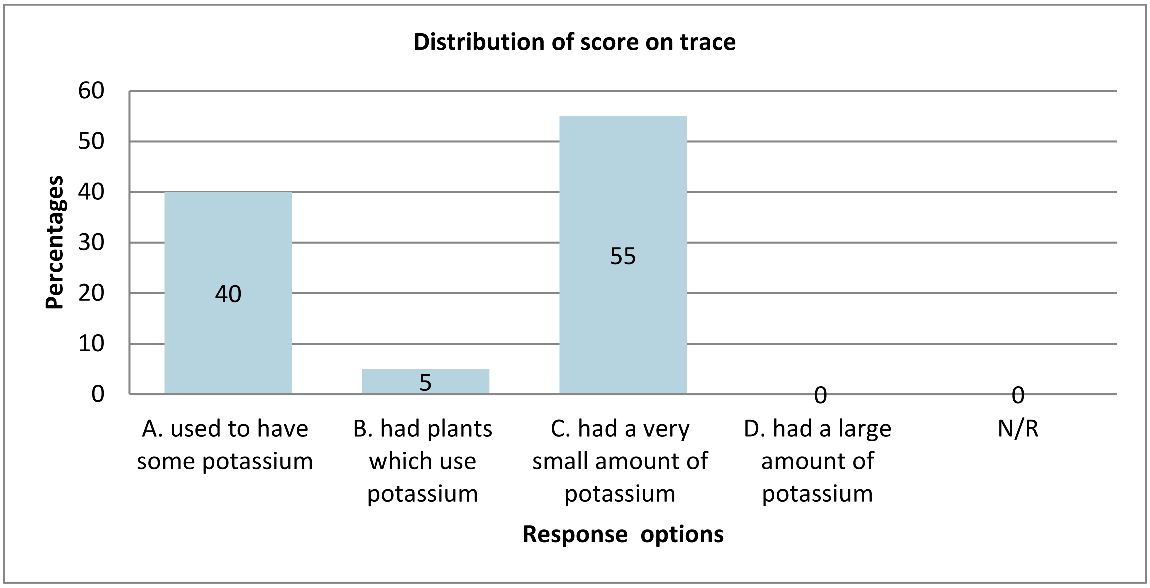

Fig: 4.9: Graphical representation of relative distribution of scores on the word 'trace'

The possible reasons for choosing these options that are not correct in the science classroom context were investigated as in the following excerpt.

> *R: … the key word in this sentence is TRACE. So I want to say how would you reason, how would you argue or try to back the person who says it used to have some potassium, the thinking behind?*
> *ST1: The thinking behind it would go to English term of trace. When something, let's say we're tracing something, it means something was here. There's an area or maybe there's a piece that something stepped on here, a particular person but this person is not there, but he left their trace here, and it's in a particular position now.*
> *ST2: …when you say that there is a trace of something it means that that something was there and then moved and left evidence of its presence there.*

The participants (ST1 and ST2) reasoned that response A (it used to have some potassium) was attractive to the participants, because this meaning was closely related to how this word (trace) is understood in the everyday context of use. The findings from the interview response were not only unique to this study. Oyoo (2017), conducting a research study with South African learners on comprehension of non-technical words used in the science classroom, had similar findings. The researcher found that some participants arrived at the incorrect meaning due to the influence of everyday contexts where they had come across the word (Oyoo, 2017). While option D (had a large amount of potassium) was not selected by any participant, it was argued that only an element available in large amounts can leave traces that can be recognized at a later stage. The excerpts below account for this way of thinking.

> *ST3: … sometimes you can trace something because of its amount, some things that are small they are hard to trace, so maybe in large quantities that's when you can see that something was here. So maybe in terms of quantities when it's small, like you can't really be sure about that, like when something is big or in large amounts therefore you can really trace or see that ja, it was here.*

It also emerged from these interview responses that participants' responses to the questionnaire could have been deeply influenced by another science related subject, namely life sciences, as the excerpt immediately below suggests.

> *ST4: …if you remember errr, Life Sciences, when we do evolution, we trace, errr, we say it's a trace of the existence of those things. So that tree there, they talk to us about, umm, trace of existence, basically.*

As mentioned in the background issues (section 1.1), from observations of classroom interactions, about two thirds of classroom talk is teachers' talk (Flanders 1970 cited in Oyoo, 2012). This means that classroom discussion is mainly dominated by teacher's talk (through teaching or asking questions) (Oyoo, 2007). This being the case, the possible role of the physical science teachers understanding of the meaning of the words was also followed up in the interview.

> *R: When you were doing content, were these words explained, when teachers were teaching physical science, do they explain that this is the meaning?*
> *ST6: Well, they are under the assumption that it's a physical science class; therefore, it's just that we are supposed to think of it in this way. However, it's like that we still come up with our definitions from what we know and start applying them like that, but then with the progress of the course then you come to meaning that oh okay, this is what it means therefore in this context.*

The participant (ST6) response reveals that when learning physical science, these non-technical words were not explained because teachers assumed that the learners/students understand. These findings corroborated the general trends uncovered by Oyoo (2012) in the study conducted in Kenya on teachers' use and beliefs of the classroom instructional language. Oyoo (2012) found that the participant teachers rated the presence of mathematics as the main difficulty in learning and teaching of science. In this regard the issue of classroom instructional language was seen as of less importance. However, as revealed in this study, language in science education requires full attention (Childs et al., 2015). A good understanding of science language helps in understanding science in classroom talks, textbooks and science examination papers. Brookes (2006) bemoans the tendency of reducing the learning of physical science to solving mathematical problems found at the back of chapters of the science textbooks. In so doing, such approach undermines the literacy component, necessary in understanding how science language is structured in different science texts.

MESSAGE FROM ENCOUNTERED DIFFICULTIES

From what has transpired from interviews, the participants arrived at the incorrect meaning due to the influence of everyday contexts, in which they had come across these words. Secondly, it appears that these non-technical words were not explained to the pre-service science teachers during science classroom discourses. Lack of explanation has resulted in pre-service science teachers failing to understand the appropriate context in which a particular word such as trace is used.

4.6 Fourth year students' performance on non-technical words

Considering the fourth year pre-service science teachers performance, full details on the performance, regarding the numbers of the participant pre-service teachers per optional response and corresponding percentages, is provided as Appendix C. However, the summary of Appendix C is presented in Table 4.5, and it shows the relative distribution of fourth year participants' scores on each of the 30 items.

In accordance with the established criterion of analysis discussed in Section 4.2. of the non-technical words on the level of their difficulty, the following words emerged to be very difficult (scoring 40-65 %) for the fourth year partcicipants: *retard 42 %, trace 47 %,* and *evacuate 61 %*. I noticed that the word *evacuate* is an outsider ,as it appeared as very difficult only among the fourth year participants. I therefore decided to include the word *senstive* for interviews instead of the word *evacuate* for the following reasons: The word *sensitive* has caused difficulties at school level among the Grade 12 learners (Oyoo, 2017). Secondly, in this study, *sensitive* has reiterated as the most difficult word to the third and second year participants and moderately difficult to the fourth years with 68 % of participants scoring it correctly. In short, it means that 32 % of the fourth year pre-service science teachers did not know the contextual meaning of the word *sensitive*.

Table 4.5: Distribution of fourth year participants' scores on each of the 30 items

PSIV Pre-service teachers' codes		Correct Answer	OVERALL % PER OPTION SELECTED (n=38)					% of Incorrect Responses	% of Correct Responses
No	**Words**		**A**	**B**	**C**	**D**	**N/R**		
1	**Consecutive**	**C**	0.00	5.26	89.47	5.26	0.00	10.53	89.47
2	**Displaces**	**B**	0.00	81.58	0.00	18.42	0.00	18.42	81.58
3	**Limit**	**D**	0.00	2.6	10.53	86.84	0.00	13.16	86.84
4	**Prepare**	**D**	10.53	7.9	2.6	68.42	10.53	31.58	68.42
5	**Dehydrate**	**A**	100	0.0	0.0	0.00	0.00	0.00	100
6	**Generate**	**C**	2.6	10.51	86.84	0.00	0.00	13.16	86.84
7	**Sensitive**	**A**	68.42	5.3	2.63	23.68	0.00	31.58	68.42
8	**Characteristic**	**B**	0.00	92.11	5.30	2.63	0.00	7.89	92.11
9	**Trace**	**C**	42.10	7.89	47.10	2.63	0.00	52.63	47.37
10	**Fundamental**	**B**	7.89	84.21	2.63	5.26	0.00	15.79	84.21
11	**Constant**	**A**	94.74	2.63	2.63	0.00	0.00	5.26	94.74
12	**Contract**	**C**	5.26	13.16	73.68	7.89	0.00	26.32	73.68
13	**Valid**	**A**	89.47	2.63	7.89	0.00	0.00	10.53	89.47
14	**Spontaneous**	**B**	21.05	65.79	7.89	5.26	0.00	34.21	65.79
15	**Factors**	**D**	0.00	0.00	100	0.00	0.00	0.00	100
16	**Concept**	**C**	2.63	5.26	81.58	10.53	0.00	18.42	81.58
17	**Diversity**	**B**	5.26	94.74	0.00	0.00	0.00	5.25	94.74
18	**Linear**	**A**	97.37	0.00	2.63	0.00	0.00	2.63	97.37
19	**Retard**	**C**	34.21	23.68	42.11	0.00	0.00	57.89	42.11
20	**Effect**	**D**	10.53	5.26	0.00	84.21	0.00	15.79	84.21
21	**Consistent**	**B**	2.63	78.95	10.53	5.26	2.63	21.05	78.95
22	**Function**	**D**	0.00	0.00	0.00	97.37	2.63	2.63	97.37
23	**System**	**D**	0.00	2.63	2.63	92.11	2.63	7.89	92.11
24	**Convention**	**A**	71.05	15.79	7.89	2.63	5.66	28.95	71.05
25	**Negligible**	**C**	2.63	7.89	84.21	2.63	2.63	15.79	84.21
26	**Evacuate**	**D**	13.16	7.89	15.79	60.53	2.63	39.47	60.53
27	**Estimate**	**B**	0.00	97.37	0.00	0.00	2.63	2.63	97.37
28	**Conserve**	**C**	0.00	0.00	100	0.00	0.00	7.89	92.11
29	**Disintegrate**	**A**	68.42	2.63	7.89	15.79	5.26	31.58	68.42
30	**Random**	**B**	0.00	92.11	2.63	0.00	5.26	7.89	92.11

While it was anticipated that the fourth year participants would score 100 % on all the words, I had thought it appropriate to consider a word such as senstive for interviews. Therefore, the words items for qualitative data analysis were: *retard 42 %, trace 47 %, and sensitive 68 %.* The words that emerged to be moderately difficult (scoring 66-85 %) were: *spontaneous 66 %, prepare 68 %, disintegrate 68 %, convention 71 %, contract 74 %, consistent 81 %,* *concept 81 %, displace 82 %, effect 84 %, negligible 84 %,* and *fundamental 84 %.* The rest of the words were regarded as just difficult (scoring 86-99 %).

I think it is appropriate at this point to note that the words *dehyrdate* and *factors,* did not pose a challenge since the participants scored 100 % in each of these items. From Table 4.5 above, I had selected all very- and moderately difficult words and summarised them in the correct responses in ascending order, and in correct responses in the descending order of their difficulty as shown in Table 4.6, below. As pointed out earlier, the words ***retard, trace*** and ***sensitive*** would be considered for interviews**.**

Table 4.6: Summary of relative score on the extreme difficult and moderately words

No	Word	% Correct responses	% In correct responses
1	**Retard***	42	58
2	**Trace***	47	53
3	Evacuate	61	49
4	Spontaneous	66	34
5	**Sensitive***	68	32
6	Prepare	68	32
7	Disintegrate	68	32
8	Convention	71	29
9	Contract	74	26
10	Consistent	79	21
11	Concept	81	19
12	Displaces	82	18
13	Effect	84	16
14	Negligible	84	16
15	Fundamental	84	16

Graph 4.10, below is a pictorial representation of the words that posed a challenge to the fourth year pre-service science teachers as very difficult or moderately difficult. Below is the graphical representation of the sampled words that posed a challenge among the fourth year pre-service science teachers. The words appeared according to the level of incorrect scores obtained on each item word.

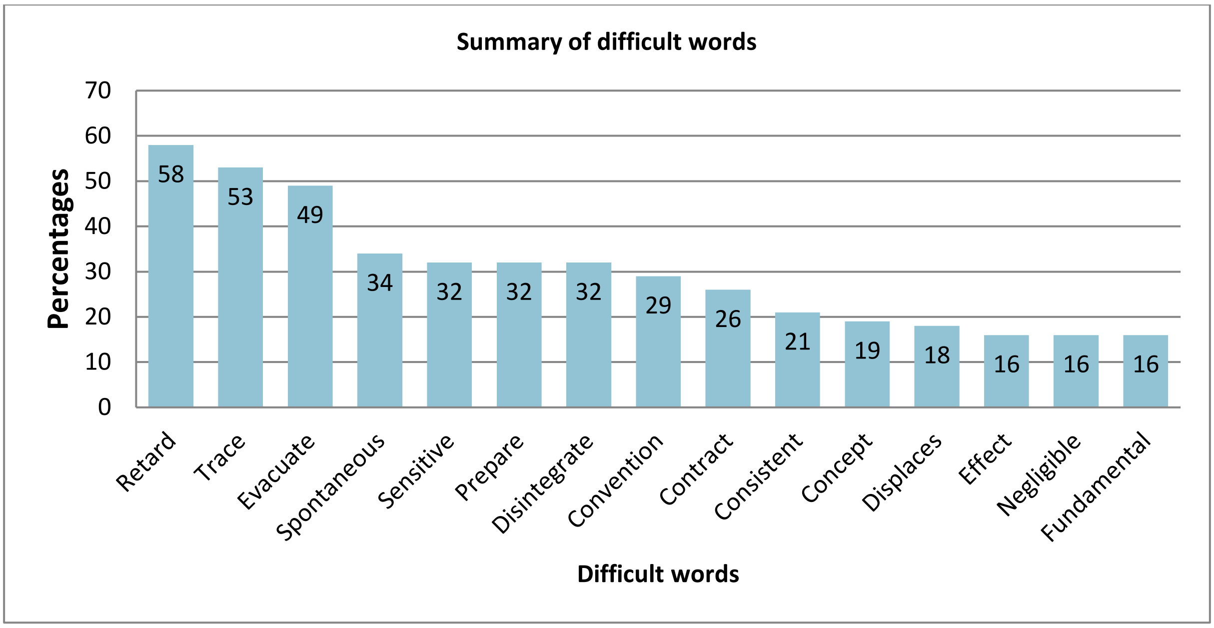

Figure 4.10: Graphical distribution of most and moderate difficult words of incorrect responses

4.7. The analysis of the extremely difficult items

Table 4.6 and Figure 4.10 show clearly that the extremely difficult items among the fourth year participants were retard, trace and *sensitive*. The literature reviewed shows that even tertiary level students experience difficulties with non-technical words (Cassels & Johnstone, 1980; Tao, 1994). As highlighted above, the qualitative data analysis involves the selected three word items namely retard, trace and *sensitive*. Fifteen items had emerged in this research study as difficult to most participants in their fourth year of study. According to the criteria set of 40-65 %, incorrect responses for most difficult, three items namely: *retard* 58 %, *trace* 53 % and *sensitive* 68 % emerged as extremely difficult. These items therefore were selected for systematic analysis on the meaning of the non-technical words when used by fourth year pre-service science teachers in the science classroom. The word *retard* that emerged as the most difficult to this group is discussed first.

4.7.1 Retard

In this word item the participants scored 58 % incorrect responses, which mean only 42 % of the participants scored this word correctly. This word, item number 19 appeared in the questionnaire as follows:

The pupil was trying to find a chemical that would retard the reaction. This means the chemical would

A. speed up the reaction
B. makes the reaction go the other way
C. slow down the reaction
D. gives maximum yield from the reaction

The correct response for this item in accordance with the science classroom context was: C – 'slow down the reaction'. However, as appeared from the responses on this item, the scores were distributed between the options as follows: A- 34 %, B- 24 %, C- 42 %, D- 0 % and N/R- 0 % respectively. In short, the total distribution of the incorrect responses chosen by the fourth year participants, was 58 %, see Figure 4.11 that follows.

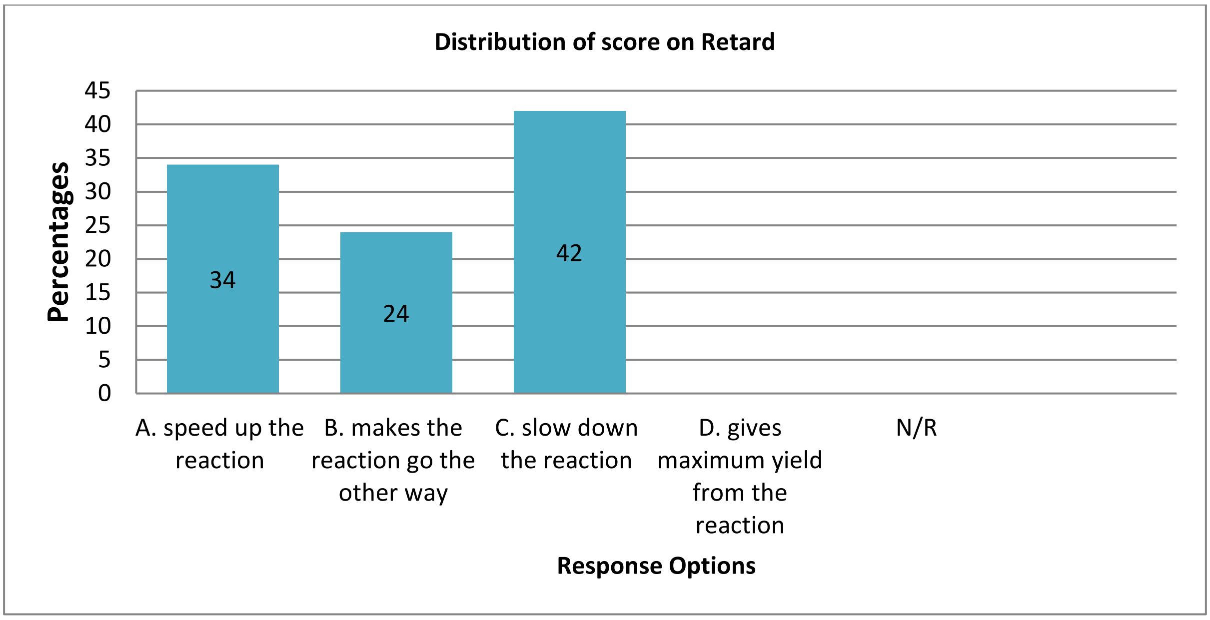

Fig: 4.11: Graphical representation of relative distribution of score on response options

As shown pictorially in Figure 4.11, option D and N/R did not attract any attention from these fourth year participants while the response options A had 34 %, B 24 % and C 42 %. Option A which attracted 34 % of participants (although wrong in the context), is now discussed.

> ***ST1:*** *My problem here is the understanding of retard and what it means in everyday language, but now that's when we need to look at technical and non-technical terms because now, retard, what process is retarded. Remember, some of the words that are applicable in everyday language, when they come to science language they change the meaning, they affect the exact meaning of the process that is happening.*

The participant (ST1) in the excerpt above had observed that some of the non-technical words change their meaning when used in the science context. It is therefore important to know the milieu in which the word had been used to understand its contextual meaning, as highlighted in the excerpt that follows.

> *ST1:…So here, we should be interested in the process, what the process that is actually happening and how can we relate it to, to what science know because we cannot be safe to take from non-technical word and directly apply it without entering it.*
> ***ST2:*** *So, the process is a chemical reaction?*
> *ST1: Ja, a chemical reaction can either be fast or slow. But now can't we use the idea of, what you call your catalyst and inhibitors?*

Participant ST1, argued for the use of catalysts (chemicals that speed up the reaction) and inhibitors (that slow down the chemical reaction). While catalysts are commonly used in chemistry in topics such as a chemical reaction, inhibitors (e.g. enzyme inhibitors) are associated with life sciences. Although participant (ST1) employed the words catalyst and inhibitors, there was no convincing explanation as to why option A was selected in response to the non-technical word, *retard*. The selection of option A (speed up reaction) an opposite meaning of the word retard, was the same as in Marshall and Gilmour (1990) in Papua New Guinea and Cassels and Johnstone (1980, 1985) in Britain, where students had also selected a meaning that was opposite to the word item in question. Lack of giving the correct contextual meaning, in this sense can be attributed to a lack of familiarity with the word or perhaps the infrequent use of the word in the science classrooms. The excerpt that follows justifies such an observation.

> *R: Yes, he's raising a nice point there, but in this case maybe, what would you say maybe the person thought when maybe they say that retard is for speeding up the chemical reaction.*
> ***ST3:*** *They might have taken it from everyday language.*

Even in everyday context and language, the word *retard* cannot mean speed up the reaction. This is a sign that words such as *retard* are not explained during classroom interaction, at least in relation with chemical reactions. I therefore found it useful to compare what is examined in relation with catalysts, in order to uncover why the word *retard* seems not to be familiar to these pre-service science teachers. In chemistry, emphasis is placed on chemicals that alter the rate of a reaction, such as catalysts, because of the advantages they have to the society (DHET, 2011). It is observed that a lot of manufactured items are produced with the use of catalysts (Silberberg, 2015). This is because a reaction with an added catalyst produces products more quickly than a reaction without a catalyst (Le May et al., 2015). As such, scientists are constantly in search of new improved catalysts in order to improve efficiency in production of goods or items. This being the case, the item (the pupil was trying to find a chemical that would <u>retard</u> the reaction), in the absence of the meaning of *retard*, but with knowledge of catalysts, option A was selected and probably with the influence of the word *reaction* in the structured item. The following excerpt, as it unravels the possible reason why some participants endorsed option B (makes the reaction go the other way), serves as the last case in point.

> ***ST1:*** *It could because it's generally for someone slow but maybe they thought someone backwards and then they thought the reaction is gonna go backwards.*

Generally, a trend was observed in this study, where participants used their everyday knowledge of the word, especially as it is associated with people, in order to give an interpretation of the word item. The association is of retarded people in the everyday context and backwardness as posited in the interview response above (see sections 4.3.4 and 4.5.2). The findings of Farrell and Ventura's (1998) research study carried out in Malta among university students, reported that some word meanings were based on connotative meanings rather than denotative meanings. The excerpt from the first respondent (ST1) reflects such inclination.

MESSAGES FROM ENCOUNTERED DIFFICULTIES

The participants were interpreting the meaning of the word, retard, due to connotative influences. The word r*etard* was therefore associated with mentally deranged people. Probably words such as *retard* are not explained during classroom interaction. Since, in chemistry, emphasis is placed on chemicals such as catalysts, the words retard is rarely used in chemistry classes. In the absence of the meaning of the word retard, option A might therefore be selected because of the influence of the word *reaction* in the structured item.

4.7.2 Trace

This word item number 9 appeared in the questionnaire as follows:

The soil contained a <u>trace</u> of potassium. This means it

A. used to have some potassium
B. had plants which use potassium 5.3

C. had a very small amount of potassium
D. had a large amount of potassium

The correct response for this item in accordance with the science classroom context was: C – 'slow down the reaction'. However, as appeared from the responses on this item, the scores were distributed between the options as follows: A- 42 %, B- 8 %, C- 47 %, D- 3 %, and

N/R- 0 %. In short, the total distribution of the incorrect responses selected by the fourth year participants was 53 %, which means that only 47 % of the participants' selection was correct. Option A- 42 % (used to have potassium) attracted a number of participants from the group as seen in Figure 4.12 below.

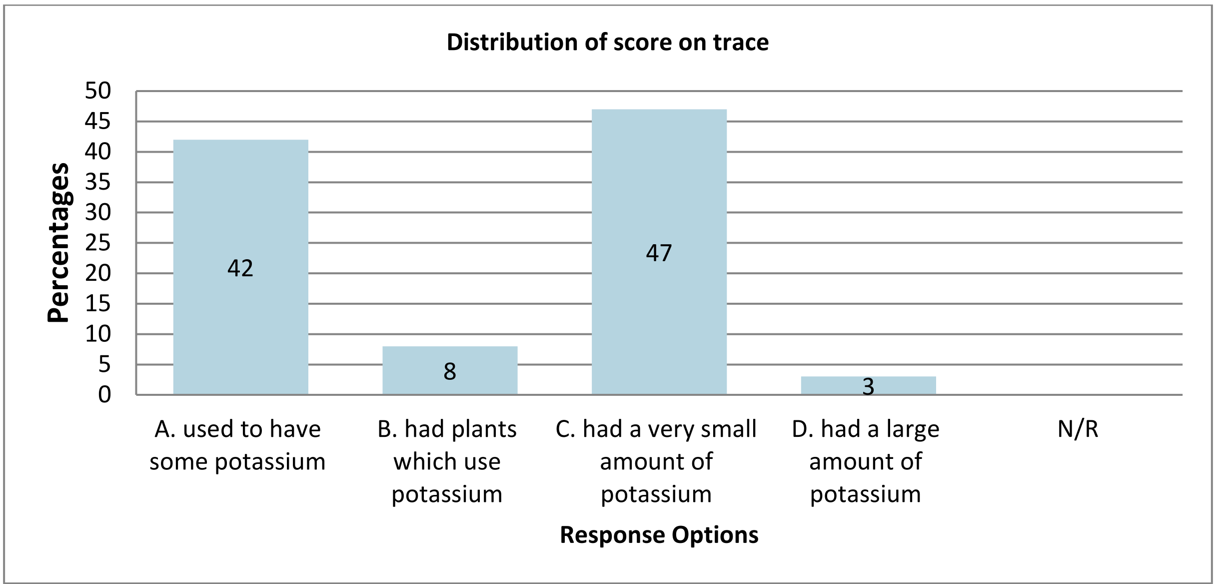

Figure 4.12: Graph of relative distribution of score on response options

As shown on this pictorial graph of Figure 4.12, option A attracted 42 % of participants, although not correct according to the science context, it is now discussed. The following excerpts highlight the argumentative conversation around this option.

> *R: ...majority of the people, who responded they chose, used to have some potassium… So that's what I wanted to find out from you, you said how you would understand a learner like that one who is answering like that?*
> *ST1: I would take it as they're using past tense so, it had, as in they looked at it, it had some, and they left and spoke about it. That's why they said had, instead of meaning it had and now it's gone. So it's a more language, I don't know, I would say that as it had.*

From the interview response above, it was found that the participants reasoned that the choice for option A was due to the sentence construction which was in the past tense. This kind of thinking was popular among several participants as seen in the excerpts that follow.

> ***ST2:*** *By the response there, it doesn't have potassium.*
> *R: It doesn't have potassium?*
> ***ST3:*** *It used to.*

However, some participants had different views on the responses regarding this word item. The different views involved option B (had plants which use potassium) citing the use of the word trace in life sciences in topics such as evolution. In other words, their response was influenced by the vocabulary from another science subject as indicated in the excerpt that follows:

> *ST4: Even in evolution, Life Sciences we use trace. There's a trace of, it shows that there's evidence of the stuff there. So there was this answer you read there so I think, I don't know if it's option (b).*
> *ST5: Had plants which use, had plants, so they were there, they are no longer there. It's a trace, but finding the potassium. So the right answer here, it would be (B), according to the question.*

The influence of the everyday use of the word trace as in any English dictionary was one of the factors that made some participants opt for optional response B. In this sense the word trace suggests the evidence of the presence of a substance or an element.

> *ST6: It's a very subjective question because first things first, we need to understand the word trace. When they say there was a trace of xxxxx here, it's a fact, he was here. He might be around here, we don't care, but he was here. The term trace, so it clearly means like evidence of, you see. So it was evidence of there were plants, like I said. The soil had plants which use potassium.*

One of the interesting observations was that one participant chose option D (has large amount of potassium). According to the quantitative data analysis on this item, option D was not well represented as it only scored 3 % selected as an accurate response. In this interview response it is argued that the presence of a trace of an element or mineral might suggest that such an element or mineral does exist or existed in large amount. The following interview response highlights why option D was regarded appropriate.

> ***ST7:*** *I would support the large amount of potassium in the soil, because sometimes when you apply mining in real life, we don't just go there mining for gold and we just start digging, we start to look for the trace of gold in the soil, by finding that trace of gold we can assume how much gold can we find when we go deep. So there, there might be a trace of that, but when we go in deeper, you might find out that there were plants which were covered by another layer of soil which you now find out that there is actually a huge amount of the substance that initially you thought there was a trace of it.*

Word items such as *trace* are very controversial because they contain multiple meanings. As such, the participants were experiencing difficulties with the meaning when presented in the science classroom context. This explains the distribution of the incorrect response options that totaled 53 % opposed to the correct option which attracted only 47 % (n=18/38). The findings of this study is that words that have multiple distinct meanings (polysemy) can cause difficulty, particularly if one meaning is preferred in a certain context, such as the science context.

These findings corroborate the international literature that demonstrates that the source of difficulty can be influenced by the multiple meanings that the word embraces. Cassels and Johnstone (1980) articulated that some words seemed to be understood in one particular sense but posed a problem when used in another. Moreover, the issue about lack of familiarity and explanation cannot be ruled out completely. As transpired from the interview responses given, it suggests that this word is either not used often, or if used, it is not explained in the physical science classroom. This probably explains why the majority of participants' explanations are pointing towards life sciences.

One participant brought up an aspect regarding relational thinking, which regard the presence of traces of gold for example on the surface as an indication of a large amount of the mineral underneath. These kinds of utterances just show how much thinking was involved when participants were responding to the items in this questionnaire. But it is crucial to reason whether the same word item could be objectively correct for some responses and objectively incorrect for others? Drawing from the content analysis (Krippendorff, 2013), the powerful predictor, as far as this word item is concerned, was the physical science context, and this context guides on what to answer. The context in which a word is used can therefore be a source of difficulty. This finding is not unique to this study; literature has indicated that the context in which the word item is used, contributes to comprehension problems (Farrell & Ventura, 1998; Marshall & Gilmour, 1990).

MESSAGES FROM ENCOUNTERD DIFFICULTIES

Lack of awareness of the distinct meaning a non-technical word can embody, has surfaced as a source of difficulty. The use of relational thinking and failure to read the context in which the non-technical word is used, has led to incorrect interpretation.

4.7.3 *Sensitive*

The word *sensitive* emerged as moderately difficult among the fourth year pre-service science teachers. However, as discussed in section 4.6, this word item was considered deliberately for qualitative analysis because the fourth participants scored only 32% in correct responses on this word. Furthermore, this word item has occured in the two previous groups of participants (second and third years), as such, it was seen fit to find out what might have prevented the fourth year participants to get 100 % on this word item. The word *sensitive* appeared in the questionnaire as reproduced below:

The beam balance is a very *sensitive* instrument. This means that

A. can be used to weigh very small things
B. can be only used by *sensitive* people
C. is hard to understand how it works
D. gets spoilt very easily

From the given optional responses, the correct response was: A –'can be used to weigh very small things' thus according to the classroom science context. In this study, the answers on this item were distributed between the given options as follows: A- 68 %, B- 5 %, C- 3 %, and D- 24 %. The following excerpt were interview responses on this word item, explaining possible reasons for choosing response D.

> *ST1: Sensitive we use in everyday life to talk about someone who's sensitive or something sensitive, and then it means it breaks easily or the person gets hurt very easily. So you could see maybe why they thought it got spoilt because in everyday life, you generally refer to something being sensitive as something that can break easily.*
> *ST2. Someone can get easily emotional, sensitive to energies, words, they can get easily emotional, they're sensitive, even this one can get easily spoilt, therefore it's sensitive, therefore (this man is right) it depends with the context.*

From the two interview responses, it emerged that the reason for choosing response option D was based on the everyday understanding of the word. In everyday context the word *sensitive* is associated with people who are emotionally easily hurt. From the excerpts above, the only explanation for the participants' choice of option D was that they based their reasoning on the everyday context. It had an everyday experience meaning that was different from the scientific context of use. This outcome of the interview response is not unique to this study. A research with South African learners had similar findings. The researchers found that participants arrived at the incorrect meaning, due to the influence of everyday contexts in which they came across the words (Oyoo, 2017; Oyoo & Semeon, 2015). Figure 4.13 shows the relative distribution of scores on response options.

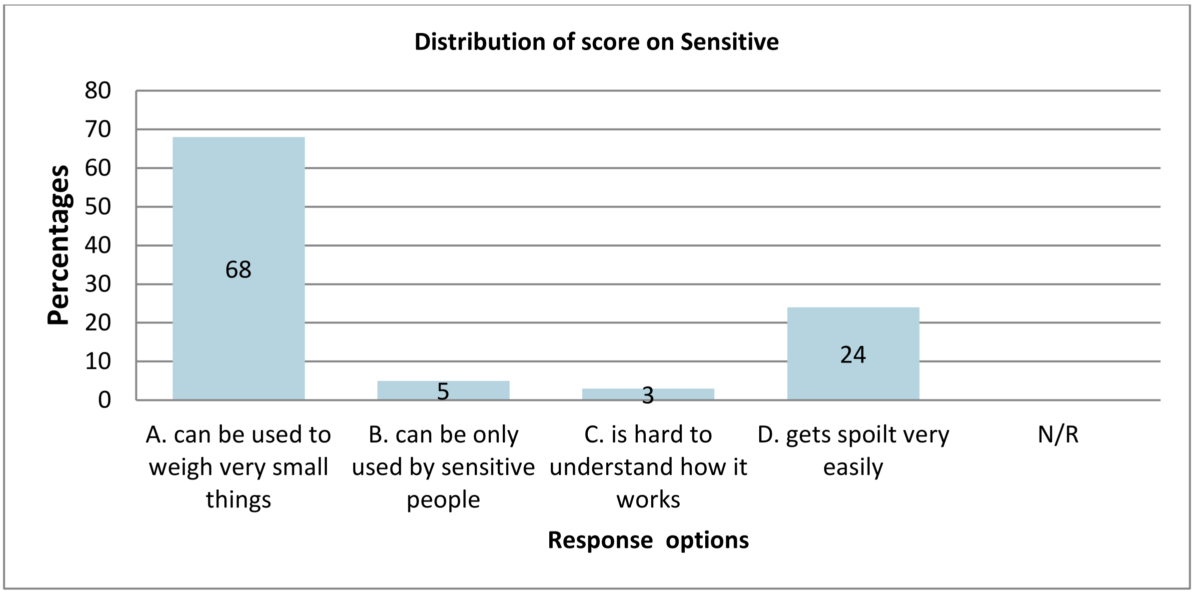

Figure 4.13: Graph of relative distribution of score on response options

While everyday words such as *sensitive* are problematic, the researcher was interested to find out why the participants performed well on some words in the questionnaire. The excerpt that follows highlights possible reasons.

> *ST2: Well, I think most of it you mentioned there were conserve, factors, dehydrate, all those words are more used, they are more used often in science. So you kind of get to an understanding of it from earlier on like linear, factors, conserve, we use in a lot of things in science, and then also I think they link that you could use in everyday language in the same way you use it in science. They are used similarly where like retard was used completely different between everyday language and scientific language.*

The same thinking was echoed by another participant who stated that the main reason for a good performance was that the meanings of these words were maintained, both in science and in everyday contexts.

> *ST3: Okay, the way I would respond to your question, if you look at, if you analyse those words they are words that don't change in context, when we talk about science and the everyday language, that's why people will get them right. They don't change in context, like linear is linear, conserve is conserve.*

Learning from the two excerpts above, it was established that the non-technical words used in the science classroom context do not pose the same magnitude of difficulties. These findings show that words such as dehydrate and factors cause fewer problems in comprehending their meaning, regardless of context of use. Previous research findings cited change of meaning due to context as the main problem in understanding non-technical words (Cassels & Johnstone 1980/1985; Farrell & Ventura, 1998). The researcher was interested to know if these words are important in the learning and teaching of science. The excerpt that follows was an interview response to this.

> ***ST1:*** *Yes I think it's very important that they know both the everyday language and the science language and where the link comes in between them, because of you don't know what it means in science and you've got your own understanding in everyday language. You're not gonna be able to make the links so they could have made the link between science and everyday language and what they meant in the question for science. So yes, I think it's important that you do know what it means in science and also to make sure there is no misconception between the science language and the everyday language.*

The findings of research on non-technical words used in the science classroom, agree with the excerpt above. Gardner (1972) emphasized that some of the common words that are used in the science classroom are not comprehended by the students. Farrell and Ventura (1998) posited that word comprehension must not be brushed aside because that is important in understanding science. Since the interview response had validated the importance of these everyday words used in the science classroom, the researcher wanted to know if these words were explained during the learning and teaching of science, whether at school or at university level.

> *R: So should we say from your own experiences, are these words explained, when they are taught in science, let's say from high school even here in the university…?*
> *ST1: They only focus on the science meaning of it. Ja, so, based on my experience as I was a learner. So I started to realize this here at university that oh, now we have the everyday meaning and the scientific meaning, ja.*
> *ST2: No, normally in science you learn the science meaning, they don't tell you where it comes from in everyday language, how we use it in everyday language, or what it means in our everyday languages.*

The two interview responses disclose that teachers at school level or university level did not explain these non-technical words during lessons. The source of difficulty with these words is the lack of teacher's explanation during class activities. The transnational literature has that these words are equally difficulty to both EFLs and ESLs, whether at university, technical college or high school level, whether female or male (Cassel & Johnstone, 1980/85; Farrell & Ventura, 1998; Gardner, 1972; Oyoo, 2017; Oyoo & Semeon, 2015). One of the participants gave an example regarding learners struggling with some familiar words used in the science classroom during the teaching experience, as follows:

> *ST3: For example, at some point I was teaching Electromagnetic Induction, and you ask them what induction means, like the word induce. So the learners what they did, they think about, okay, it's induce, and then it sounds the same as reduce, so which means it means to compress something, so you can see that, the general proficiency, they don't really have it. And then now, you come to science you teach them about this*

concept which is used in everyday life, it becomes even more difficult for them to understand, so they are really important.

The outcome such as the one elaborated on in the excerpt above is familiar. International literature has confirmed that learners or students confuse words that are phonetically or graphologically similar (Marshall & Gilmour, 1990; Tao, 1994). It was with findings of this nature that Pickergill and Lock (1991) recommended science teachers to spend more time to explain these non-technical science words during their daily science classroom activities.

MESSAGES FROM ENCOUNTERED DIFFICULTIES

The findings point to the issues regarding the influence that everyday context has in interpreting non-technical words used in the science classroom. The words, which are phonetically and graphologically similar, also cause problems. Lastly, is the observation that lack of teacher explanation of the meaning of non-technical words contributes to all these incurred difficulties.

4.8 Summary of the chapter

This study was on pre-service science teachers' understanding of the meaning of the non-technical words used in the science classroom context. As such, this chapter has presented the findings from this study. It has clearly emerged from this study that pre-service science teachers have difficulties with non-technical words used in the science classroom. The following words have proofed difficult across all participating groups: *sensitive*, trace and retard. It has also transpired in this chapter that the sources of difficulty vary with each word and is unique to the word item. However, the following sources of difficulties have emerged common to these three non-technical words: influence of context, lack of familiarity, graphological and phonetical issues and lack of explanation by the teacher.

CHAPTER FIVE: Discussions on trends and sources of difficulties from quantitative and qualitative findings

5.1 Introduction

This chapter examines the trends that have been found during the analysis of both the quantitative and qualitative data. Largely, what has emanated from the marked questionnaires was that some words items emerged extremely difficult, moderately difficult and just ordinary difficult. The purpose of the interviews was to scrutinise possible reasons why those words emerged as extremely difficult and why some enjoyed a good performance from the participants. In this chapter, special attention is given to specific issues that were observed as the cause or reason which actually explained the performance of specific items.

5.2 Trends from the quantitative analysis

This discussion about the analysed data, concentrates particularly on what had transpired in the quantitative data. The quantitative data in particular, reflected statistical findings regarding the marked word items from the administered questionnaires. The following observations made are now discussed in line with the research questions:

- To what extent do pre-service science teachers encounter difficulties with non-technical words used in a classroom context?
- Which non-technical words emerged as difficult to the pre-service science teachers?
- What are the sources of the difficulty of these words as encountered by pre-service science teachers?
- What possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training?

In the course of analysing the quantitative data, there were particular trends that came to the surface with regards to how some word items were performed among the second year, third and fourth year participants. The observed trends are discussed under the following sub topics: Non-linear performance on the word items and difficult words across groups.

5.2.1 Non-linear performance on the word items

The quantitative data findings have shown that the performance on the word items was not linear. In general, one would expect the fourth year participants to have obtained a better score on the word items, compared to the second and third year participants. However, as observed from Section 4.3.1(Table 4.1), Section 4.3.2 (Table 4.2) and Section 4.3.3 (Table 4.3) the performance do not conform to the expectation. The following are the observations from the tables mentioned.

Words scored 100%

The second year participants had four word items on which they scored 100% namely*:* *constant, linear, system* and *conserve*. The third years had five word items on which they scored 100% correct responses: *characteristics, constant, linear, system* and *negligible*. The fourth year participants scored 100 % on only two items namely: *dehydrate* and *factors* respectively. As seen from the above italicised words, the second and third year participants have similar words, which have received 100 % score, such as *constant, linear* and *system*. On the contrary, those words that have received 100 % score among the fourth year participants (*dehydrate* and *factors*) are neither found in second nor third year scores. The table 5.1 shows the distribution on the words that received 100% score from the participant groups. The bold italicised words highlight those words that are both in the third and fourth year participating groups.

Table 5.1 Showing words that had a score of 100% among three groups

WORD SCORE	PARTICIPANT GROUPS		
	second Years	third Years	fourth Years
100%	***Constant***	***Constant***	Dehydrate
100%	***Linear***	***Linear***	Factors
100%	***System***	***System***	
100%	conserve	Characteristics	
100%		Negligible	

Table 5.1 illustrate pictorially what has transpired in this study. The kind of trend shown in this pictorial figure (Table 5.1) is non-linear because, arguing on the basis of experience and overall science content, one would assume that the fourth years could have a good comprehension of these non-technical words used in science context. They might have experienced and encountered these words during lectures, tutorials and practical activities. From the interviews conducted, it had emerged that the meaning of these words does not change whether used in science context or everyday context. From the interview responses, one of the fourth year participants had this to say.

> *ST2: … conserve, factors, dehydrate, all those words are more used, they are more used often in science. So you kind of get to an understanding of it from earlier on like linear, factors, conserve, we use in a lot of things in science and then also I think they link that you could use in everyday language in the same way you use it in science. They are used similarly where like retard was used completely different between everyday language and scientific language.*

Now how can one explain the fact that second years and third years showed more words scoring 100 % than the fourth year group? Moreover, the words that fourth year scored 100 % for are just unique to this group, as they are not reflected in other groups. From these findings, it would appear that the lack of familiarity (discussed in detail in section 5.3.2) of the contextual use of these words is one of the reasons why the fourth years did not get 100 % on most words. The teachers' assumptions that, the fourth year students are aware of the meaning of these words, at their stage of training, has proven that the lack of explanation (discussed in detail in section 5, 3, 5) is detrimental to students' performance.

Recurring difficult words across groups

The general observations based on the quantitative data, were that some of the word items emerged as extremely difficult across all three groups, such as *retard* and *trace*. Some words appeared in all three groups but with different status, for example the word *sensitive* appeared twice in the second and third year groups as extremely difficult and once as moderately difficult in the fourth year group. The word *effect* emerged as extremely difficult in the second year group and as moderately difficult in the third year group. The words *convention* appeared as moderately difficult in the second and third year groups, while *evacuate* appeared as an extremely difficult word. Lastly, the word *spontaneous* was categorised as moderately difficult among the fourth year participants. The table below, Table 5.2 highlights the distribution of these non-technical words according to their levels of difficulty. The colours are added to show the performance of each word across the participating groups.

Table 5.2 *Summary of how each word item performed across the participant groups*

Position of difficult of the recurring words	PARTICIPANT GROUPS		
	2nd Year students	3rd Year students	4th Year students
1st difficult	Sensitive	Sensitive	Retard
2nd difficult	Effect	Retard	Trace
3rd difficult	Trace	Trace	Evacuate
4th difficult	Retard	convention	spontaneous
5th difficult	convention	Effect	sensitive

From Table 5.2, the following words *retard, trace* and *sensitive* recurred in all three participant-groups. The performance of these words in these groups was not linear. This was because there was a constant shift in terms of difficulty of these words. For example, the word *sensitive* dominated in the second year and third year questionnaires as the most difficult word (first position) but dropped to the fifth position among the fourth year participants. The word *retard*, which was in the fourth position in the second years' group, progressed to the second position in the third years' group and eventually emerged the most difficult item among the fourth year participants. The words *trace* however, was in third position in both second and third year groups, and then progressed to the second position (extremely difficult) item among the fourth year participants.

Words such as *retard* and *trace*, as they move from second year up to the fourth year became more difficult to the participants. On the contrary, *sensitive* was extremely difficult to the second and third year participants but moderately difficult to the fourth years'. As discussed in section 3.4.1, regarding the curriculum of these pre-service science teachers, words such as *trace* and *retard* may be experienced in their science content while *sensitive* may be encountered in practical activities. Although 32 % of the fourth year participants had the word meaning wrong, the influence of practical activities may be the reason for 68 % of participants getting it right.

Comparatively, at this stage of their training, the fourth year group had done a lot more practical activities than the second- and third year participants. Whether, a word such as *sensitive* was explained to these participants, is another question, otherwise, all of them at this stage of their study would have known the correct meaning. Non-teachers' explanations of these words may therefore be the confounding element that the participants did not get a 100 % score. As highlighted above, the words *trace* and *retard* were encountered in the science context. To begin with, the word *trace* is found in chemistry, which refers to elements that are found in small quantities (LeMay et al., 2015). On the periodic table, the elements required by living organisms in small quantities include copper (Cu), Zinc (Zn), cadmium (Cd) and selenium (Se). The word retard appears in both the chemistry and physics component. Retardation in physics refers to an object moving at decreasing velocity (slowing down) and in chemistry the idea of slowdown is equally applicable in a chemical reaction (Giancoli, 2014).

Since the words *retard* and *trace* have proven difficult among the third- and fourth year participants, less use of these words or lack of teacher explanation, as already discussed in this very section, may be the contributing factors to this poor performance. As discussed in the literature review (chapter 3, section 3.4.3) , the fourth year is the final stage of the students' certification, but does not guarantee teacher effectiveness and superior subject matter knowledge (Darling-Hammond & Youngs, 2002). As such, what counts most is not necessarily the stage of their formation to becoming science teachers, but the knowledge that has been effectively mediated and internalised (discussed in the theoretical framework in section 1.3.1) in the process of their teacher formation. These findings do not only speak to the fourth year stage of training, but also as to what has been accumulated in the previous years of becoming a science teacher.

5.2.2 Difficult words across the groups

In order to determine the most difficult word in this study, the use of the quantitative data was useful. All the words in Table 5.3 were considered in terms of how the participants in each group performed on each word, and this information was extracted from observations already noted previously in section 4.2.2 (Table 4.1), section 4.4 (Table 4.3) and section 4.6 (Table 4.5). Since these word analyses were already expressed in percentages, I had to add scores to each word in all three groups studied divide the scores by 300 and multiply by 100. This was to find the average percentage as shown in the following formula: $\frac{2nd\ score+3rd\ score+4th\ score}{300}$ X100 . Table 5.3 shows the distribution of the average score per word as calculated using the above formula.

Table 5.3: Average distribution of the difficult words per ~~word per~~ year group

	% SCORE PER WORD PER GROUP			%
Non-Technical word	2^{nd}Year students	3^{rd}Year students	4^{th}Year students	Average incorrect response
Sensitive	50.00	65.00	31.58	48.86
Retard	35.85	47.50	57.89	47.08
Trace	39.62	45.00	52.63	45.75
Effect	44.34	25.00	15.79	28.37
Convention	23.80	27.50	28.95	26.75
Spontaneous	25.47	15.00	34.21	24.89
Evacuate	19.81	15.00	39.47	24.76

As evident from Table 5.3, quantitatively, the most difficult word in this study was *sensitive* with an average score of 48.86 %, which was seconded by *retard* scoring 47.08 %. The word *sensitive* emerged as the most difficult word because quantitatively it was in the first position both in the second year (n=106) and in the third year groups (n=40). These two groups had many participants and the word *sensitive* did not perform well in these groups. The word reoccurred on two occasions (in the second- and third year groups) as the most difficult and in the fourth year group as a moderately difficult word. This study therefore posits that non-technical words are not just difficult but there is an observable hierarchy of difficulty among these words. In this study, *sensitive* is thus the most difficult word among the pre-service science teachers.

As discussed in the literature review in section 2.4.1, this word item, as it appeared in the questionnaire, reflects its usage during practical work activities, where instruments such as a beam balance are used to weigh different materials. One would therefore expect these pre-service science teachers to have a good understanding of this word, knowing that their training involves both content and practical work. While the second- and third year interview responses on this word was more inclined to everyday understanding, lack of explanation of the contextual meaning of the word can be the cause of the incorrect responses. For the fourth year participants, 32 % got the incorrect contextual meaning of the word *sensitive*, of which 24 % chose option D (get spoilt easily). Since the interview responses unveiled that these words were not explained, it serves as the reason why some fourth years were lagging behind even considering their year of study, and their proficiency in the LOLT at such level.

Figure 5.1, shows how each word performed by the three participating groups. As seen from this graph the word *sensitive* was very difficult for second and third year participants. Among the fourth year students, it was not noted as difficult. The words r*etard* and *trace* indicated that their level of difficulty increased as students progressed from second- to fourth year. From the graph, it is clear that the fourth year students experienced much difficulty with words such as *retard* and *trace*.

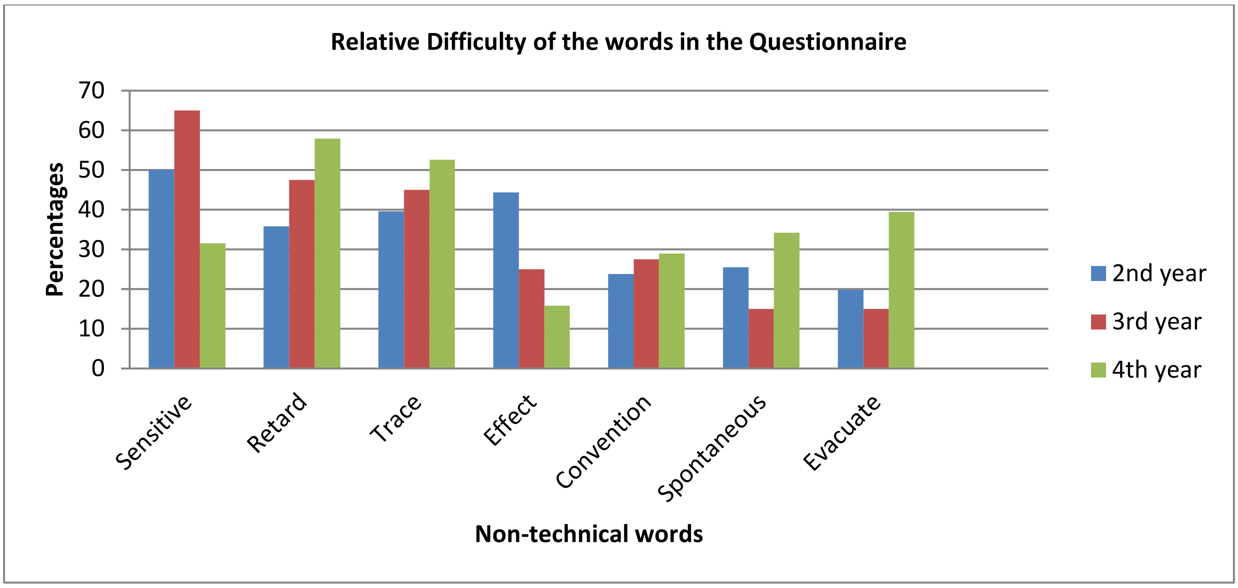

Figure 5.1: Graph of relative distribution of score per word per participant group

The other words: *Effect, convention, spontaneous* and *evacuate* were also difficult but did not meet the criteria to be discussed in this study. When the scores per ye participant group were averaged, the most difficult word across the years of study was *obtained*. The Figure 5.2 is a graphical representation that graphically shows the most difficult word across all participating groups. It has been arranged in the order of incorrect score and hence the word item with the highest score is in fact the most difficult word. In this bar graph of Figure 5.2, the hierarchical order of difficulty is expressed in percentages.

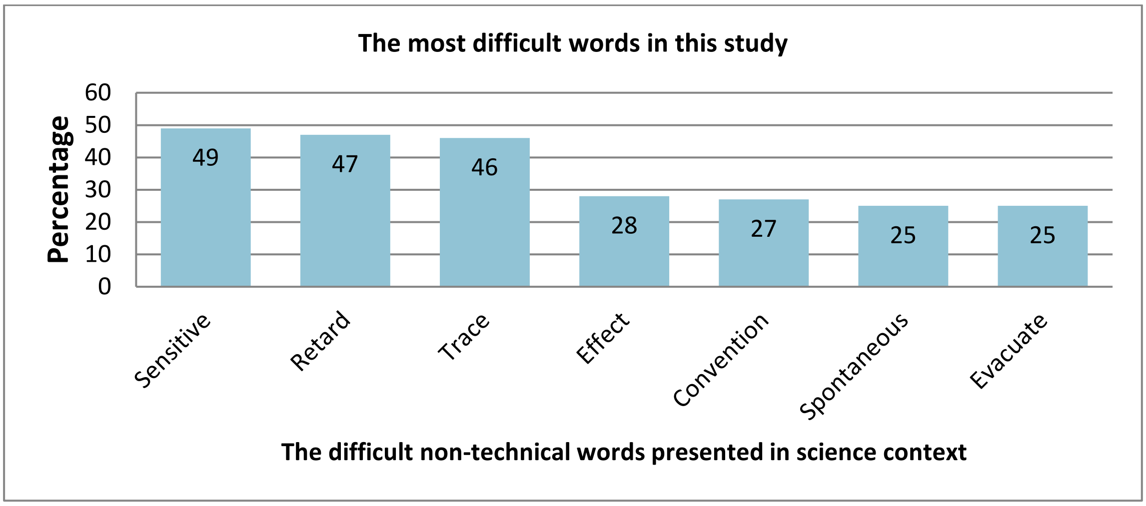

Figure 5.2: Graph of relative distribution of average score on non-technical words

The word item *retard* on average was regarded the second most difficult item in all the participating groups. This word registered as the fourth difficult item among the second year group, the second difficult item among the third year group and first difficult item among the fourth year participants respectively. In short, as we move from the second to the fourth year group, the difficulty of this item increased. From the interview responses, the second years' have mentioned that they encountered this word in their physics content. According to the physics context, *retardation* implies that an object is slowing down (Oyoo, 2017). It suggests therefore that some of second year participants were aware of the contextual meaning, because of the content of physics lectures attended. This explains why this word was in fourth position in terms of difficulty among the second year participants.

As seen from the Table 5.3, this word item emerged as very difficult to the third year group (second position) and most difficult to the fourth year group (first position). The third- and fourth year participants gave the opposite meaning of the word; different from the one conceived in physics. Although, how this word item was structured on the questionnaire, applied to chemistry, the meaning of this word was the same, both in chemistry and physics. The message from such a mistake was probably that in the absence of what retard meant in a chemical reaction, the participants resorted to the everyday use of the word. Again, the deficiency of explanation and relevant instruction on these non-technical words continues to manifest its impact on the contextual meaning of these words.

The third word item , which appeared to be most difficult across all the participants, was *trace*. Referring to the Table 5.3, the word registered as the third difficult item among the second year- and third year participants and second among the fourth year participants. This word item was understood in view of life sciences of which its meaning was conceived as an indication of existence of something. This meaning of the word *trace* is very common and known within an everyday context of use. It was these kinds of sources that betrayed the participants' way of thinking, hence selecting the wrong options.

However, it is appropriate to mention that within the life science subject, the word *trace* has multiple meanings as well. One of the meanings of the word *trace* refers to small or minute amount. Reece et al. (2011) regard *trace* elements as those that "are required by an organism in only minute quantities" (p. 78). The typical example of trace elements would be iron (Fe), an element that is needed by all forms of life (Reece et al., 2011). The message from the mistakes made is therefore that the pre-service science teachers harboured only one meaning that is familiar to them. In addition to the context, lack of familiarity with other meanings of everyday words was one possible reason why participants selected the incorrect options.

5.3 Sources of difficulties from qualitative data

Research questions 3 and 4 were investigating the sources of difficulties and the possible messages from such difficulties, regarding the training of pre-service science teachers. The qualitative data which was collected through interviews, had disclosed some of the reasons for pre-service science teachers choosing options that were not correct in the context of the study questionnaire, for various reasons. In this study, those reasons are taken as the sources of difficulties , which led the participants to select incorrect options. Research question three read: ***What are the sources of the difficulty of these words as encountered by pre-service science teachers?*** The following are some of the sources of difficulties that have become obvious from the interview responses.

5.3.1 Influence of context

One of the features that stand out clearly in this research study is that pre-service science teachers selected options based on their previous experiences and encounters of the words in the questionnaire. These encountered experiences, although erroneous according to the scientific context, provided a fertile ground for explaining the reasons for the difficulty of these non-technical words, when presented in a science context. As transpired in this study, there was more than one context that influenced the pre-service science teachers' choices. These were influence of everyday context and influence of meaning from science related contexts. These contexts are now discussed.

Everyday context

The findings from this study have recognized that everyday meaning, associated with some non-technical words, were very influential in the participants' selection of the incorrect responses. One of the words in this study that has proven difficult in all three groups is the word *sensitive*. The reviewed literature has reported the same findings on this word (Oyoo, 2017, Oyoo & Semeon, 2015). In this study, the second year participants conceived *sensitive* as meaning something that can be easily damaged such as the skin. As already presented in section 4.3.1, the excerpt below from the first respondent (ST1) of the second year group validates such an understanding*:*

> *ST1: Yes; because from everyday knowledge, when you say like, my skin is sensitive to the sun, like the meaning, like, obvious the skin can get spoiled easily, or, I don't know which term to use. Something like that, so whoever chose that number (D), I agree with.*

The third year participant group conceived the word *sensitive* within the everyday context as referring to something that is fragile. As such, precautionary measures must be taken to guard against being damaged. The excerpt that follows is taken from section 4.5.1, as one of the third year participant's interview responses, who happened to be the second respondent (ST2) on the item.

> *For me I'd go with (D), I'd agree more with (D), because something sensitive is something which is fragile, which is easily damaged, like, which reacts very quickly to slightly changes of the environment or whatever the case.*

The fourth year group understood the word *sensitive* involved in both fragility of a material object such as glass, but also referred to the person who can easily get emotionally hurt. The extract below from section 4.7.3, is an interview response from the first respondent (ST1) from the fourth year participant group.

> ***ST1:*** *Sensitive we use in everyday life to talk about someone who's sensitive or something sensitive, and then it means it breaks easily or the person gets hurt very easily. So you could see maybe why they thought it got spoilt because in everyday life, you generally refer to something being sensitive as something that can break easily.*

Reading the interview responses from the three participant groups, one realises that for every word, the context meaning was the most dominate aspect, which first came to the respondents' mind. Even though the meaning was correct in this everyday context, it was regarded as wrong in the science classroom context. The change of context means the change of meaning of the word in question. While this aspect is difficult, educating the future educators in this area is crucial.

Moreover, the influence from other science related subjects cannot be overlooked. It has transpired from the interview responses that words such as *trace* was selected based on life science's usage of the word. The use of some of the non-technical science words in the life science subject is very close to everyday experiences and encounters, which is contrary to subjects such as physics and chemistry. The word *trace* embraces multiple meanings. In terms of the life science, the word *trace* would mean remains of something, in topics such as dinosaur remains. However, if we consider how this word item was structured in the questionnaire (see Appendix A) it meant small amount (minute).

5.3.2 Lack of familiarity

One of the causes of difficulty as emerged from this study is lack of familiarity with some of the non-technical words used in the science classroom such as *trace, retard and sensitive.* As discussed in section 5.2.1, basing the argument on Table 5.2 (already discussed), the word *retard* was in the fourth position in the second years' group, it shifted to the second position in the third years' group and eventually emerged the most difficult item among the fourth year participants. The word *trace* however, was in third position in both the second- and third year groups, and then progressed to the second position (extremely difficult) item among the fourth year participants.

From this kind of observation, lack of familiarity with these words can be attributed to infrequent usage of these words, and if these words were used in the science classrooms, they were not adequately explained. On the other hand, on the words that were familiar to the participants, the students performed well. Such words include *characteristics, system, dehydrate, constant, linear, negligible etc.* The positive performance on these words can be attributed to regular use of these words in the science classrooms as confirmed in the following excerpts from a fourth year participant.

> *ST2: Well I think most of it you mentioned there were conserve, factors, dehydrate, all those words are more used, they are more used often in science. So you kind of get to an understanding of it from earlier on like linear, factors, conserve, we use in a lot of things in science and then also I think they link that you could use in everyday language in the same way you use it in science.*

5.3.3 Influence of connotative meanings

Some of the response options selected by the participants were due to the influence of connotative meaning associated with the words. Farrell and Ventura (1998) explained that denotative meaning refers to the actual meaning of the word as it appears in dictionaries. The connotative meaning on the other hand refers to the "*range of possible mental connections a particular word may suggest*" (Farrell &Ventura, 1998, p. 251). As such, some of the response options selected was inclined to connotative understanding of the word. The word *retard* for example shows such orientation. The following excerpt from a third year participant supports the connotative argument:

> ***ST3:*** *To me in my understanding, when we talk about retard, we talk normally like older people, or someone who has a disorder. Those who are really struggling and we know when this person is retarded, you can say run and they'll be like….., bala, (write something), they don't want or they are doing their own things, that's why you'll be like, aay this one.*

I therefore argue that those who selected option B (makes reaction go other way) to some extent were influenced by the connotative meaning of the word retard rather than the denotative meaning. I however do recognise the available literature that argues that choosing incorrect response option B was due to everyday context (Oyoo, 2017). However, in addition to everyday context, the pre-service science teachers' responses raised the issue about the connotative meaning of the words, since it associates the word, *retard*, with people who cannot think in a normal way. Generally speaking, the word such as *retard,* whether used in chemistry or physics, in the English dictionaries (Oxford dictionary, 2010) posits the same meaning, slowing down or delay. However, I have to acknowledge that some of the incorrect scores were choosing option A. Largely, in this study, the word *retard* is one of the words that had two of its options (option A and B) receiving competing scores. This observation is true for all three participant groups. The table below illustrates this observation.

Table 5.4: Distribution of incorrect options A and B of the word "retard"

Incorrect options	PARTICIPANT GROUPS		
	2nd Year students	3rd Year students	4th Year students
A	16%	22.5%	34%
B	15%	15%	24%

I have attributed the option B to connotative influence and the selection of option A is probably due to infrequent usage of the word in the third- and fourth year groups. As seen from Table 5.4 and Figure 5.2, and as discussed already in section 5.3.2, the difficulty of the word r*etard* increases as we move from second- to fourth year participants. This indicates that perhaps words such as *retard* are not used in the physical science classroom in connection with chemical reactions. When dealing with topics on chemical reactions, emphasis is placed on chemicals that alter the rate of reaction such as catalysts (DHET, 2011). This is because of the benefits these chemicals bring to the industrial world. It is observed that a lot of manufactured items are produced with the use of catalysts (Silberberg, 2015). Using catalysts in chemical reactions produce the final product faster than a reaction without a catalyst (LeMay et al., 2015). This being the case, when the item: *The pupil was trying to find a chemical that would <u>retard</u> the reaction* appeared, in the absence of knowledge of what retard would mean, option A was selected because chemical reactions need to be fast to produce more products.

5.3.4 Phonetically and graphologically similar words

The interview responses have disclosed that pre-service science teachers experienced difficulties with words that sound-alike and or look-alike. Literature has long established that learners or students confuse words that are phonetically or graphologically similar (Tao, 1994; Marshall &Gilmour, 1990). Findings such as these motivated Pickergill and Lock (1991) to recommend science teachers to spend more time explaining non-technical words in their pedagogical practices. In this study, it was found that the word *sensitive* was confused with sensible. In the following excerpt below, a third year participant (respondent three: ST3) explained her reasoning during the interviews:

> *ST3: I choose it can be used by sensible people.*
> *R: Why?*
> *ST3: Because 'sensitive', is near to 'sensible' in English, so the learner just decided it can be used by sensitive people. Sensible, sensible and sensitive they are look-alike yes.*

These kinds of utterances and thinking experienced in the interview response above, point to something different from context and connotative meaning, namely the lack of English exposure to the meaning of these non-technical words. Although the words *sensitive* and sensible looks and sounds similar, it cannot be taken for granted that they have the same meaning. As transpired in this response interview, learners confused the words *induce* and *reduce* because they sound similar. The consequences are that they choose wrong answers.

Having examined the sources of difficulties as suggested by the interviews, I now turn to the last question of this study. The research question four read: ***What possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training?*** From the analysis made from the interviews responses, there is a general agreement among the participants that these words are not explained during teaching and learning of science. Therefore, the lack of explanation is now discussed.

5.3.5 The lack of explanation

The theoretical framework guiding this study (discussed in section 1.3.1), has emphasized the importance of mediation whether explicitly or implicitly in facilitating the understanding of the contextual use of non-technical words. This study has revealed that the meanings of these non-technical words when used in the science context were not explained to the participants as learners in schools or during pre-service science teachers' education. Given that there is a lack of a language component in their curriculum, one would argue that the contextual meaning of these words cannot receive adequate attention and explanations. The consequences were that pre-service science teachers encountered difficulties with contextual proficiency, familiarity, connotative meaning, graphological and phonetical similar words as shown in the figure 5.3 below.

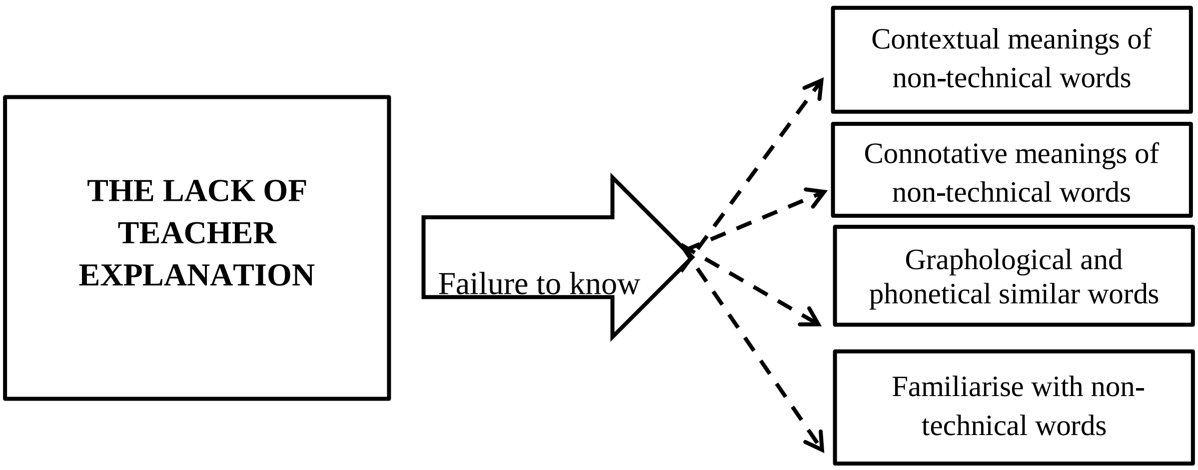

Figure 6.2

: Summary of sources of difficulties with non-technical words

Above summarizes these findings highlighting the lack of explanation of these words as the main reason that pre-service science teachers encountered difficulties with non-technical words. From Figure 5.3, it has become clear that the two thirds of classroom talk should be adapted to the needs of learners in schools and during pre-service science teachers' education; otherwise science classroom language will remain a problem in the learning of science.

It is an established finding in this area of research that everyday words, when used in the science context, cease to be mere English words (Marshall & Gilmour, 1991). This means that a word when used in a different context may embody a meaning very different from its original meaning. The conceptual framework of this study emphasised words as language and as knowledge. Therefore, the understanding of the word is not only important but also crucial in giving the correct meaning during formal and informal assessment, as highlighted in the excerpt that follows:

> *ST5: So, if a learner doesn't understand those words, how do you expect the learner to answer the question? Because the main thing is understanding those words in order for you to answer the question.*

The findings from this excerpt corroborated the general trends revealed by Farrell and Ventura (1998) that word comprehension is essential in the learning of science. Hence, the authors advised that it is important that special attention should be given to this endeavour. In addition, the theoretical framework accentuates the context as a significant feature in meaning making. As such, the same word can mean one thing in science and a different thing in another science related subject such as in life science, chemistry etc. The excerpt that follows serves to heighten such an observation.

ST4: Every subject is a language. English is a language, science is a language. So as much as we might have compound in Mathematics as an interest, in physical sciences we also have compound, but these two words mean different things.
R: Do you think these words they contribute to the performance of the learner?
*STs**:** They definitely do.*

It would appear that the understanding of these words as used in the science classroom context is crucial, even in answering questions during tests or in examination settings. The experience of some participants is that code-switching was used when they were in high schools. While code-switching is being subscribed as an alternative method to make learning science easily accessible to learners, it has transpired in this study that it does not help much because these everyday words change meaning due to context. As a result, during exams the code-switched words do not appear at all. The result is that learners struggle with understanding the questions. The excerpt below accounts on this observation.

ST6: Because if we are using those words and the learner doesn't have the science understanding of the word, how do you, in an exam room for instance I don't know if this would relate. I've been taught, not for all my life for my high school life I've been taught physics in isiZulu, so when it comes to the exam room, such words in isiZulu, they are not there so when it comes to the exam room you read the sentence three times and you don't understand what they want, because you don't understand those words.

The theoretical framework leading this study argued that a dynamic relationship exists between language and thought, and that the concepts that teachers teach, cannot be fully understood if they are not represented in words (Vygotsky, 1978). It is in this context that word comprehension should not be thrown to the peripherals of the science classroom, especially in the case of using non-technical words (Farrell &Ventura 1998). As evidenced in this study some words are more easily comprehended than others. The following excerpts explain the unique characteristics of these words as observed by the participants.

R: There are some words like conserve, system, factors, dehydrate, linear and constant, most people got 100%. What is so special about these words?
ST4: Because they are specifically used in science that is what I can say.
ST5: The meaning is the same.

Even though these everyday words change their meaning due to context of use, it has transpired from these interview responses that some words maintain their meaning whether in science or everyday context. It is therefore easy for the participants to understand them when used in the science classroom context.

5.4. Summary of the chapter

This chapter has presented the analysis of the extremely difficult items per participating group. The interviews have disclosed the possible sources of difficulties as perceived from the different groups as follows: context of use, words that look-alike or sound-alike, connotative meaning and the lack of teacher explanation of these words. It has also transpired in this chapter that some words were easily understood by the participants such as conserve, system, linear, constant, characteristic, negligible, factors and dehydrate because they are frequently used during class interactions. Due to a lack of a language component in their curriculum, the lack of teacher explanation of these words is the main reason that pre-service teachers encountered difficulties with non-technical words.

CHAPTER SIX: Conclusion, implications and recommendations

6.1 Introduction

The main aim of this study was to explore the pre-service science teachers' meaning of the non-technical words when used in the science classroom context. The study sought to investigate whether the pre-service science teachers also encountered any difficulties with the non-technical science words presented in the science context. As such, it was also of interest in this study to establish which non-technical words, when presented in the science context, were perceived as difficult and the possible sources of difficulty (or lack of comprehension of their meaning) when used in the science context. In view of these outlined objectives, this study in particular was geared towards addressing the following research questions:

- To what extent do pre-service science teachers encounter difficulties with non-technical words used in a classroom context?
- Which non-technical words emerged as difficult to the pre-service science teachers?
- What are the sources of the difficulty of these words as encountered by pre-service science teachers?
- What possible messages can be drawn from the encountered difficulties with non-technical words used in light of their initial teacher training?

Although, how the data analysis for this study was done has already been described in sections 3.6, a brief summary is presented here as a prelude to the summary of findings of the analysis. For the quantitative data, it involved the analysis of the questionnaires, which contained the 30 word items. These word items were subjected to descriptive analysis where they were marked against correct responses, and then recorded in terms of their frequency and meaning and then converted to percentages in terms of correct responses and incorrect responses. Through this analysis, the word items that turned out to be well performed and poorly performed were chosen for qualitative data analysis, through semi-structured interviews.

During the qualitative data analysis the participants' interview responses were recorded and later transcribed, followed by the content analysis of the transcribed manuscripts, in order to ascertain the participants' explanations of the difficult and well performed items. The theoretical framework that endorses mediation as a necessary tool for teaching and learning, informed this. As disclosed in this study such mediation processes must not underestimate word comprehension, especially of the non-technical science words. It is with this in mind that the conceptual framework that conceives and appreciates words as language and as knowledge, further informed the study. A summary of findings as conclusions in this study is as below.

6.2 Findings of this study

The findings of this study as presented in line with research questions 1 and 2, have unveiled that pre-service science teachers had trouble with non-technical words when used in the science classroom context. Indeed, all of the 30 non-technical words have been considered as a source of difficulty except for the few that the participant groups obtained an overall score of 100 %. The second year participants obtained an overall score of 100 % in the following words, *constant, linear, system* and *conserve*. The third year group produced a 100 % score on words such *as characteristics, constant, linear, system* and *negligible.* Lastly, the fourth year participating group performed well with only two non-technical words namely *dehydrate* and *factors*. As transpired in this study, the participant groups performed well on these words because the meanings of these non-technical words do not change with context. Further, as the collected data for this study suggests, most participants encountered these words during their schooling years when learning science. As such, the participants were very familiar with the everyday meaning of these words as opposed to their contextual meaning.

Research question 3 was investigating sources of difficulties of these non-technical words, while research question 4 contemplated on the messages drawn from such difficulties, bearing in mind the pre-service science teachers' preparation. From the interview responses obtained from the participants, the main cause of difficulty is the lack of teacher's explanation of these non-technical words. It has become clear during interviews that teachers and lecturers do not explain these non-technical words in their teaching of science. The three groups of participants that took part in this study gave a unanimous observation that during their science content and practical activities, language was not an area of focus.

The findings of this study have disclosed that the lecturers (university level) and teachers (school level) assume that the science students or learners know and understand these everyday words used in contexts as they present themselves in physical science classrooms. Although, not articulated by the participants in this study, the fact that lecturers and teachers assume that learners know the meaning of these everyday words is a clear indication that they consider science classroom language to be of minimal relevance to the learning of science (Wellington & Osborne, 2001). As already discussed in section 1.1, that generally, it is observed that teachers are mostly in a hurry to finish the prescribed syllabi; and as a result, they tend to use science classroom language with an assumption that learners understand this language (Cassels & Johnstone, 1985).

Also revealed in this study, is that the sources of difficulties with these non-technical words are due to the alternative contextual meanings these non-technical words embody. The pre-service science teachers associated the meaning of these non-technical words with other contexts in which these words were encountered. These contexts include the everyday context and other science related disciplines, such as life sciences etc. Largely, as emerged from these study findings, these contexts have meanings that are not compatible with the required contextual meaning. As a result, the participants used the meaning from these other contexts when selecting the optional responses, which resulted in wrong answers according to the science classroom context.

As transpired from this study, the aforementioned contexts explain the non-technical words in concrete terms and show agreement between thought (what is expressed by it) and reality e.g. *sensitive* object referring to fragile objects such as glass etc. The science classroom contexts on the contrary, embody meanings that are abstract in nature and thus sometimes present meanings that are diametrically opposite to the everyday understanding e.g. *sensitive* person and *sensitive* instrument. Therefore, paying attention to the context in which non-technical science words are used, can improve the word comprehension among the participants. More important in this regard is the aspect of mediation or teacher explanation, because these non-technical science words appear at different levels and times during pedagogical practices. For example, some non-technical words are used when learning physical science content such as *retard* and *spontaneous,* while some are regular words during practical activities such as *sensitive*. The use and understanding of science language is crucial in all activities such as tutorials, practical work and learning of the content itself (Oyoo, 2012).

6.3 Implications and recommendations

This study has established that 184 pre-service science teachers from this English medium university encountered difficulties with the meaning of the non-technical words used in the science classroom context. This was regardless of the fact that the participants were considered highly proficient in the English language. This study employed a case study as a research design and although the findings may not be normally, generalizable over the whole South African English medium universities, there are common features between participants in this study and those of learners and students across South Africa. Since the published research in this area, focused on South Africa (Oyoo, 2017; Oyoo & Semeon, 2015) and concentrated on high school learners, these findings at a university level serve as a very important indication of the problem of science language in learning science in South African school classrooms, as well as at universities.

It has been substantiated in this study that teachers (at schools attended by participants prior to joining university) and lecturers (at an English medium university) do not explain the meaning of non-technical words that appear in abundance in science textbooks and their science classroom talk. The lack of awareness could probably be contributed to such neglect and oversight (Oyoo, 2012). There is therefore an urgent need for those involved in training science teachers to consider the issue of language as an element that can immensely improve the understanding of the non-technical component of science classroom language. Since there is no component in pre-service science teachers' training on science language, research outcomes such as this, has suggested a need to adjust the curriculum of the science teacher education accordingly. Hence, the findings from this present research regarding teacher preparation may be considered timely.

Halliday and Martin (1993, p. 2) argued, "Adults may choose to deny it, but children in school know very well that there is a language of science". This study was for and on pre-service science teachers. These findings serve a double function; creating awareness on learners' difficulties with non-technical words and also as a wakeup call for science teacher educators to mediate pre-service science teachers regarding science classroom language. This study stands therefore as a testimony, which may stimulate and convince those in training institutions to reconsider a science language component as a valuable ingredient to be added to teacher training pedagogical approaches.

I am building my argument from the above discussion and on the fact that there is no module on language in the science teacher education curriculums, and neither in the learning and teaching of science. The possible recommendation would be that teacher training institutions reflect on including a science language component to its programmes. This move will facilitate a process of closing the existing gap in teacher training. Speaking from my own experience, during my training as a high school science teacher in one of the South African English medium universities, the component on the role of science language was non-existent throughout the four-year course. By and large, as evidenced by this study, the science language gap in the initial teacher education of the science teacher may affect teachers' abilities to present science in the best interest of the learners. Therefore, workshops on science languages may be a viable recommendation for those already in the field. This is suggested, as some teachers did not perhaps have the opportunity to concentrate on language during their training. It is therefore recommended to expose them to non-technical word use.

6.4 Limitations of the study

In this study, I would like to pinpoint two limiting factors as observed during the analysis of the qualitative data namely the number of participants who availed themselves for interviews, and the participation of EFLs for interviews, as I will now discuss.

6.4.1 The interviews

The total number of participants who took part in the questionnaire collection was 184. It should be mentioned that in all three groups there were participants of both EFLs and ESLs. The first limitation regarding interviews resides with few participants turning up for interviews. The participants who honoured the interviews were as follows: The second year participants of the Natural Science Methodology Course who presented 8 % (n=9/106); the third year participants who presented 28 % (n=11/40) and the fourth year participants who presented 37% (n=14/38) . The fourth year- and third year participants were better represented in the interviews as compared to the second year participants, yet the second year participants were in the majority, when responding to the questionnaire.

The second limiting aspect concerning the interviews was that second year- and third year pre-service science teachers who were EFLs, did not honour the invitation for interviews, even though they did indicate that they would attend. Their contribution towards the collection of qualitative data would have served the study in extremely important ways.

6.5 Future research

In section 3.2, I discussed two categories of research namely basic research and applied research (Merriam and Tisdell, 2016). Basic research studies are concerned with intellectual curiosity to know more about a particular phenomenon (general extension of knowledge) while applied research studies, are geared towards influencing how a certain practice should operate. The findings of this study may influence administrators or policy makers to improve on language education (Merriam & Tisdell, 2016).

This study has found that pre-service teachers have difficulties with non-technical words used in the science classroom. The study therefore recommends future research on education intervention programmes on third- and fourth year students. Education intervention is meant to equip students with the needed skills, so that they can be effective in their future practice. Hence, a follow up study should be done when they go into the fields of teaching to see how their knowledge of non-technical words enhances their teaching styles. Moreover, important would be to observe on how their teaching influences the performance of the learners.

6.6. Research reflection

In this research, I have learnt that language difficulty in the science classroom is not only important but also crucial in the understanding of science content. This is based on the fact that even the pre-service science teachers experienced problems with comprehension of the meaning of these non-technical words, when presented in the classroom context. This study divulged that the issue of science language is about not only general proficiency of LOLT, but also more about proficiency in science language. It was a shocking experience to observe that all groups involved; second year-, third year- and fourth year participants had problems in selecting correct response options for the word items in the questionnaires. Failure to select the correct response options of these non-technical words suggests lack of understanding of the contextual meaning of these non-technical words as appeared in the questionnaire. Although a disturbing experience, it has turned out to be a realisation and personal learning event in terms of the significant role of science language in the training of teachers and the science teaching community as a whole. Conducting this study has been a personally worthy experience to the world of research.

However, at this point in time, I think it is not only appropriate but also valid to mention and acknowledge that the use of the MM in this research area has been very cumbersome. I felt the heavy burden of marking all the 184 questionnaires, each having 30 items and indeed with each question having 4 response options, the task of finding the mean, frequencies, correct and incorrect responses and then converting it into the respective percentages. While that was not the end of the journey, inviting the student teacher participants for interviews, especially when they were pre-occupied with assignments and preparations for exams, was even harder. In short, I have learnt tremendously, in terms of how to be involved in research and how to actualise the findings as they present themselves in black and white.

6.7 Conclusion

This study was on investigating pre-service science teachers' understanding the meaning of the non-technical words used in the science classroom context. The findings from this study have disclosed that pre-service science teachers have difficulties in telling the contextual meaning of non-technical words used in the science context. The difficulties include influence of context, lack of familiarity, connotative meaning, phonetical and graphological issues. These findings are regardless of their enrolment level and home languages. As transpired from this study, lack of teacher explanation on the contextual meaning of these words during the classroom talk has led to incorrect interpretations of these words. The main message of this study is that lack of preparation, both at school and tertiary levels, in science language, are major contributing factors in the teaching and learning of science. Since there is no component in pre-service science teachers' training regarding the science language, research outcomes from studies like this one, suggest a need to adjust the education curriculum of the science teacher accordingly.

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APPENDICES

APPENDIX A: QUESTIONNAIRE

Investigation of Meanings of Everyday Words used in the Science Context Questionnaire

This questionnaire has questions which are to find your ideas about some words used in School Science. It is not a test, so you need not worry about your answers being right or wrong. Your responses will be kept confidential and anonymous. Please supply all information requested and attempt all the questions. After finishing, please drop your questionnaire in the communal return envelope for immediate sealing.

(a) Name………………………………………………. (b) Adm. No. ………………

(c) Gender: Female ☐ **Male** ☐ (Please tick)

(d) Language used most while at:

(i) School…………………………. (ii) Home (after school)……………….……

****

Read each question carefully and think about the word that is <u>underlined</u>. Put a CIRCLE round the letter (A, B, C or D) next to the sentence or phrase that you think represents the nearest meaning of the <u>underlined</u> word.

1. The rabbit was weighed at midday on ten <u>consecutive</u> days. This means it was weighed
   A. on the first and tenth days
   B. every tenth day
   C. every day for ten days
   D. ten times every midday

2. When the stone is lowered into a beaker of water, it <u>displaces</u> some of the water. This means it
   A. reacts with some of the water
   B. pushes away some of the water
   C. gets bigger
   D. simply falls through the water to the bottom of the beaker

3. The speed <u>limit</u> for the vehicles was 40 km/h this means that vehicles could travel
   A. at exactly 40 km/h
   B. between 45 and 35 km/h
   C. at an average speed of 40 km/h
   D. at not more than 40 km/h

4. If you are asked to describe how to <u>prepare</u> oxygen, it means that you are to say
   A. the substance it is made of
   B. what it is used for
   C. how it behaves
   D. how it is made

5. The child is dehydrated. This means it has
   A. not enough water in its body
   B. too much water in its body
   C. the right amount of water in its body
   D. just drunk a lot of water

6. Animals generate heat through respiration. This means they
   A. lose heat
   B. gain heat
   C. produce heat
   D. do not need heat

7. The beam balance is a very sensitive instrument. This means that it
   A. can be used to weigh very small things
   B. can be used only by sensible people
   C. is hard to understand how it works
   D. gets spoilt very easily

8. The gas had a characteristic smell. This means the gas had a
   A. nice smell
   B. smell unlike any other
   C. strong smell
   D. bad smell

9. The soil contained a trace of potassium. This means it
   A. used to have some potassium
   B. had plants which use potassium
   C. had a very small amount of potassium
   D. had a large amount of potassium

10. Some students were studying the fundamental laws of science. This means they were studying the
   A. old laws of science
   B. most important laws of science
   C. modern and newly discovered laws of science
   D. most easily explained laws of science

11. The temperature of the liquid was constant. This means it was
   A. staying the same
   B. getting colder
   C. getting hotter
   D. getting hotter then colder

12. The experiment was to prove that the brass rod would contract when cooled. This means the rod would
   A. change colour
   B. become harder
   C. become shorter
   D. become longer

13. The explanation the student gave of the experimental results was valid. This means the explanation was
   A. well argued
   B. not correct
   C. brief
   D. very new

14. The two chemicals seemed to combine in a <u>spontaneous</u> reaction. This means the reaction
    E. was very quick
    F. happened by itself
    G. once started increased vigorously
    H. was explosive

15. The outcome of the chemical reaction depended on many <u>factors</u>. This means it depended on
    A. the method
    B. accomplishments
    C. the experimenters
    D. influences

16. Working through many exercises improved the student's <u>concept</u> of chemical bonding. This means the student's
    A. issue improved
    B. designed improved
    C. idea improved
    D. method improved

17. The class is studying the <u>diversity</u> of plant life in the school compound. This means they are looking
    A. for new kinds of plants
    B. at the variety of plants
    C. at the rate of growth of plants
    D. for plants they can eat

18. The car's movement was <u>linear</u>. This means the car
    A. moved in a straight line
    B. kept stopping and starting
    C. was dangerous
    D. swerved from side to side

19. The pupil was trying to find a chemical that would <u>retard</u> the reaction. This means the chemical would
    A. speed up the reaction
    B. make the reaction go the other way
    C. slow down the reaction
    D. give maximum yield from the reaction

20. If you were asked to find the <u>effect</u> of adding acid to a metal, this means you would try to find
    E. the reason for adding the acid
    F. the quantity of acid used
    G. how long the reaction took
    H. what happened

21. The results of three experiments were <u>consistent</u>. This means the results were
    A. variable
    B. the same
    C. adequate
    D. adjusted

22. The pupil knows the <u>function</u> of her heart. This means she knows
    A. how the heart is made up

B. what is wrong with the heart
C. what influences the heart
D. what the heart does

23. The students were asked to describe the human digestive <u>system</u>. It means they were asked to describe
    A. what humans eat
    B. what forms a balanced diet
    C. the difference between the foods human eat
    D. the link between the organs involved in breaking down the food

24. By <u>convention</u>, when writing a chemical formula, the symbol of the metal is usually written first. This means that this way of writing
    A. has been accepted as an agreed practice
    B. is a result of chemical formula
    C. was developed as metals were discovered first
    D. has been arrived at but is still not accepted by everybody

25. After studying the various conditions that may be affecting the quantity of solid produced from the reaction, the pupil concluded that the effect of pressure was <u>negligible</u>. This means that the pupil felt that pressure
    A. was the only factor operating
    B. was the most important factor
    C. need not be taken into account
    D. was the first factor to operate

26. Your science teacher said that she was going to <u>evacuate</u> the flask. This means the teacher will
    A. cool it in a vacuum
    B. close the flask
    C. clean the flask
    D. empty the flask

27. The students were able to <u>estimate</u> the volume of water in the container. This means they
    A. measured the volume carefully
    B. made a careful guess of the volume
    C. poured out some water from the container
    D. filled the container from the tap

28. People are asked to switch off light whenever they leave a room in order to <u>conserve</u> energy. This means people are asked to
    A. avoid risk of a fire
    B. make light brighter on switching on again
    C. use energy carefully to make it last
    D. not make use of the light at all

29. The tube may <u>disintegrate</u> when the reacting gases are released into it. This means the tube may
    A. break up into small pieces
    B. change colour
    C. be seen to glow
    D. collapse in on itself

30. The motion of the solid particles suspended in the water was described as <u>random</u>. This means that the motion

A. was very fast
B. had no order at all
C. was starting and stopping
D. occurred every ten seconds

Participation in Small Group Discussions

Would you be willing to take part in small group discussions of the meanings of the underlined words in this questionnaire?

Please tick one box **YES** ☐ **NO** ☐

This is the end of the questionnaire. Please check that you have answered every question.

Thank you for your time.

APPENDIX B

Wits School of Education

WITS UNIVERSITY

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

1 August 2017

Student Number: 681901

Protocol Number: 2017ECE028M

Dear Lufeyo Yohane Mpaha

Application for Ethics Clearance: Master of Education

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics clearance for your proposal entitled:

Pre-service teachers' meaning of non-technical words used in science classroom context at an English medium University in South Africa

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

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

MMabeta

Wits School of Education

011 717-3416

cc Supervisor - Prof. Samuel Oyoo

APPENDIX C

THE SEMI STRUCTURED GROUP INTERVIEW SCHEDULE

1. Have you ever heard about words e.g. sensitive, disintegrate in your studying whether at high school or at university levels?
2. Are these words important in the learning and teaching of science? If so explain in what way?
3. Do your science lecturers use these words, if so do they provide their meaning in science context? (**Whether using content or methodology classes).**
4. I have the following words **TRACE, RETARD, EFFECT** and **SENSITIVE**

   (e) TRACE: Majority answered: **Used to have some Potassium.**

   (f) RETARD: **Speed up the reaction** OR **make the reaction go the other way.**

   (g) EFFECT**: The reason for adding the acid.**

   (h) SENSITIVE: **Gets spoilt VERY easily** OR **can be used only by sensible people.**

5. How can students be helped to know the meanings of these words?

6. There some words that the participants got almost 100 %. What do you think is the reason for that e.g. Second Year students:(characteristics, constant, linear, system and negligible); Third Year students: (Conserve, System, Linear and Constant) and Fourth Year students (Dehydrate and factors)

APPENDIX D1

SECOND YEAR PARTICIPANTS DATA TABLE

No	Pre-service teachers codes: Word	Correct Answer	TOTAL NUMBER OF OPTIONS (N= 106): A	B	C	D	N/R	TOTAL	NUMBER CORRECT RESPONSES	OVERALL % PER OPTION SELECTED: A	B	C	D	N/R	NUMBER OF INCORRECT RESPONSES	PERCENTAGE INCORRECT	PERCENTAGE CORRECT	CONFUSING COMBINATIONS
1	Consecutive	C	0	3	98	5	0	106	98	0	2.83	92.45	4.716	0	8	7.547	92.45	
2	Displaces	B	2	87	2	15	0	106	87	1.886	82.08	1.886	14.15	0	19	17.92	82.08	
3	Limit	D	1	1	4	100	0	106	100	0.943	0.943	3.773	94.34	0	6	5.66	94.34	
4	Prepare	D	21	2	2	79	2	106	79	19.811	1.886	1.886	74.52	1.886	27	25.47	74.52	
5	Dehydrate	A	104	1	1	0	0	106	104	98.113	0.943	0.943	0	0	2	1.886	98.11	
6	Generate	C	5	10	89	0	2	106	89	4.716	9.433	83.96	0	1.886	17	16.04	83.96	
7	Sensitive	A	53	3	3	46	1	106	53	50	2.83	2.83	43.4	0.943	53	50	50	
8	Characteristic	B	0	99	6	0	1	106	99	0	93.4	5.66	0	0.943	7	6.603	93.4	
9	Trace	C	38	3	64	1	0	106	64	35.85	2.83	2.83	0.943	0	42	39.62	60.38	
10	Fundamental	B	5	93	6	1	1	106	93	4.716	87.74	5.66	0.943	0.943	13	12.26	87.74	
11	Constant	A	106	0	0	0	0	106	106	100	0	0	0	0	0	0	100	
12	Contract	C	10	12	76	7	1	106	76	9.433	11.32	71.7	6.603	0.943	30	28.3	71.7	
13	Valid	A	104	0	2	0	0	106	104	98.113	0	1.886	0	0	2	1.886	98.11	
14	Spontaneous	B	19	79	3	4	1	106	79	17.924	74.53	2.83	3.773	0.943	27	25.47	74.53	
15	Factors	D	4	2	4	96	0	106	96	3.773	1886	3.773	90.57	0	10	9.433	90.57	
16	Concept	C	0	0	103	3	0	106	103	0	0	97.17	2.83	0	3	2.83	97.17	
17	Diversity	B	0	105	1	0	0	106	105	0	99.06	0.943	0	0	1	0.943	99.06	
18	Linear	A	106	0	0	0	0	106	106	100	0	0	0	0	0	0	100	
19	Retard	C	17	16	68	4	1	106	68	16.037	15.09	64.15	3.77	0.943	38	35.85	64.15	
20	Effect	D	17	28	2	59	0	106	59	16.037	26.42	1.886	55.66	0	47	44.34	55.66	
21	Consistent	B	5	81	16	3	1	106	81	4.716	76.42	15.09	2.83	0.943	25	23.58	76.42	
22	Function	D	1	0	1	104	0	106	104	0.943	0	0.943	98.11	0	2	1.886	98.11	
23	System	D	0	0	0	106	0	106	106	0	0	0	100	0	0	0	100	
24	Convention	A	76	11	6	7	6	106	76	71.69	10.38	5.66	6.603	5.66	30	28.3	71.69	
25	Negligible	C	5	4	95	1	1	106	95	4.716	3.773	89.62	0.943	0.943	11	10.38	89.62	
26	Evacuate	D	6	4	10	85	1	106	85	5.66	3.773	9.433	80.19	0.943	21	19.81	80.19	
27	Estimate	B	1	101	2	2	0	106	101	0.943	95.28	1.886	1.886	0	5	4.72	95.28	
28	Conserve	C	0	0	106	0	0	106	106	0	0	100	O	0	0	0	100	
29	Disintegrate	A	87	3	2	13	1	106	87	82.08	2.83	1.886	12.26	0.943	19	17.92	82.08	
30	Random	B	1	104	0	1	0	106	104	0.943	98.11	0	0.943	0	2	1.886	98.11	

APPENDIX D2

<u>SECOND YEAR PARTICIPANTS INTERVIEW DATA</u>

Interviewer

WELCOME AND INTRODUCTION

One of the things we have been doing was to see that there are some words that are used in everyday life, but also they are used in science, you see, that’s what we did. There are words like disintegrate, words like spontaneous. So that’s what we examined. So one thing I want to know is do you think those words are important? Do they play a particular role in the learning and teaching of science?

Male Respondent

Can I answer?

Interviewer

Yes

Male Respondent

I think they are sought, cause they use the everyday word that we understand and take it into the science discipline because if you take something that you know and we use most of the time and then you take it into the science, and then now we understand better because we know the word, because the word we are using it every day, I think so.

Interviewer

But when the word is used? Yes

Female Respondent

I feel like it creates confusion because when we use it in everyday context it carries a different meaning when we use in in scientific context, that’s why you find that most learners don’t understand the word disintegrate when it is used in everyday I think context, it carry a different meaning when used in a scientific context.

Interviewer

Oh so, the meaning changes?

Respondent 2

Ja, it does change.

Interviewer

Okay… Okay.

So let us just try to look backwards.

When you were in high school and even here, when you were doing your content in the physics and the chemistry. Let us take out the methodology class of Prof. XXXX. When a teacher uses a word like displace, like disintegrate, like spontaneous, do they explain, even the lecturers, do they explain the meaning of the word? Do they say, this word means, this, this, this, this?

Do they take time to explain the meaning of the word to say this word in science is like this, this word in everyday is like this?

Do they do that?

Yes.

Female Respondent

Okay, like on a perspective at school, neh, they didn't like explain the difference between the everyday knowledge and the school knowledge. They just introduced… okay there's the cells. Like they won't tell the difference between like the cell that they use as an everyday term and the one that they, we use at school, so there's no difference (***Pause).*** Ja, there's no difference

(Pause)

And as I was saying, there's no difference, and for me also I can say like everyday concept they are important at the same time they are not important because we're taught at school that the cell is, in physics, it's, it's ahhh, half a battery or the unit that produces electrical current, but when it goes to everyday life, a cell is that unit that they keep, ummh, prisoner in, still it won't change the meaning. It won't change, a cell is a cell, when you live it at the school but when you come here at home when you talk about a cell, we talk of that one in prison and not the one at school.

Interviewer

Mmmh, okay

Okay, okay. So there is that change of meaning?

Respondents

Ja, yes.

Interviewer

All right

Now, there is some words normally that I sampled out, that people used them. They were used in the questionnaire. I think we did this with Prof. This questionnaire, remember?

Respondents

(Approve)

Interviewer

That we filled there. I was around I think.

So there are some words that I chose from this questionnaire and then we want to see how they were reasoned out. The first word here is the word Trace (spelt out as T.R.A.C.E), the word was used as follows "The soil contains a trace of potassium", this means, it used to have some potassium, had plants which use potassium, had a very small amount of potassium, had a large amount of potassium.

So many people they chose, it used to have some potassium, and others they say had a large amount of potassium.

So you're like people who have done this everyday words, the word is TRACE, but this are the options and somebody said, If the sentence said the soil contains the trace of potassium, it means it used to have some potassium.

What do you think can be the reasoning behind that?

Female Respondent

Biology, maybe?

Interviewer

Biology

Mmh, what about Biology?

Female Respondent

When something has got a trace, like it used to, so I think it's from, maybe it's someone put in Biology chose that answer.

Interviewer

Mmh, how is it used in Biology? The word trace.

Female Respondent

Can anyone help me?

Interviewer

Mmh, give examples of how the word trace is used in Biology?
Or when does it appear, when we are talking about what in Biology?

Female Respondent

When we are doing fossils?

Other Respondents

Ja, fossils.

Interviewer

When talking about the fossils?

Female Respondent

Yes, tracing of fossils.

Respondent

Fossils

Interviewer

Ok, trace, all right

And if a person chose to say it had a large amount of potassium, what do you think can be the reason behind?
They said the soil contain a trace of potassium. This means it had a large amount of potassium.
What do you think can be the reason?

Pause

Female Respondent
I think that's… that, that one is from the everyday context of trace whereby you say when something has got a trace it contains that thing.

Interviewer
Mmh, so they trace something.

Female Respondent
Another thing we said that, she mentioned Biology where we say trace is used when we talk about fossils. So if they gonna find traces of, let me say, a bone of a dinosaur somewhere here, it means it used to live here. So that person might have that impression that it used to have the large amount of, of, of sodium and then due to time it was depleted. So yeah, that's why they found smaller traces of that so it shows that it used to be there. Ja, so I think.

Interviewer
Okay, all right, anyone, from the word trace?
Okay, the second word that I chose was retard (spelt out as R.E.T.A.R.D).
So the word was used in this sentence said "The learner was trying to find a chemical that would retard the reaction.''
And they said this means, it would speed up the reaction that's (a),
(b) it make the reaction go the other way,
(c) it will slow down the reaction and
(d) it gives maximum yield from the reaction.
So those are the option, but the most important word we are concentrating is
Interviewer & Respondents
Retard

Interviewer

But, so, some people they wrote that if you do use the word retard in this sentence, it means it will speed up the reaction or it makes the reaction go the other way.

So, *(Pause)*… what is your take on that?
Or what can be the right word for you to say I think the answer to that word is this one.
If they say the "The learner was trying to find a chemical that would retard the reaction.''

Female Respondent

Okay, I think retard like it makes the reaction go other way, because from what Professor XXXX taught us in Physics, he said we shouldn't say the car decelerates but it retards, if I remember well, so meaning it goes opposite direction.

Interviewer

Retard is opposite direction.
Yes

Female Respondent

From the everyday context retard would mean slow, if I'm correct. So the answer there, if I'm correct, that learner was looking for a chemical that would slow down the reaction.

Interviewer

So that would be the correct answer?

Female Respondent

For me, since retard means to be slow.

Interviewer

So, for the learner who said it makes the reaction to go the other way, what do you think will be the thinking behind, with your explanation of slow?

Female Respondent

Okay, so we are a group right, so majority of you are fast learners, and then I'm slow. You guys are doing one thing and then I'm diverting from you guys so perhaps that learner would have….

Interviewer *(intercepts)*
So you'd be doing the other thing?

Female Respondent *(continues)*
….Ja, instead of doing what you guys are doing, I'm doing something else. That would be the explanation of that. I don't know, I'm just…..

Interviewer
Mmh, okay mmhh.
Anyone?
You don't need to think a lot about it, you just….
That's why I said it's an engagement.
By the end of 15 minutes it will be over, we're about almost to finish.
Okay, the other word I chose is EFFECT.
It said if you were asked to find the effect of adding acid to a metal, this means you'd find the reason for adding the acid, the quantity of acid used and how long the reaction took or, what happened.
So those are the four answers
The effect of adding acid to a metal means the reason for adding the acid, the quantity of acid used and how long the reaction took or, what happened.
So we use the word effect in Science, so what do you think was…..
Some people they wrote when you say effect it means the reason for adding the acid.
Or in the first place what would be your answers?

Female Respondent
How long the reaction took, I think.
Interviewer
The effect would be how long the reaction took, okay.
Why?
Female Respondents

The last one.

Interviewer

The last one?

Errr, what happened?

Female Respondent

Yes

Interviewer

What happened, Okay.

Who else?

Male Respondent

I think it's how; it's what happened because it's a result, the effect, yes.

Interviewer

Okay, but if the person says the reason for adding the acid is.

Male Respondent

Eish, okay.

Can you read the question again?

Interviewer

If you were asked to find the effect of adding acid to a metal, this means you'd try to find the reason for adding the acid, the quantity of acid used, how long the reaction took and what happened.

Male Respondent

I don't think it's the reason.

Interviewer

It's not the reason?

Male Respondent

Yes, because already the effect, they want to find reasons, so we can’t say the reasons again.

Interviewer

So according to you the answer would be?

Male Respondent

The last one

Interviewer

What happened?

Male Respondent

Yes

Interviewer

Yes, and you also.

Female Respondent

Aaah, yes.

I would say if a person doesn’t really know the meaning of effect, then he or she will probably choose the wrong answer.

Interviewer

Mmh

Female Respondent

Yeah.

Interviewer

Okay

Female Respondent

But sometimes I feel like it's not necessarily about knowing the, the, the meaning of the word because we come across, like everyday life, we come across different meanings. So I might have a certain meaning, she might have a certain meaning of effect and when we're answering that question, it would probably be different.

Interviewer

Oh, depending if you're experienced with the word?

Female Respondent

Ja, depending on the experience, everyday experience.

Interviewer

Mmh, so in your case what would you choose from the four answers?

Female Respondent

Well I would go with the last one because, it's about, like, giving the end reason, what caused the effect

Interviewer

Mmm, okay… All right

Okay, and then, the other word that I chose was I think the last one is a very famous one, Sensitive.

It says "The beam balance is a very sensitive instrument.

That's the statement.

Then there are four answers to that. It means

(a) Can be used to weigh very small things, (b) can be used only by sensible people, and (c) it is hard to understand how it works and (d) it gets spoiled very easily.

Female Respondent

What was the first one?

Interviewer

The first one? The first one says it can be used to weigh very small things, that's the first one, the second one can be used only by sensible people, the third, it's hard to understand how it works and the, the last one it gets spoiled very easily.

Female Respondent

Okay, I would go with the last one.

Interviewer

You would go with the last one?

It gets spoiled easily.

Female Respondent

Yes

Because from everyday knowledge, when you say like, my skin is sensitive to the sun, like the meaning, like, obvious if like the skin can get spoiled easily, or, I don't know which term to use. Something like that, so whoever chose that number (d) I agree with.

Interviewer

You agree with number (d)

Female Respondent

From the everyday knowledge.

Interviewer

From the everyday knowledge, but is that the also same in science, according the statement, the way you look at it.

Female Respondent

Sort of

Interviewer

You.

Hands first.

Okay, let's start this side,

Female Respondent

No, she can talk.

Female Respondent

From Science, I think (a) is the correct one, because, obviously it's an instrument and if it's sensitive it can only weigh other things, smaller things, not things with a larger mass.

But from an everyday knowledge, like, of the word (d) is correct.

Interviewer

The (d) is correct?

Aah, okay

So what you are telling me that there is the same word it has a meaning in the everyday life, but now it comes to this side.

Respondents

Science language.

Female respondent

It carries a different meaning.

Interviewer

It carries a different meaning?

Male Respondent

Because that sensitive means, it can sense anything that is very small.

That sensitive doesn't mean with a scale you must be careful when you use it means it can sense anything that is very small.

It can just count, for instance.

Interviewer

And there are some words here, the words like CONSERVE, SYSTEM, FACTORS, DEHYDRATE, LINEAR and CONSTANT.

Most people *(inaudible)*

What do you think can be the reason?

What's so special about these words?

Yes.

Female Respondent

I think the science meanings of the words are more less the same with the everyday meaning of the words, so that's why people got it correct.

Interviewer

So, the moment you just pick up the answer, automatically it applies both science and everyday meaning.

Female Respondent

Yes

Interviewer

Bathin' abanye?

What do others say?

Male Respondent

Angizwa kahle.

Angithi sithe masichaza i, these words, when we take them from every day they change to science language, so I don't understand why it will be the same because for instance if you underst… ok… let me not go to examples. But as we, we stated first, neh, about the meaning of the words that iyachinja ngapha.

Aay angazi, can you explain, I don't understand.

Female Respondent

Some words they carry a different meaning when used in the everyday context than when used in a science context.

So now what she was saying I agree with that, the word linear means in a straight line, so it carries the same meaning? Linear in everyday is straight line; it's the synonym for straight line. So that's that.

Interviewer

So even when it goes to science it doesn't change?

Female Respondent

It doesn't change, because we talk about a straight line, something which is straight.

Interviewer

You guys Arrr, when you are doing science in high school particular, was the teacher, were the teachers explaining this words?

Female Respondent

No, they were just using the textbooks to explain the words.

(Intercepts)

They assumed as if they knew, ja

They were just using the textbook

Interviewer

What do you mean they were just using it?

They were reading the text book?

Female Respondent

No, no, they were using the meaning of the textbook, the meaning of science without considering the everyday knowledge.

Interviewer

Oh, they just give that according to what is given in science?

Female Respondent

According to science.

Female Respondent

Because sometimes my teachers used to say, when you ask questions, like, but we don't understand this term, that's how it is. They don't relate the term to the everyday learning.

Interviewer

Okay

Now we have seen these words, the words like retard, effect, sensitive, they are kind of; live a chameleon character, isn't it? This side they present something, this side also they come.

So you guys, you are in the system of learning. How can you, what can you suggest be done in order to help the students understand these words, because I've seen that these words they cause a bit of problem in terms of how you understand it in everyday life and how you understand in class.

So what can be done to help the students to understand it, such kind of words?

Female Respondent

I think as a teacher, because we become teachers right, so as a teacher you should first explain the everyday meaning of the term and then bring it to the classroom, explain the school knowledge term of the, like meaning of the term. That's how you can now give the kids the distinction between the everyday and the school. Sometimes cause, what we have learnt here is that every day it's like school knowledge built up from everyday life, so in that case I don't understand because some words totally carries a different meaning, you can't relate them to classroom knowledge, so how are we going to deal with such a situation because we say a school knowledge builds up on everyday knowledge and everyday terms.

Female Respondent

To add on what she said we said that school knowledge builds up from everyday knowledge. We as teachers we're not there to actually eliminate what the learners know, so we're there to rectify it, it's like a misconception we know these words from the everyday context, but when we're in science this is what it means. I'm not saying forget about it I'm just rectifying it. You find that a learner understands the question, but because there is a word he or she understand it from a different context, so when they apply it to science it doesn't make sense. They know the answer but how to tackle it because there's that everyday word, so they get disturbed by that. So we as teachers we're not there to just say take this, but we're there to correct it.

Interviewer

So can we say these words can contribute to the performance of learners?

You guys are going to the fields to teach, sooner than later, do you think understanding of these words can contribute to the performance of the learners? Or in the understanding of physics?

Female Respondent

Understanding the…?

Interviewer

The everyday words, the use of everyday word in science context, do you think it can contribute to the performance of learners during tests, exam?

Female Respondent

I think it can, I also think it cannot.

Interviewer

Ja, explain yourself.

Female Respondent

So, like she said, that knowing the term from the everyday it makes it easy for you to actually apply it in the school context, but me saying that, it cannot, it confuses the kids. So basically I think what is learnt at home should stay at home.

Let’s say the kids are the middle class, and the working class, they don’t have the same meaning we make, like we have different meanings to them. Maybe like someone form the middle class will have a different meaning and someone from the working class will have a different meaning of the word.

Female Respondent

Coming to that, middle class children have a different meaning to that. I am a teacher so I would prefer using the constructivist approach so we have the learner, I gather them and their prior knowledge then from there I start to actually rectify. She knows something, she knows something, she knows something, and they are different, so I as a teacher I come in and I correct it.

Interviewer

Okay guys. Thank you very much, as I mentioned that it will not be a long thing, that's the end of the interview on the words and I thank you for respecting my invitation when I requested you and for coming and participating meaningfully to the interview. Thank you very much.

……..………………………..**END OF THE INTERVIEW SESSION**

APPENDIX E1

THIRD YEAR PARTICIPANTS DATA TABLE

Pre-service teachers codes		Correct Answer	TOTAL NUMBER OF OPTIONS (N= 40)					TOTAL	NUMBER CORRECT RESPONSES	OVERALL % PER OPTION SELECTED					NUMBER OF INCORRECT RESPONSES	PERCENTAGE INCORRECT	PERCENTAGE CORRECT	CONFUSING COMBINATIONS
No	Word		A	B	C	D	N/R			A	B	C	D	N/R				
1	Consecutive	C	1	1	33	5	0	40	33	2.5	2.5	82.5	12.5	0	7	17.5	82.5	
2	Displaces	B	2	31	0	7	0	40	31	5	77.5	0	17.5	0	9	22.5	77.5	
3	Limit	D	0	0	9	31	0	40	31	0	0	22.5	77.5	0	9	22.5	77.5	
4	Prepare	D	7	0	3	30	0	40	30	17.5	0	7.5	75	0	10	25	75	
5	Dehydrate	A	39	1	0	0	0	40	39	97.5	2.5	0	0	0	1	2.5	97.5	
6	Generate	C	3	2	35	0	0	40	35	7.5	5	87.5	0	0	5	12.5	87.5	
7	Sensitive	A	14	2	1	23	0	40	14	35	5	2.5	57.5	0	26	65	35	
8	Characteristic	B	0	40	0	0	0	40	40	0	100	0	0	0	0	0	100	
9	Trace	C	16	2	22	0	0	40	22	40	5	55	0	0	18	45	55	
10	Fundamental	B	2	31	2	5	0	40	31	5	77.5	5	12.5	0	9	22.5	77.5	
11	Constant	A	40	0	0	0	0	40	40	100	0	0	0	0	0	0	100	
12	Contract	C	1	7	32	0	0	40	32	2.5	17.5	80	0	0	8	20	80	
13	Valid	A	38	0	2	0	0	40	38	95	0	5	0	0	2	5	95	
14	Spontaneous	B	5	34	1	0	0	40	34	12.5	85	2.5	0	0	6	15	85	
15	Factors	D	3	0	4	33	0	40	33	7.5	0	10	82.5	0	7	17.5	82.5	
16	Concept	C	1	0	38	1	0	40	38	2.5	0	95	2.5	0	2	5	95	
17	Diversity	B	1	39	0	0	0	40	39	2.5	97.5	0	0	0	1	2.5	97.5	
18	Linear	A	40	0	0	0	0	40	40	100	0	0	0	0	0	0	100	
19	Retard	C	9	6	21	4	0	40	21	22.5	15	52.5	10	0	19	47.5	52.5	
20	Effect	D	7	3	0	30	0	40	30	17.5	7.5	0	75	0	10	25	75	
21	Consistent	B	0	33	6	0	1	40	33	0	82.5	15	0	2.5	7	17.5	82.5	
22	Function	D	0	0	1	39	0	40	39	0	0	2.5	97.5	0	1	2.5	97.5	
23	System	D	0	0	0	40	0	40	40	0	0	0	100	0	0	0	100	
24	Convention	A	29	6	3	2	0	40	29	72.5	15	7.5	5	0	11	27.5	72.5	
25	Negligible	C	0	0	40	0	0	40	40	0	0	100	0	0	0	0	100	
26	Evacuate	D	0	3	3	34	0	40	34	0	7.5	7.5	85	0	6	15	85	
27	Estimate	B	4	35	1	0	0	40	35	10	87.5	2.5	0	0	5	12.5	87.5	
28	Conserve	C	1	0	39	0	0	40	39	2.5	0	97.5	0	0	1	2.5	97.5	
29	Disintegrate	A	32	8	0	0	0	40	32	80	20	0	0	0	8	20	80	
30	Random	B	0	39	1	0	0	40	39	0	97.5	2.5	0	0	1	2.5	97.5	

APPENDIX E2:

THIRD YEAR PARTICIPANTS INTERVIEW DATA

Female Respondent

They play for being technical terms; they also play for being analytical terms, because there is technicality in these words. In the sense classroom you can't use them as if you are using them in a different, the language of, I don't if I'm making sense. Can someone ***(inaudible).***

Female Respondent

If you look at science as a language, you can define science in different forms, so as per course, this course, we'll define science as a learning of a new language, then those words become important because then the learners now understand that they are not just learning ideas or phenomenal, like what happens like what, they understand ukuthi now we are learning a language and if I know that and if I am in an English class and I use disintegrate in a certain way it's language, English is a language. You read the dictionary, you see disintegrate means that, now, when I'm in a science class because I'm learning a new language, for me to learn the sub-concepts under disintegrate or the ideas about disintegrate, I have to first know what disintegrate means in the science context. So if you look at the learning of words in terms of learning of a language then they are very important because you as the teacher, you will raise awareness to the learners that disintegrate, I'm aware that you might have this preconception of disintegrate from your everyday language, from life sciences or from wherever, but now because we are in a science class, when we talk about disintegrate, we are referring to these, and these are the ideas about disintegrate. So if you look at it like that, then it's very important and you as the teacher you also raise awareness of the contextual meaning of the terms. Once the learners appreciate and understand that there is a science context, there's an English context, there's a Life Sciences context, there's a maths context then I think Mathematics, I think then your teaching will differ in a sense and make more sense.

Female Respondent

Just to add on what she said, technical words or non-technical words don't exist ***(inaudible),*** so basically teachers have to also explain the meaning of the words in order for the learners to understand the concept.

Male Respondent

Yes, can I emphasize on what she's saying, it's the idea that you normally have ***(inaudible)***

The only reason why we use the language is because we want to emphasize, we want to create an idea, try something that is meaningful, try something that they are familiar with, which is the area of language into classroom language, however ***(inaudible).*** However, this everyday language is just a tool that helps us to make sure that our learners are on the same page. However, that is not the juice of the cause of the cause of talking about general knowledge ***(inaudible)*** because, I feel like as leaders to the science context ***(inaudible)*** there's actually a way that they can link to each other. So don't we say disintegrate in life sciences and in physics doesn't disrupt the thinking of these kids.

Female Respondent

Well, It's just what XXXX has said that you just need to put an emphasis on the contextual meaning of the word, so maybe in life sciences it had its own meaning but then there's a shift in discipline, therefore we need to put the emphasis on the shift from one form to another then you put the correct meaning of what it means, therefore, in that particular concept so it's just shifting it in respect to the field itself or the discipline.

Female Respondent

Every subject is a language. English is a language, science is a language. So as much as we might have compound in Mathematics as an interest, in physical sciences we also have compound, but these two words mean different things. For compound interest it talks about something else in mathematics, in science, because I remember when I was teaching, experience teaching about compound interest they gave me a science definition. I asked them, what does the word compound mean, and they gave me a science definition so as a teacher it's important, oh okay, maths is science as well, to some extent, but then in physical sciences as a teacher it's important for you to highlight in the beginning of every new topic that these are the terms that we have in other fields, but here in the physics or maybe in the physics component when we're talking about reaction because even in the physical sciences as a whole reaction speed it and reaction in chemistry means two different things.

So it's important for you as a teacher to highlight that these are the words we have in physics but here they mean something else so that the learners will be able to understand the content that you are trying to teach because if the learner comes to class, you're doing mechanics and you talk about reaction about forces and everything else and you just taught the learner about chemical reaction. A learner, because it's a learner, they might take whatever the definition you told them before and they can argue that mam, that's what you said, you said reaction in chemistry is, you said reaction in other lesson is, and now you're telling us it's different.

So for you to avoid such misconceptions and everything it's important for you to highlight the meaning of the lesson, these are terms before you can do this, at the beginning of the lesson but introducing a new topic you can say "This is the terminology that we're going to use, go home, find the definition of this term within this content and see what the learners will bring, and I'm sure, If those learners are doing grade 10, they'll come up with some definitions that are English, like reaction in English, and people react to feelings and everything else. So from that you can be able to see the misconception and misconceptions are a way of learning but as teacher we have to address them as it's gonna help in understanding.

Interviewer

***(inaudible)*.. When you are doing content, was these words explained, when teachers were teaching physics, do they explain that this is the meaning?**

Female Respondent

Well, they are under the assumption that it's a physics class; therefore, it's just that we are supposed to think of it in this way. However, it's like that we still come up with our definitions from what we know and start applying them like that, but then with the progress of the course then you come to meaning that oh okay, this is what it means therefore in this context.

Interviewer

Oh, so you learn when you're on it?

Female Respondent

Yes

Female Respondent

I wouldn't say that they were not explained, the teachers did, they were defined, and then after defining the teacher explains the concept, so we can't really say they were not explained. The argument here is that did the teachers link our preconceptions of this concept with the science conceptions, you see.

So the argument there is that the teachers didn't use what we already, the ideas that we already had about the concept, to introduce the science concept. Some writers said that in teaching science, of a science term, you must create dissatisfaction in the child's mind about the conception that they have about that conception, and after having created that dissatisfaction you are provoking the child to think about what is it that they think they know about the concept.

Having thought about what they think they know about the concept already, you are making them see that the definition or the understanding of this science term or this term is not narrow, there is also other ways of looking at this concept and once you open up that there's other ways of defining this concept in the learner, then it's easy for you to tell them that okay in science you can look at this term like that and if you present the writer further says "If you now having created the dissatisfaction and then you introduce or you make the new understanding of the term to be more meaningful or more fruitful " that new understanding will stay in the learner. So the teachers failed to create that dissatisfaction that we had about the terms, they just gave us the definition and the alternate understanding of the term because we did not question ourselves about the understanding that we had about the terms, it became difficult for the new conception to stay, and that's what the theory of teaching concept came ***(inaudible)..***

Male Respondent

(inaudible).. We are under assumption that when we are inside the class, we should expect and even talk about reaction to these learners. So teachers here in varsity or when we are teaching there in high school, you have that thing that, because you know I'm a science educator, I don't have to explain English to these kids, even though in some cases they see the other point in some cases being explained where a particular term or concept comes forward, however, it's not ever the case, the problem comes when a particular term or concept creates a misconception in class where they don't understand. When you are marking you see that okay, these learners I see now, they didn't understand what I mean ***(inaudible)***. You have to explain it scientifically; it's not about our feelings. Sometimes when we mark or teachers' mark it's all like oohh, there is the bridge of the language ***(inaudible)..***

Female Respondent

But then we have a problem here, when we're coming to Wits, especially when we did NS1 or whatever, they never did what you're saying there like integrating and whatever, but when you register for this course they don't tell you that even if you did Life Science you can take NS and then you get into a chemistry class they'll say they will teach you, then you learn. You get into a chemistry class then you have these words of disintegrate and whatever. In this thing of yours Life Science, you didn't do physics in school, now you are here for Life Science for NS that carries two components, physics and what not. That's why you find that we have the highest rate for NS2, there's no one who fails here like NS2, we fail that thing. People go there with a perception that they will be taught Physics, they get there, we're only taught. They don't even say reaction, reaction they are feelings, the what not, they just get straight to point of just saying physical science is this. That's why now we find that ey, we're failing mos.

Interviewer

Okay, the last one on that point.

Female Respondent

In some cases, I think that ***(inaudible)*** like the context, just like us ***(inaudible)*.*.** high school, they didn't tell us that reaction in its context means this and in English it means that, somehow we get it out when we're going through, so that's why I say its embedded in a context. Sometimes you don't really need to go through text picking up the terms and you know.

Male Respondent

You don't.

Male Respondent

Teach science, focus on the science, forget about teaching English.

Female Respondent

Ja, teach science.

(Inaudible)

Male Respondent

It can actually be like the one of gravity. You cannot just say, when you talk you just say he's a fundi, no guys.

In a scientific manner you have to talk about gravity is a force of preventing you to fall.

the use of the language of teaching and learning.

Female Respondent

But how do they understand that falling and whatever and the force and what, through?

Male Respondent

That's why we have to go back to the original menu which was the science language.

Interviewer

Okay, let us move forward.

I sampled some of the words that you did *(inaudible)*.. So I'm talking about generally they are some words that cause of bit of *(inaudible)*..

So the first word that I would like to examine is the word TRACE, the way it was used, they say that "the soil contains a trace of potassium" this means, it used to have some potassium, it had plants which use potassium, it had a very small amount of potassium, it had a large amount of potassium. So most of the people who reacted to this question they got to say it used to have some potassium.

Female Respondent

Mmhhh, which is correct

Interviewer

And there are other people who put it that it had a large amount of potassium. That's how the answers were put. So the word, the key word in this sentence is TRACE. So I want to say how would you reason, how would you argue or try to back the person who says it used to have some potassium?

The thinking behind?

Male Respondent

The thinking behind it would go to English term of trace. When something, let's say we're tracing something, it means something was here. There's an area or maybe there's a piece that something stepped on here, a particular person but this person is not there, but he left their trace here, and it's in a particular position now. So in that case you can say it's like, no, there used to be something but you can see a trace, but the percentage is not huge, if it was there we were going to say we can see that there's potassium but we can see that somehow this chemical or in this reaction or whatever, there was a particular thing but in a science context we can say, it's little maybe because there was like 99% of another.

Female Respondents

I want to say that it comes from the characteristics of ***(inaudible)*..** when it says it used to be here but it's no longer there, what that element that used to be here, has left a small characteristic, that's when you detect whatever that soil had characteristics of potassium in that place, whereas potassium is no longer there.

Female Responded

Umm, Okay. You said that the people opted for there was a large amount of potassium.

Interviewer

Oh, Ja, but the answers were it used to have some potassium, another one (b) had plants that used the potassium and (c) had a very small amount of potassium and (d) had a large amount of potassium. So those are the …….

Female Respondent

Arrr, so the answer there is that it has the small amount of potassium and from what they have said, when you say that there is a trace of something it means that that something was there and then moved and left evidence of its presence there. Now someone may have chosen that there was a large amount of that thing, if you remember errr, Life Sciences, when we do evolution, we trace, errr, we say it's a trace of the existence of those things. So that tree there, they talk to us about, umm, trace of existence basically.

So let's say I am a learner, I will say it does not mean that the apes were small, you see. The apes were there. I am trying to reason for someone who is going to say there was a big amount of potassium. The giants, what are they, the dinosaurs. The dinosaurs were there, it does not mean the dinosaurs were small, you see, but now they are not there. So if I say that there was a large amount of dinosaurs, the potassium was dinosaurs for example, and then I say there was a large amount of dinosaurs, I am not wrong, because according to my understanding from Life Sciences a trace means existence of something.

Interviewer

So the way you react to the word, it depends with this thing that (inaudible)..

Female Respondent

Yes it depends on what concept you internalized or what understanding you internalized of the word trace.

Interviewer

Thank you very much

Female Respondent

I think they have a problem.

Interviewer

You want to add?

Female Respondent

Okay to add what Sandra was saying is that trace, sometimes you can trace something because of its amount, some things that are small they are hard to trace, so maybe in large quantities that's when you can see that something was here. So maybe in terms of quantities when it's small, like you can't really be sure about that, like when something is big or in large amounts therefore you can really trace or see that ja, it was here.

Interviewer

So the remains tell you how much it was?

Female Respondent

Yes, so maybe, not really. Okay, I'm trying to say that for someone saying that it has large amounts, so maybe it might be the conception that you can trace something that is big, but not really small because, but it might that small that I cannot see it.

Male Respondent

The issue here would be the sentence there "it has" it didn't say it had.

Interviewer / Female Respondent

No it had,

Interviewer

But the emphasis is on the trace

Male Respondent

The emphasis is on the trace, so I'd argue, okay its fine.

Male Respondent

Maybe I'm having a problem with understanding the English language because the way the statement is like, if it was, we say like has the large amount of this whatever, wouldn't the statement be like the soil contains……

Male Respondent *(intercepts)*

Yes, that's the thing, wouldn't it be like

Male Respondent *(continues)*

The soil is made up of……

Male Respondent

Because now we are talking about trace, it means something that was there, now it's gone.

Male Respondent

We cannot say it's huge.

Female Respondents

That's the physics, that's the understanding, that's the correct reasoning, but we are trying to reason for someone else who chose the other thing and think about this. You know that when you were drawing in high school, and you couldn't draw, what did you do?

Other Respondents

Trace.

Female respondent

You were tracing right. The trace diagram is not small from the original diagram, it's the same size. So I can't say because now I have traced this thing and it's here and then the original diagram is not there, then I say it means that the diagram was small.

Male Respondent

So here the issue is the context.

Female Respondent

The issue is how you understand trace.

Interviewer

Ja, that's the issue. Thank you. Let's go to the next word. The next word I sampled out was RETARD (spelt out as R.E.T.A.R.D). So it goes like this "The learner was trying to find a chemical that would retard the reaction.''

This means that the chemical would speed up the reaction that's (a),

(b) It will make the reaction go the other way.

(c) It will slow down the reaction and

(d) It gives maximum yield from the reaction.

So the answers that I have that were popular we have here

It would speed up the reaction, and (b) it would make the reaction go the other way.

Male Respondent

No, no. All of them they are correct

Interviewer

All of them are correct?

But in terms of someone who chose to say it will make the reaction go the other way, what would you think they're thinking?

Female Respondent

Arrr, okay. For me I understand that a retarded person is a person who just thinks……

Male Respondent *(intercepts)*

Slow.

Female Respondent *(continues)*

….. does things of their own, you see. That's my understanding. It's like basically someone who is dumb. If they say to class, they say everyone in class, they say fill in whatever that is happening and then they say three and then they leave the operation symbol empty then they say three, and then there they write six per, perhaps. The normal ones what are they going to say? They are going to put plus, isn't it? And then the retarded ones they will just put other things, you see. So I am not wrong when I say retard, you are going the other way because then you are opposing normality if you, you are retarded, So, ja.

Interviewer

Arrr, the ones that said it speeds up the reaction?

Female Respondent

Aay, aay, I don't understand that one.

And in most cases retarded children it's like those children who are slow academically, but when you take them outside the classroom, it's not the same thing, they are very street smart, if you can put it like that. Again if I say there it is going to speed up, then I can take a retard and say a retard outside the classroom is fast.

A retarded person is someone, to us as teachers, is someone who is slow in books, and in reality, those children, they are the sporty ones, you see. They are the gamblers, the tsotsis, you see. They are smart outside, they are very fast.

Male Respondent

When you are retarded it's like symptoms. Someone who is lazy in all aspects, it doesn't matter that you are academically so. To me in my understanding, when we talk about retard, we talk normally like older people, or someone who has a disorder. Those who are really really struggling and we know when this person is retarded, you can say run and they'll be like….., bala, write something, they don't want or they are doing their own things, that's why you'll be like, aay this one.

Female Respondent

I think because we are talking in the context of teaching, hence I' m saying as a teacher when you say a child is retarded, you are usually referring to their academic performance, so…

Interviewer

So this goes the other word that I found was EFFECT (spelt out as E.F.F.E.C.T). If you were asked to find the effect of adding acid to a metal, this means that you would try to find the reason for adding the acid, the quantity of the acid used, how long the reaction took or (d) what happened. So the word, the key word is effect.

Female Respondent

Please reread the options again.

Interviewer

If you were asked to find the effect of adding acid to a metal, this means that you would try to find the reason for adding the acid, the quantity of the acid used, how long the reaction took or what happened.

Female Respondent

At this point, okay, in my head, the word effect is synonymous to purpose *(inaudible)*..

Interviewer

So many people they put, the reason for adding the acid.

Female Respondent

(Inaudible).. the consequence of something happening and the reasoning behind it.
So in a way this word kind of have a lot of meaning, and that confuses learners, it also confuses everybody like I'm forced to choose between (a) and (d), I'm not really sure which is it because I'm thinking these are more like one and the same thing.

Male Respondent

So the fact here is what is the effect of adding that, what is the purpose of adding that, what is the effect?

Female Respondent

In this case you are saying that effect is synonymous to purpose?

Male Respondent

That's what I'm saying, what is the effect of adding this there, what is the purpose of trying to be here?

Female Respondent

Oh, Okay

Interviewer

What is the purpose of being here, what is the effect of being here?

Male Respondent

Ja, I'm saying that, I'm saying it like that what is the purpose of adding this in that specifically.

Interviewer

What is the effect of adding acid to the reaction or to a metal?

Female Respondent

The fact that they put the statement as it has not yet been added, the whatever that is being added; it has not yet been added. Someone can understand that because I want to add something, why do I want to add it, hence they will say what is the purpose, but if they had said put it like it has already happened…….

Female Respondent *(intercepts)*

What was the effect?

Female Respondent (continues)

…..What was the effect, you see. It's easy to reason that it's how long, but because they are saying what is the effect

Interviewer

We say if you were asked to find the effect of adding acid to a metal, this means that you would try to find the reason for adding the acid that's (a), (b) the quantity of the acid used, and (c) how long the reaction took, and (d) what happened. That's the option that *(inaudible)*..

Female respondent

You are saying that people opted for (a).

Interviewer

Yes, ja.

Female Respondent

Reason for, yes if they had put it like already it has happened, then it would be easy for people to look at the effect as consequence after, not purpose.

Interviewer

Okay

Male Respondent

But in reality, in our sober minds, you have to take what happens, because we want that, we don't want the results….

Female respondent *(intercepts)*

We want the results

Male Respondent *(continues)*

….not necessarily because they say if and then it's like we want the effect what would happen. Ja, but now it's like I understand the other part but in our sober mind, we have to pick the other one.

Female Respondent

Mara you remember, when we did error analysis. They said that when you are looking at the responses that learners give, you don't focus on how many got the right one, you focus on how many got a wrong one, and what could be the possible reasons for that, so that you can improve your teaching. So if we look at it like a normal person is going to choose this, so when you're teaching, you'll be teaching only to a normal person.

Male Respondent

It makes sense because these are student teachers, so it means that….

Female Respondent *(intercepts)*

A lot is wrong

Male Respondent *(continues)*

….There's a reason why. I'm sure all of you, you're here, you chose that.

Interviewer

Okay, let's go to the other word. The other word is *SENSITIVE*. I think that is a word you use every time. So the beam balance is a very sensitive instrument, this means that it can be used to weigh very small things, it can only be used by sensible people, it is hard to understand how it works, and the other one says it gets spoiled very easily. I think most of the answers were around, it gets spoiled very easily**.**

Female Respondent

It can be used by sensitive people?

Interviewer

It can be used by sensitive people; no it says it can be used by sensible people.

Female Respondent

Sensible?

Female Respondent

Yes

Interviewer

Ja, give the explanation for that.

Female Respondent

Let's come again with the responses.

Interviewer

The beam, you know the beam balance, the one we use in the lab. The beam balance is a very sensitive instrument, this means that it can be used to weigh very small things, it can be used only by sensible people, it is hard to understand how it works, or it gets spoiled very easily.

Female Respondent

I think the reasoning behind that, getting it spoiled very easily because if a person is sensitive, right, you can't just joke, they are very fragile, they are easily, you know, taunted and stuff. So, ja that's why people might think that it's sensitive and it can get spoiled easily.

Interviewer

So it's from the everyday life.

Female Respondent

Everyday life that you view someone or a sensitive person as someone who is very ***(inaudible)…***

Male Respondent

I choose (a)

Female Respondent

Ja, (a) is the correct one, weighs a very small thing.

Female Respondent

I choose it can be used by sensible people.

Interviewer / Respondents

Why?

Female Respondent

Because sensitive, is a synonym of sensible in English, so the learner just decided it can be used by sensitive people. Sensible and sensitive they are sound alike and look alike, yes.

Interviewer

Because it’s sensitive it can be used by sensible?

Female Respondent

By sensitive people. Sensible can mean reasoning and it can also mean sensitive, so that fact that it’s sensitive it can be used by sensible people.

Interviewer

Okay, that’s your understanding?

Female Respondent

Yes

Interviewer

Okay, anybody else

Yes

Female Respondent

For me I’d go with (d), I’d agree more with (d), because something sensitive is something which is fragile, which is easily damaged, like, which reacts very quickly to slightly changes of the environment or whatever the case. So, I’d go for (d), although the fact that they used the word spoiled in a way which is very sensitive, which is very important for teachers to kind of specify the ways that they are using in relation to the context.

Female Respondent

Oh, okay. If you look at that thing as a tool, as a tool, as an instrument, you see. As if you look at it as an instrument, then it’s for you to think that it’s an instrument used to weigh small things, but if you look at it as an object, then you can say it gets spoiled very easily, and then if you look, if you use relational thinking, then you can relate a sensitive person to that object and say that it is designed for sensitive people then you can choose (b), if you use relational thinking.

Male Respondent

I have a problem with this point, because we are talking about an instrument, we are talking about a tool and only check the word spoilt, is like…

Interviewer

Spoiled, spoiled (spelt out S.P.O.I.L.E.D), not spoiled like ukuthi you are given cakes, you are given cakes, you are given this, you are given lot of *(inaudible)*…

Female Respondent

Awulethe iquestion Thandeka. Ikuphi?

Female Respondent

Beam balance

Female Respondent

And again someone can disregard the fact that it is used to weigh very small things because think about the protractor, a small protractor, think about a thirty centimeter ruler, you see. All this things that we, the small rule that we use, we use them for thirty centimeters, you can't really be using a thirty centimeter ruler to measure fifty meters, you see. So a learner can… it does not make sense because there's a meter ruler, there's a tape measure

Interviewer

Okay

Female Respondent

Ja.

Interviewer

So guys, knowing that these words, they are everyday words, they can use them at home but also they are use in science and from our discussion the kind of question can be a challenge in terms of understanding how they are reasoned out in actual when they are using science. What help can be done to the students. We are talking about the everyday words, these ordinary words like, SENSITIVE, every day like RETARD, DISPLACE, what can you advice.

Quickly

Male Respondent

Quickly uhm, I think when we are teaching we have like our objectives, and our objectives have to be in line with the scientific language that they're using. In this case, let's say, we have to always abide by, okay, this is a science class and I've got to teach in science language, so these words, sensitive and other stuff, they are there to help us. The two are like a tool to help us to let us have a deeper comprehension.

Interviewer

So what can be said to the learners you are going to teach?

Male Respondent

As a teacher, what I would do, I would just like, okay, these are the words that we are using, and be clear that these words, I would explain these words before we can go anywhere and if I knew they a going to create misconceptions I'll be like, okay, you know sensitive in this case is this and this, but in our science class it's going to be this and this.

Interviewer

Okay, yes

Female Respondent

The challenge comes with teachers **(inaudible)…** Like for example, if I were to teach this topic, the fact that they say sensitive in a while I will assume that all the learners know what that means. So as teachers we need to pay special attention to new things which might confuse them. So in a way if you plan your lessons there's that section which talks about vocabulary and terminology, in most cases, in that section I'll think of the scientific words only, while neglecting the everyday language ways that might confuse the learners as well.

Interviewer

Do you think these words they contribute to the performance of the learner?

Respondents

They definitely do

They do

Definitely

Female Respondents

Because if we are using those words and the learner doesn't have the science understanding of the word, how do you, in an exam room for instance I don't know if this would relate. I've been taught, not for all my life for my high school life I've been taught physics in isiZulu, so when it comes to the exam room, such words in isiZulu, they are not there so when it comes to the exam room you read the sentence three times and you don't understand what they want, because you don't understand those words that are the main concept, the key points to the sentence like sensitive there, like those words we were highlighting, those are the key words in the sentence, those are the words we have to understand in order for you to solve the problem.

So, if a learner doesn't understand those words, how do you expect the learner to answer the question? Because the main thing is understanding those words in order for you to answer the question. As a teacher in real life, I haven't been a teacher but I've observed teachers, they don't do lesson plans, they don't, like I've only seen one person in my whole teaching experience, who plans for their lessons before like, they become the learner, if I was a learner, I'd think like this, because this is important as a teacher, you graduated, you went to varsity, you don't care about abo-sensitive, and abo-retarded, you know the meaning. So sometimes it's always important for a teacher to always put yourself as a learner, be a learner first and then become a teacher put yourself in the learner's shoes although like maybe it can't happen like every time, but it's important for you to that. Like when I was still in high school I never understood what sensitive was in the science concept…..

Interviewer (intercepts)

Context

Female Respondent (continues)

…Context, ja, sorry.

Female respondent

Umh, okay. To answer your first question do you think they are important. During TE my teachers doing displacement, she was teaching learners' displacement. She asked them what it means, and then learners thought about dis- as opposing something and then -place, being somewhere,- mend of. And then they defined displacement as removing something from where it is, and then they were talking about girlfriend, that if I have a boyfriend and then ngikushaya ngestina, meaning that's their exact word, ukushaya ngestina, meaning that it's taking someone's boyfriend, you see.

Basically they are not far from the scientific understanding of displacement, because they know that there is a change in something, but you as the a teacher if you don't say okay, yes, yes, yes, you are coming along, yes it is a change in something, but this is science we are not talking about girlfriend, you see, we are talking about motion. So can you link the topic motion and the idea that it's a change in something, then you say, it's a change in position, you see.

The teacher failed to do that, when the learners wrote the test they we still saying it is change in something, for example when you change a girlfriend, you see, and then the conclusion there, I think teachers should appreciate, and acknowledge that there is a parallel and skewed meaning of the terms, and if skewed like they meet somewhere like with the displacement, there is something common about the everyday understanding of displacement and the scientific understanding. If you as the teacher understand that, then I mean, you know.

Female respondents

For the learners we all know that science, okay maybe not everybody, but growing up, they told me that physical science is difficult , nobody does that, like not everyone, It's for critical to people. So it's important for a teacher in a classroom to show that you appreciate their prior knowledge, and the, uyazi learners, like kids, they, they, they you know, it's very good for them to feel important when they are in class. Let them say all those ideas that might sound crazy and take those…

Interviewer *(intercepts)*

Based on that word that they are learning?

Female respondent *(continues)*

… yes, yes, take those ideas and relate them , well In teaching experience, my major ones, my major focus in teaching experience was Mathematics. So we are doing congruency, I asked them what do you think congruency is? They said example, pumps, when you buy pumps from Mr. Price, those pumps like shoes they are congruent, all those things, take them, bring them in the classroom, those learners mind outside the classroom that also shows that there's a relationship between the science world and the real world, as a result it motivate the learners to do science, because there's also a relationship.

Interviewer

There are some words like CONSERVE, SYSTEM, FACTORS, DEHYDRATE, LINEAR AND CONSTANT, most people got 100%. What is so special about these words?

Female Respondent

Because they are specifically used in science, that is what I can say.

Female Respondent

(Inaudible)

Interviewer

The words like, CONSERVE, SYSTEM, FACTORS, DEHYDRATE, LINEAR AND CONSTANT

Female Respondent

The meaning is the same

Male Respondent

The meaning is the same

Female Respondent

The meaning is the same; the science meaning is the same.

Interviewer

So is the science in the everyday life?

Female Respondent

Ja, the meaning is the same

Interviewer

Thank you very much

Female Respondent

Skill, skill

Interviewer

Thank you very much it was good to be with you.

……………………………… END OF DISCUSSION

APPENDIX F1

FOURTH YEAR PARTICIPANTS DATA TABLE

Pre-service teachers codes		Correct Answer	TOTAL NUMBER OF OPTIONS (N= 38)					TOTAL	NUMBER CORRECT RESPONSES	OVERALL % PER OPTION SELECTED					NUMBER OF INCORRECT RESPONSES	PERCENTAGE INCORRECT	PERCENTAGE CORRECT	CONFUSING COMBINATIONS
No	Word		A	B	C	D	N/R			A	B	C	D	N/R				
1	Consecutive	C	0	2	34	2	0	38	34	0	5.263	89.47	5.263	0	4	10.53	89.47	
2	Displaces	B	0	31	0	7	0	38	31	0	81.58	0	18.42	0	7	18.42	81.58	
3	Limit	D	0	1	4	33	0	38	33	0	2.631	10.53	86.84	0	5	13.16	86.84	
4	Prepare	D	4	3	1	26	4	38	26	10.526	7.894	2.631	68.42	10.53	12	31.58	68.42	
5	Dehydrate	A	38	0	0	0	0	38	38	100	0	0	0	0	0	0	100	
6	Generate	C	1	4	33	0	0	38	33	2.631	10.53	86.84	0	0	5	13.16	86.84	
7	Sensitive	A	26	2	1	9	0	38	26	68.421	5.263	2.631	23.68	0	12	31.58	68.42	
8	Characteristic	B	0	35	2	1	0	38	35	0	92.11	5.263	2.631	0	3	7.894	92.11	
9	Trace	C	16	3	18	1	0	38	18	42.105	7.894	47.37	2.631	0	20	52.63	47.37	
10	Fundamental	B	3	32	1	2	0	38	32	7.894	84.21	2.631	5.263	0	6	15.79	84.21	
11	Constant	A	36	1	1	0	0	38	36	94.736	2.631	2.631	0	0	2	5.263	94.74	
12	Contract	C	2	5	28	3	0	38	28	5.263	13.16	73.68	7.894	0	10	26.32	73.68	
13	Valid	A	34	1	3	0	0	38	34	89.473	2.631	7.894	0	0	4	10.53	89.47	
14	Spontaneous	B	8	25	3	2	0	38	25	21.052	65.79	7.894	5.263	0	13	34.21	65.79	
15	Factors	D	0	0	38	0	0	38	38	0	0	100	0	0	0	0	100	
16	Concept	C	1	2	31	4	0	38	31	2.631	5.263	81.58	10.53	0	7	18.42	81.58	
17	Diversity	B	2	36	0	0	0	38	36	5.263	94.74	0	0	0	2	5.263	94.74	
18	Linear	A	37	0	1	0	0	38	37	97.368	0	2.631	0	0	1	2.631	97.37	
19	Retard	C	13	9	16	0	0	38	16	34.21	23.68	42.11	0	0	22	57.89	42.11	
20	Effect	D	4	2	0	32	0	38	32	10.526	5.263	0	84.21	0	6	15.79	84.21	
21	Consistent	B	1	30	4	2	1	38	30	2.631	78.95	10.53	5.261	2.631	8	21.05	78.95	
22	Function	D	0	0	0	37	1	38	37	0	0	0	97.37	2.631	1	2.631	97.37	
23	System	D	0	1	1	35	1	38	35	0	2.631	2.631	92.11	2.631	3	7.894	92.11	
24	Convention	A	27	6	1	3	1	38	27	71.052	15.79	2.631	7.894	2.631	11	28.95	71.05	
25	Negligible	C	1	3	32	1	1	38	32	2.631	7.894	84.21	2.631	2.631	6	15.79	84.21	
26	Evacuate	D	5	3	6	23	1	38	23	13.157	7.894	15.79	60.53	2.631	15	39.47	60.53	
27	Estimate	B	0	37	0	0	1	38	37	0	97.37	0	0	2.631	1	2.631	97.37	
28	Conserve	C	1	0	35	0	2	38	35	2.631	0	92.11	0	5.263	3	7.894	92.11	
29	Disintegrate	A	26	1	3	6	2	38	26	68.421	2.631	7.894	15.79	5.263	12	31.58	68.42	
30	Random	B	0	35	1	0	2	38	35	0	92.11	2.631	0	5.263	3	7.894	92.11	

APPENDIX F2

FOURTH YEARS INTERVIEW DATA

WELCOME AND INTRODUCTION.

So one of the things that I would be interested to look at was to say, especially you guys, you have been doing this, especially methodology. So I'd like to say have you ever heard in the course of your studies form university about these everyday words that are used in science, being used in the classroom by a lecture r or a teacher in high school.

Male Respondent

You mean the concept?

Interviewer

Yes, I mean the everyday words that are used in science, but also they are used in everyday language like for example, the words like DISINTEGRATE, the words like SPONTANEOUS. Have you ever heard of those words being used in science personally?

Male Respondent

Yes of course.

Interviewer

Should I take it that it's from high school or the university?

Respondents

No, from high school of course.

Male respondent

Actually from primary school.

Interviewer

From primary school?

Male Respondent

But we were not aware of them.

Interviewer

Okay, thanks.

So, you guys have done the methodology class and you have seen how the experiments have been done.

Do you think those words are very important in science? And if they are important, try put flesh on it.

(silent)

Anyone can shoot.

Female Respondent

Can you please rephrase your question?

Interviewer

Ja, I'm saying that do you think these words that are used in everyday language, but they are also are used in the science language, are they important in terms of understanding science, when they are used in the science context.

Male respondent

Are you asking that do they play a role in making things easier?

Interviewer

Yes, ja, ja.

Male respondent

Ja, I think some of them do but some of them have different context, if I'm not wrong, so in everyday language you can use it to mean a different thing, than you can use it in like science language. So it maybe one word with two contexts, ja.

Male Respondent

And it seems like these words are different based on different contexts just like he said. It seems like there is a high school science which is much related to the everyday science, everyday ways of doing things, the everyday words, and there is the science here. So these words are very important depending on where you are. When we're here, we tend to go deeper into saying things for what they are, teaching science for what it is, but then when you go to the high schools, we just teach, we don't say those little words, or those little differences. Little things that help learners understand, we don't consider them

Female Respondent

I think they are important. They are important in the sense that in as much as we use them in the everyday context or the everyday language we also use them in science and they kind of like apply to science in sort of like a similar way except there's like a small-nyana difference there. So what's important to you is that you as the teacher you then need to tell the learners what the difference is exactly.

For example, nowadays we've been doing the mole and we were talking about how amount is used in everyday language and how it is used in school, so, like when we use it in school we mean it as in like it's the number of moles, but when we speak about amount at home, you can actually say the amount of sugar is 2 kg, then now learners start confusing whether amount means mass or whether amount means number.

They start confusing those two, so it's quiet important that when you use the everyday words in a science context you then make sure that you tell the learners the difference between the two, and actually point out to them that I know that at home you use this term to point out one, two, three, but here in the science context we actually mean, so and so and so, because the difference is usually something small.

Male Respondent

I also think they're very important, but I now feel like they are adding a lot of work to teachers, because now it's going to be difficult for maybe a learner to remember that oh, current means something that is related to charges in science, but when it comes to English current means something that is related to time, the current time that we are in now. So I feel like it's adding more of work.

Interviewer

So in that case it applies to people who were born speaking English?

Male Respondent

Yes

Interviewer

Because there is a kind of *(inaudible)*.. that defines.

Male Respondent

I think they are very important, some of them, they can help learners to understand actually the, let me say resistance, you know you can actually use resistance in both everyday language and scientific language. So if I want learners to get the actual meaning of the resistance in scientific language, I can say in everyday language resistance means you do in opposite of what you are required to do, and then in science it's like opposing that. Like for example, the resistance to the floor of charge, so you can, you know, boost the understanding of learners by just using the difference between, not their meanings, ja.

Female Respondent

Just to add on what they have said, I think it's very important because at some point you realize that learners, actually, they don't have the general proficiency. They don't really understand some of the concepts that those words that are used in everyday life, and coming from there, now they meet them in science. From the word go, they don't understand what this concept means. So coming back to Amos idea, that it brings more, much of the work to teachers, now you have to teach the general proficiency and then relate that to the context of science to say, okay, in science this is what it means.

For example, at some point I was teaching Electromagnetic Induction, and you ask them what does induction mean, like the word such as induce. So the learners what they did, they think about, okay, it's induce, and then it sounds the same as reduce, so which means it means to compress something, so you can see that, the general proficiency, they don't really have it. And then now, you come to science you teach them about this concept which is used in everyday life, it becomes even more difficult for them to understand, so they are really important.

Interviewer

So should we say from your own experiences, are these words explained, when they are taught in science, let's say from high school even here in the university do lecturers take this *(inaudible)*.. to say that this word in this context it means what or they just go with the stuff?

Female Respondent

No, they don't.

Male Respondent

Sometimes they assume that you know.

Male Respondent

From the context.

Female Respondent

Ja, they tend to assume, and then when they are now dealing with their own study, particularly in methodology then they now want you to apply what they are saying in methodology, but when they are teaching it themselves, they don't apply it.

Male Respondent

So do you mean the teachers, the lecturers here or teachers back in high school?

Female Respondent

Even teachers in general

Interviewer

Just teachers or lecturers do they explain?

Male Respondent

Of course if like a lecturer is teaching method, he or she will focus on teaching that language….

Interviewer ***(intercepts)***

That is the method.

Male Respondents ***(continues)***

…..but then back in high school it's a different story, ja, it's a different story.

Male Respondent

Today, they didn't even like the teacher, didn't say current in your everyday language is this, and then in science is this. They only focus on the science meaning of it. Ja, so, based on my experience as I was a learner. So I started to realize this here at university that oh, now we have the everyday meaning and the scientific meaning, ja.

Interviewer

Anything, addition this side

Okay, so I think guys you did, this questionnaire you did it I think with Prof XXX, but interesting though I have sampled a few words that I want just to do, that we can debate on, we can give our views. The first word that I want to talk about was the word TRACE (spelt out as T.R.A.C.E). so in the questionnaire here it reads as follows, they say "the soil contained a trace of potassium", so they are asking what does the word TRACE in this context mean this means, so they said (a) it means it used to have some potassium, and (b) it said it had some plants which use potassium, and (c) it says it had a very small amount of potassium, and (d) it had a large amount of potassium in it. So most of, from the, not necessarily you, but from the responses that was given to that, most of the people they give like, it used to have some potassium.

The statement says "the soil contained a trace of potassium", but then the response that was chosen was saying it used to have some potassium. How would we think in terms of that kind of reason, by giving that kind of answer?

Male Respondents

I think the person assumes that the soil doesn't have potassium anymore.

Male Respondent

Mm, that's the problem.

Male Respondent

By the response there, it doesn't have potassium.

Interviewer

It doesn't have potassium?

Male Respondents

It used to.

It used to

Male Respondent

But I think they're using the, if the people who are doing it they have done geography and evolution and stuff so when they look deep for scientific evidence, if we look at the word trace, in another subject like geography it means looking at the evolution and stuff. So when you, immediately when you see that word, that's how they applied it, they applied it directly from the evolution perspective that a trace of evolutionary trends or something. I don't know if I'm making sense.

Male Respondent

I want to support what he say to say when you trace it's like you are tracking for pieces of evidence, and now it cannot be directly the potassium but it might be maybe other organisms lived there and used to, you know, make use of potassium. So finding them can make inferences and say, maybe this soil used to contain potassium.

Male Respondent

But what I think, to trace evidence of, see when you trace someone, using our mobile, they use evidence, and evidence, facts, understand, he was there, he was there, he was there.

Male Respondents

So it's more English, it's more going to the English

Interviewer

More the dictionary kind of

Male respondent

Ja, dictionary

Male Respondent

Even in evolution, Life Sciences we use trace. There's a trace of, it shows that there's evidence of the stuff there. So there was this answer you read there so I think I don't know if it's option (b)

Male Respondent

It's option (c),

Male Respondent

Had plants which use, had plants, so they were there, they are no longer there. It's a trace, but finding the potassium. So the right answer here, it would be (b), according to the question.

Male Respondent

There's a different approach on that question, I would say, I would support the large amount of potassium in the soil, because sometimes when you apply mining in real life, we don't just go there mining for gold and we just start digging, we start to look for the trace of gold in the soil, by finding that trace of gold we can assume how much gold can we find when we go deep. So there, there might be a trace of that, but when we go in deeper, you might find out that there were plants which were covered by another layer of soil which you now find out that there is actually a huge amount of the substance that initially you thought there was a trace of, but it's just showing you that unless you go in deeper further, you don't know if whether there is a huge amount or a small amount, so that's why they use the word trace.

Interviewer

Okay, yes.

Male Respondent

I think I'll go with (c).

Interviewer

You'll go with (c)?

Male Respondent

Ja

Interviewer

Had a very small amount of potassium.

Male Respondent

Ja, so I think for me the word trace literally means like a small amount of something or a bit, ja, small concentrate in physics I think, so I think when you saying a trace, it means, there was a small amount of potassium in the soil.

(Silent)

Male Respondent

It's a very subjective question because first things first, we need to understand the word trace. When they say there was a trace of Nimrod here, it's a fact, he was here. He might be around here, we don't care, but he was here. The term trace, so it clearly means like evidence of, you see. So it was evidence of there were plants, like I said. The soil had plants which use potassium.

Male Respondent

So actually the potassium is not, they're not detecting the potassium from the soil

Male Respondent

They are

They are

Male Respondent

They are, there was a trace, like small samples, he's right when he say small sample is a trace. It comes in smalls samples.

Male Respondent

Is the potassium exactly or there are other substances which might suggest that there was potassium involved

Male Respondent

Ja, even that you can say it because there were plants which were using potassium

Male Respondent

So they get the potassium from the soil right? ***(pause)..*** Because for plants to grow, they need a ratio of potassium, phosphorus and nitrogen, right. So you get potassium from the soil.

Male Respondent

They use it up and then they die.

Male Respondent

Exactly.

Male Respondent

And then they give it back to nature.

Male Respondent

To the soil

Male Respondent

Great, so the potassium was found in the soil?

Male Respondent

Even though the concentrations were different.

Male Respondent

But then it was found in the soil.

Male Respondent

In the soil, there were traces, small samples to show that here, there was potassium. So when plants decompose, they give back, decomposition breaks down, things break down right so they give back what belong to nature, if they were using up that potassium, take it back to the soil.

Male Respondent

The question was tricky

Male Respondent

It’s very subjective as long as it can give us that answer without bringing the context.

Interviewer

With the context of it and how it is used.

So all the option given they are...

Respondents *(intercepts)*

Possible answers

Interviewer *(continues)*

…Possible in that context

Respondent

Ja, in that context.

Interviewer

I sampled also one RETARD (spelt out as R.E.T.A.R.D)

Respondents

Retard?

Interviewer

Ja, retard

Interviewer

Ja, retard, ja. The statement reads as follows The pupil, I think the pupil in this case they want to mean the learner, in the present language "the learner was trying to find the chemical that would retard the reaction.'' And they said this means that the chemical would (a) speed up the reaction that's, and

(b) make the reaction go the other way.

(c) slow down the reaction and

(d) give maximum yield from the reaction.

And most of the answers were in (a) and (b) which was speed up the reaction and make the reaction go the other way round.

Male respondent

It's (c).

Male respondent

Well number (c) says to slow down

Male Respondent

To slow down

Male Respondent

Coming from the everyday use of retard, everyday use of retard, so when say someone is retarded this means that they are mentally processing something slowly, so to retard the process is actually to slow down the reaction of the process.

Male Respondent

And also coming from the context of physics, simple ammonic motion. When you apply force to a spring, and then bounce, bounces, bounces, eventually it slows down, so they say it's experiencing a retarding force.

Male Respondent

My problem here is the understanding of retard and what it means in everyday language, but now that's when we need to look at technical and non-technical terms because now, retard, what process is retarded. Remember, some of the words that are applicable in everyday language, when they come to science language they change the meaning, they affect the exact meaning of the process that is happening. So here, we should be interested in the process, what the process that is actually happening is and how can we relate it to, to what science know because we cannot be safe to take from non-technical word and directly apply it without entering it.

Male Respondent

So, the process is a chemical reaction?

Male respondent

Ja, a chemical reaction can either be fast or slow.

Male Respondent

But now can't we use the idea of, what you call your catalyst and inhibitors?

Male Respondent

Exactly.

Male Respondent

So since we have inhibitors in science, as a technical term, we have inhibitors, then it would be safer to speak of inhibition than retard, I don't know.

Male Respondent

Ja, he's raising a nice point there, but in this case maybe, what would you say maybe the person thought when maybe they say that retard is for speeding up the chemical reaction.

Male Respondent

They might have took it from everyday language.

Female Respondent

I don't think so, because retard in everyday language also mean slower, so maybe that person just doesn't understand what retard means.

Interviewer

Also in the first place

Male Respondent

Because it's in a wrong context.

Interviewer

But the one who said making the reaction go the other way round?

Male Respondent

They all don't understand the question.

Male Respondent

So that one might be right, you know why? It's subjective you need further explanation for this, like he said when you pull the spring, like current as well, resistance, you understand. So resistors are resisting current, making current do what, go down, isn't it? If you're agree on that, it retarded makes it slow, right, therefore, something….

Male Respondent *(intercepts)*

It’s going the other way round.

Male Respondent *(continues)*

….Ja, it’s opposing, you understand what I’m saying.

Male respondent

Oh, ja, ja.

Male Respondent

They might be right depending on..

Male Respondent

It’s acting as a resistor, opposing. I mean if you are running towards me and I’m opposing you, no matter how fast you are you gonna be slow, so, you understand.

Interviewer

Oh, that’s why you chose the, to make the reaction go the other way round.

Male Respondent

Possibly.

Interviewer

Okay, thank you.

The other word which I chose here was EFFECT (spelt out as E.F.F.E.C.T), effect. So the statement reads as follows If you were asked to find the effect of adding acid to a metal, this means you would try to find the reason for adding the acid, the quantity of the acid used, how long the reaction would look or the last one what happened. So the answers, that I, most of the answers they are rotating around the reason for adding the, I think the acid. If you were asked to find the effect of adding the acid.

Male respondent

Can you read them again?

Interviewer

The answer that follows, the reason for adding the acid that’s the first, the second the quantity of the acid used, and the third how long the reaction took and the last one what happened.

Male Respondent

I think it’s what happened, because effect means consequence.

Interviewer

The consequence?

Male Respondent

Ja, consequence.

Interviewer

But in this regard the person who put the reason for adding the acid.

Male respondent

Ja, it can also relate to what happened, because you can think of it, I don't know, in a reverse way, like to say that okay, let's say that I don't know the reason of pouring that acid, let me find out by pouring the acid on whatever thing.

Male Respondent

And check the effect.

Male Respondent

To check the effect, so that might also be right.

Male Respondent

So here we're concentrating on the term effect?

Interviewer

The term effect in this sentence

Male Respondent

What does it mean in everyday use and in science?

Interviewer

And the way they understand it in science.

Male Respondent

Okay, I see.

Male Respondent

I think it can be (a) and (d).

Interviewer

(a) and (d) according to you.

Male Respondent

I think I can test the effect of acid in chemical reaction, by just looking at the rate of the reaction, what would happen like for now.

Let me say I pour sodium hydroxide in the chemical reaction and look at the rate of the reaction and then now I pour acid, and look at what is the effect, it would increase or decrease. Like I can still use the rate of the reaction, the rate of the reaction to test the effect of acid.

Interviewer

So in that case how do you understand the word effect, when you say I want to find the effect of this because the key word is effect?

Male Respondent

Sodium Hydroxide

Female Respondent

Consequence of results.

Male Respondent

I'm not a science person and I don't know this sodium what, what, what, but what know its language the importance of language in science education. You see in science, when we talk about effect, we're checking the behavior, the outcome, the behavior (the results), unlike when we go to, on our everyday language.

Effect it's, are those factors which affect you to behave in a certain way as well. So this is how I understand it to be but I cannot answer the question myself because I'm not good with chemistry at all.

Male Respondent

So acid is a factor in a way, it causes an effect which we cannot tabulate

Male Respondent

Ja, it changes, it manipulates the behavior.

Male Respondent

And that's a fact

Male Respondent

I think also the responses that they give there they can build on each other if you look at them, as far as the word effect is concerned. One might say, the effect of pouring acid on a metal but now you can be, there they were interested in what will generally happen I can say, but now one can also be interested into but what amount now is quantitative to say if I pour 200 ml or 30 ml what will be the effect, now that's why that man was talking about rates and everything.

Interviewer

Okay, any other addition

The last one that we have here, I think it is very familiar, it was SENSITIVE, the word sensitive and the word was constructed here, it says the beam balance is a very sensitive instrument, this means that (a) it can be used to weigh very small things, (b) it can only be used only by sensible people, and (c) it is hard to understand how it works, and (d) it gets spoiled very easily, and most of the I think, the group had to put, it gets spoiled very easily.

Very sensitive instrument and the other one was that it can be used to weigh very small things, and it can be used only by sensible people. I don't know how you can make out; I want to start by people who said that it gets spoiled very easily, from the word sensitive.

Male Respondent

They looked at it in the everyday language, whereby you know, when someone, you see, when someone, you know we have people who are sensitive to energies, you know, as we talk, like when we talk I might emit like negative energies, they might be very very sensitive towards those energies and that if they are affected spiritually obviously it's gonna manipulate their physical realm and they might end up being sensitive.

I don't know if you understand what I'm saying. Like I said I apologise for being too inclined. So if, do you understand what I'm saying?

Interviewer

Just repeat that. You’re starting with these energies.

Male Respondent

I think maybe apologize for slipping out of context, for being out there. He’s talking about the spiritual level now because energies are those and we cannot deny that. So we have those people like in everyday no interaction whereby we have people who are very, very sensitive to arguments for example. When you argue with them they just can’t that’s why those people they end up saying, it gets spoiled very easily, you see. It cannot handle energies, it’s just too sensitive. I don’t know, I mean a child is sensitive, you understand, to some external energy. So in a science context I’m happy that this gentleman here understood what I said. In the science context, I would say sensitive, according to this the right answer would be the (a), it used to weigh very small things, because you know, they’re very light so if something is light, obviously these guys are doing science so they know it means something which is sensitive to skin.

Male Respondent

Well, I would go with (a) an (d).

Interviewer

(a) and (d)?

Male Respondent

Ja, (a) for the same reason that we said and (d) because, let’s say you have weighed something that weighs 10 kilograms, not kilograms I mean grams, 10 grams which is small, but you can spoil it by maybe blowing air into the, what you call the beam balance or whatever you can spoil it, you can spoil the reading, right, let’s say maybe there’s too much air in the room, something like that.

Interviewer

So it would be that case right?

Male respondent

It would be that case.

Interviewer

It’s not settled.

Male Respondent

It’s not settled, yes, so that’s why I would go with (a) and (d).

Male Respondent

So a beam balance, can a beam balance weigh a grain of hair?

Male Respondent

No, it can’t.

So can you use the word sensitive? If you can’t weigh a grain of hair.

Male Respondent

Ja, that’s what I wanted to ask what is the difference between a triple beam balance and a beam balance.

Respondents

It’s the one that we used, the one with that thing.

Male Respondent

That is looking at its behavior and the mass that it can be sensitive to, right.

I think it’s not sensitive, I think if you also consider that quantity of what you are measuring even the chemicals skills that we use in the labs cannot measure a gram of a, it’s not that sensitive.

Male Respondent

Up to which certain extent is it sensitive?

Male Respondent

But it’s sensitive to the degree of sensitivity.

Male Respondent

I don’t know if I’m lost or what, is this sensitivity referring to when you are adjusting there or what you put on top of the scale.

Male Respondent

It’s what you put on top of the scale, like it measures small things.

Male Respondent

Not the adjusting part of it.

Female Respondent

But it has to do with the adjusting there, because remember when we were doing the practical on galvanic cells, you had to use one volt, but what would happen if we use five volts.

Male Respondent

There’s not gonna be a reading.

Female Respondent

But maybe if not five volts, but more than one volt.

Male Respondent

Ja, because certain volts were like 0.02.

Female Respondent

Which means it’s not that sensitive to that measurement so it has to do with the adjustment as well.

Male Respondent

Because one thing, when you are busy adjusting there, if you’re moving too much those things, and then that thing falls if you move it.

Male Respondent

So fall into adjustments.

Male Respondent

But that's it being sensitive you are manipulating it for it to be at equilibrium, but can you see how sensitive it is.

Male Respondent

It is.

Female Respondent

So basically sensitivity is the property of the true balance.

Male Respondent

Ja, that's what I'm saying, you are manipulating it.

Male Respondent

Akere we have this one which use electricity, I don't know, electric balance, and then you understand, there's no need to, that's modify…, it evolves from there to something else.

Male Respondent

Ja, even that one, can you see how sensitive it is because you have to manipulate the accurate, it's not about you adjusting.

Interviewer

So it gets spoiled easily you say is the fitting one.

Male Respondent

Spoiled also is a term that refers to something that goes wrong angithi?

Male Respondent

Ja, you can say that.

Male Respondent

Is that term correct for that thing?

Male Respondent

In what way would you say it's correct because it's not balanced? If we are using an electronic scale also it can be spoiled easily because everything is electronic and electronic don't go with water if you're bringing water like a beaker leaking water you can easily spoil that electronics, beam balance, I don't see how we can spoil a beam balance.

Male Respondent

Oh, we're talking about the reading

Male Respondent

About measurement

Male Respondent

Not the apparatus.

Male Respondent

We're not talking about the whole thing, here ha re ka e wisa, e tlo wa, it's gonna be spoiled, no. We talk about the reading specifically.

Male Respondent

Ja, it's easy to get wrong results.

Male Respondent

That I understand, you can easily get wrong results that are why we say it's sensitive. Someone can get easily emotional, sensitive to energies, words, they can get easily emotional, they're sensitive, even this one can get easily spoiled, therefore it's sensitive, therefore (this man is right) it depends with the context.

Male Respondent

I think this question is much related to the previous one saying the effect. If something is sensitive to you, another something, maybe my eyes are sensitive to light, the pupil contracting and going back, something like that. It goes to mean it's been affected by that particular thing.

Some other chemical reactions need light or heat not light to say benison burner in order to take place. So heat, that reaction is sensitive to what, to heat, I could say that. So sensitive is much related to effect of something.

If I’m sensitive to eating something we can see that by the effects that particular thing brings up.

Male Respondent

The behavior of your body, the way it responds to whatever you ate.

Interviewer

Ja, so teachers, because very soon you’ll be in the field anyway, so, you’re already teachers. I just want to ask this question to say having the debate like this on the words that we know already being used at home, and then we grow up in the course of using English,

I’m not a first English speaking person and there are a lot of languages before that. So how can the students in this case are helped in terms of learning science if we find that just a single word can cause a lot of confusion.

What can be your intake on that to say in terms of the learning processes and teaching processes both considering you as teachers who are going into the field but also knowing that you are going to meet learners. You have mentioned it that this word has never been touched in high school.

Yes

Male Respondent

Although it’s not fair but I feel like as a science teacher you should also be an English teacher or a language teacher. Although it’s not fair because learners are learning English from grade 1 up until maybe, maybe you find them in grade 11. What were the teachers doing by that time? So it’s not fair but I feel like you should also teach language.

Interviewer

In what senses when you’re teaching the language?

Male Respondent

It is also teaching them like the English language and also the science language at the same time.

Interviewer

So you got to do like a double job there?

Male Respondent

Yes.

Male Respondent

But then what about the curriculum, what about the syllabus, because we gonna fall back on the syllabus, so me I'd say that it depends on how competitive you are, not competitive, what's this word I'm looking for, competent, how competent you are as a teacher, if you'll be able to integrate language and content at the same time. It will also depend on how competent you are, how you plan for your lessons and stuff like that

Interviewer

So you have to be conscious about that.

Male Respondent

You have to be conscious about that and maybe think of those language barriers beforehand, before going to the class and maybe highlighting them, right, but then, it also comes back to how much are you willing to do that cause I know for a fact that I wouldn't do that, cause it's a lot of work.

Interviewer

You'll just go straight.

Male Respondent

I'll just go straight.

Interviewer

But with conscious these words can cause problems.

Male Respondent

Ja, cause now, we're facing a lot of challenges in the education profession, right, and basically we're not, there's no justice in it at all.

Two weeks back teachers were, I mean two days back, teachers were striking for wages and stuff, salaries but now if you have to, ja, that's why I'm saying it depends on how competent you are. Maybe if you are very passionate teacher, you'll do that, but then, ja.

Interviewer

But In this case don't you think words like these can affect eventually the performance of the learners?

Male Respondent

Not necessarily.

Interviewer

Not necessarily?

Male Respondent

Not necessarily because it depends on how a learner learns, like me, I learn through practice as long as, if I can do maybe ten question papers of a certain subject, I'd be ready to write an exam.

Interviewer

Oh, just practicing?

Male Respondent

Just practicing, I just find patterns what did I do wrong this time, next time I won't do it. Some people just learn quicker, right; they learn not to do mistakes, right, quicker. So I learn by doing mistakes and later working on those mistakes.

Interviewer

Okay, ja.

Male Respondent

It think, it's just a matter of emphasis as you are teaching in a science classroom, you tell your learners of course you gonna have your content, and within that content you gonna have technical and non-technical words. Then if it is current, tell them in science the meaning of current is this, in your everyday life the meaning of current is this, but however, just focus on the scientific meaning of it. I heard the question that, can words affect the performance of learners, it can…

Interviewer ***(intercepts)***

It can?

Male Respondent ***(continues)***

…..Because now let me say you have a question like this, neh, and then here there are words and some words they can be used in everyday and scientific language, right. So now, words they can bring understanding, so if I don't get the meaning of words, I won't get the understanding of what is required.

So if you are reading a science text, you have words and they give you understanding and if you have understanding you get knowledge, after getting knowledge then you can apply it in general to the general. So I think words can play their factor at the performance of learners

Interviewer

Okay, yes.

Male Respondent

What I've noticed what most teachers do in the kasi schools, I don't know how do you call them, locations, what....?

Male Respondent

Township.

Male Respondent

Ja, township schools. They usually would say, they usually use their own home language like isiZulu to explain, so if, maybe they are explaining a question that a car moves from where to where, from here to main campus with an initial of what, they would explain that in Zulu and after in Zulu they gonna explain what it means. They gonna read it in what, in English and explain it in Zulu, then they continue. Then they're like, I think explaining the word exactly like within English, using the English word, how should I put this? Using the everyday use of the word like, which word can I use, let me say speed. If you're not relating speed to the everyday word of speed but use speed as an everyday Zulu language, I'm talking in terms of a township school, it's much helpful like using it in a home language.

Let me say in a Vernac language, like trying to remove, because I was taught physics in Zulu, you see. I was taught physics in Zulu, when the teacher comes, even when he's walking around, he'll be saying, imoto isuka kuphi? With an initial velocity of what, isuke, izekuphi, ideccelerathe, kanjalo, so those things, so most of what the teachers do in the township schools they use their home language to explain words which are in the physics context , and I find it very helpful because even sometimes I can't well explain the physics concept so when I read it, and I make it to my own home language, that's when I would understand it better, then when I understand it better, if I can understand it within the physics context, the learners might not understand, but if I'm able to understand it and explain it further.

Interviewer

So that's what we call cold switching.

Male Respondent

Ja, cold switching.

Male Respondent

I was hoping teachers should encourage learners to use these words, even at their home, like when you're talking to your mother, mom hey I'm using velocity. It helps them to be able to remember the terms

Male Respondent

Okay, I may differ from his perspective that they are not that important but I think, language is very important, I think physics itself is a discipline. I might do to an extent that physics is a language it's a language itself, it's a new language so you have to be able to differentiate between your everyday usage of language and your physical science language because you have to be very exact and learners, they will come with their prior knowledge, their everyday usage of the languages and, oh sorry, the words and they'll come there and say, retard, and actually I'll be offended if you say retard or something despite the context that you are using the word retard, but if you teach the learners and you show them the everyday use and the scientific use or the language, then the word retard might no longer be offensive so it is very important for one to actually realize the use, the word and they are able to differentiate between the everyday language and the scientific language.

Male Respondent

But then how would your account for those learners that get distinctions in physics, and not distinctions in English?

Male Respondent

Arrr, well, either way there is, we do know that there is procedural, or road learning and then there's conceptual understanding, so just because you are getting hundred percent it doesn't mean that you have a conceptual understanding of a concept but that's another topic for another day.

Male Respondent

But that's what's important right.

Interviewer

But if you say.

Male Respondent

That's what's important, right, because if now I have a deep understanding of language but still I'm failing that language, that subject, I mean the greater effect is with my marks, right. So I feel that if you practice more than you dwell on languages you'll be able to pass well.

Male Respondent

But it's not about passing, you don't understand.

Male Respondent

But you'll reach a stage in life where you can't continue long because of a lot has been left behind, you understand.

Male Respondent

And what would be the part of teaching physics, if you are just teaching it for marks?

Male Respondent

Science is not only for programming, writing and getting hundred and what, it's liberation of the mind, it's continuous, so if we don't take care of the foundation, like a simple thing other words in everyday language, when you translate them to science they completely mean (different), a different thing. Now you gonna carry that misconception.

Male Respondent

Okay, nna my point is that if look at question papers, let's say maybe grade twelve question papers for the last maybe five years or so nothing much changes, nothing much changes, they probably much bring the same questions in different ways. My point is that if you focus on practicing how to answer questions, how to answer questions, you'd pretty much overrule this thing of language barriers and stuff like that, because you'll be familiarizing yourself with how to answer questions, than to dwell on language and then fail to answer questions.

Male Respondent

But you are familiarizing yourself with a system that can change at any time, do you see the dangers of it?

Male Respondent

Exactly, exactly, but then you are doing it currently, but it won't change as you do it.

Male Respondent

But CAPS is gonna change

Male Respondent

Yes I know, but when I was doing grade twelve, we're the last people to do NCS, then the guys that were coming behind us were doing CAPS, so it doesn't change on the spot, like on you.

Male Respondent

So that is you, you're just finding an escape, it's just an escape for time being, here we're looking at the…

Male Respondent

Actually I'm focusing on results, right. I may be speaking on the basis of realism I'm a realist in nature, right. I believe in results, I don't believe in the process, I believe in results.

Male Respondent

And those results you must be aware that they are cornerstones, it's someone's, it's another man's standards. What about understanding of the concepts itself

Male Respondent

Exactly, that's what I believe is the problem in our education system because, because we're forcing people to …

Male Respondent ***(intercepts)***

Because we cannot learn science just to always respond what is charge, charge is ***(inaudible)..***

Male Respondent ***(continues)***

..But that's what happening, being realistically politically speaking.

Male Respondent ***(intercepts)***

Which is why we are here,

Male Respondent ***(continues)***

…That's what happening.

Male Respondent

But seriously say you focus on results, so if I get two hundred out of two hundred in an assignment would you say that's key for me, would you say I understand if that happens, if you are focusing results.

Male Respondent

I'm talking about something that you wrote on your own or something that you copied

Male Respondent

You're firm to exams, I understand.

Male Respondent

I'm firm to exams, the results that you're getting…

Male Respondent

Our concern, our concern, our concern right, for us especially me I salute education for liberation, I don't wanna teach you, I don't care about your marks. I want you to learn, apply this thing outside and vet your own thing. Think, be a critical thinker, I don't care about your marks, you see, but he cares about marks, I respect your point of view and all that. But for my side, I wanna liberate people; I don't wanna make people the slaves of the system. I want them to think.

Male Respondent

I think it also depends on what subject we're talking about.

Respondents

Science

Male Respondent

Science is philosophy my man.

Male Respondent

I know science is philosophy, but then realistically speaking, what are these kids doing about science in the everyday life?

Male Respondent

So for you, as a teacher, is your job to create those guys to be great, great philosophers. Science itself is a philosophy, Mathematics, I mean the relationship between science and mathematics itself, they explain a philosophical thinking, which we have to take that into consideration, you understand.

Female Respondent

I feel like we are kind of losing the plot here because now you guys are kind of debating about philosophy and stuff.

Male Respondent

No, the thing is they are too micro, they're too micro. We're talking about things we cannot touch and see.

Male respondent

Actually it's a matter of addressing the issue of saying, are these words important

Female Respondent

Well, I will come up with a controversial answer to say let's just do away with everyday words being used in the classroom, let's try to stick as much as possible to science words, of which that would have to be like a lot of work. A lot of work in sense that even the curriculum has to be changed because, for example, let me take you back to the example of amount.

So they were still explaining the mall as the amount in that CAPS document, and if wena now you come in class and say no, we'll actually say this is the number of mall, now you're kind of like going against the curriculum, even though you are not really going against it but it kind of looks like you are and the learners now when they write the final exam they are going to write what you told them and not what is in the curriculum, then they get marked wrong.

So I'm saying, is it possible for the science community to actually try to slowly but surely filter out the everyday words being used in science and try to replace them with science? Well that's all I'd say.

Interviewer

So can you teach science alone without using, when you say science word only you mean words like…

Male Respondent *(intercepts)*

Ja, technical language and technical words.

Interviewer *(continues)*

Technicality.

So how do you start your teaching by just coming to say acceleration, speed, class?

Male Respondent

You can't

Male Respondent

Just form a link between technical and non-technical, make sure that you don't create misconceptions

Male Respondent

What you're saying, I like telling people that I like acknowledging nature and how important words are. I like saying words are a wireless connection between two individuals, understand. So there's no way, like you said you cannot get inside the classroom and start saying acceleration, speed, we need to have a platform in which we communicate, you throw words. Like he said, acknowledging their everyday use of language and the science language, acknowledge them both.

When you teach, tell them that in your everyday language, this is what you say, but in science it's this, that's the only way.

Interviewer

Okay, last there guys, you acknowledge the everyday and in science, but there are some words like CONSERVE, SYSTEM, FACTORS, DEHYDRATE, LINEAR AND CONSTANT, people they got most 100%. How do you expect that? What is so special with these words?

Male Respondent

Because they are not used in everyday language like conserve, conserve to them it comes as when someone they say, conserve nature. Someone might come, save take care of nature you see. They are not used in everyday language, conserve, the first time I heard the term conserve, it was only in science. Okay, the way I would respond to your question , if you look at, if you analyze those words they are words that don't change in context, when we talk about science and the everyday language, that's why people will get them right. They don't change in context, like linear is linear, conserve is conserve.

Male Respondent

Dehydrate is dehydrate, or you might even say lose water

Male Respondent

Lose water, sure.

Male Respondent

Dehydrate would be technical, but lose water would be non-technical.

Male Respondent

Of which lose water is not a single word, but I get your argument.

Interviewer

Okay, anyone to add.

Otherwise guys, thank you very much for the contribution, for your inputs, I think. We have come to the end of the whole thing. I have to appreciate your contribution as well, so I actually didn't expect it to be so hotly debated. So I say thank you very much.

……………………..……………**END OF DISCUSSION**…………………………………

<u>APPENDIX F3</u>

<u>FOURTH YEAR STUNDENT INTERVIEW DATA</u>

<u>Interviewer</u>

These are the people who can at least give me something concerning my research; basically I'm working on having (inaudible) in science language. So that's the interest. So while are you guys exiting going to the field very soon, you'll be teaching these things. That's why I say let me check with the seniors, at least you are the seniors of the university coming all the way from first year, so I work on, I'm working with the everyday words so we use the words that can be used in science and everyday language, but also they have got a use in science.

So that's actually what the whole interview is about. So let me start by saying, you are an English speaking person?

Respondent

Yes

Interviewer

Ja, but have you ever heard about these words like DISINTEGRATE, the word EXTINCTIVE being used in science. Holistically that is all the way from high school.

Respondent

Ja

Interviewer

Had they been used?

Respondent

I'm sure, ja.

Interviewer

So were they explained, maybe all the way from first year up to now or from high school? When these words are used in science particular, were they explained, to say this word, maybe means this in everyday life, but in this context it is……..

Respondent

No, normally in science you learn the science meaning, they don't tell you where it comes from in everyday language, how we use it in everyday language, or what it means in our everyday languages, normally I tell you in science, ja.

Interviewer

Okay, that is quite interesting, now because that's what I wanted to get an interest to say if though, so maybe in your experience now, talking about a personal experience, so you haven't met any lecturer or any teacher who has said to say this word means this, but in science it means this, they just go.

Respondent

Professor XXXX kind of touched on it in fourth year, and other than that, not really. We looked at it what's in science itself, not in everyday language, so I don't know, like this placement we were with Professor XXXX, we looked at what it meant in everyday language and then what it meant in science, but with many most of the lecturers it was just the science meaning.

Interviewer

So there was no explanation in whatever that he provided, and that is methodology isn't it?

Respondent

Methodology

Interviewer

And in your content?

Respondent

In our content, not really, not that I can think of. I'm trying to think, but no, most of the lecturers just stuck to the science meaning. That I can remember anyway.

Interviewer

So what happened is that I have some words, which I remember, there's a questionnaire, I don't know if you remember it. You did answer a questionnaire like this sometime before?

Respondent

I don't think so, for you.

Interviewer

No, no, not for me but for any methodology.

Respondent

I don't think so, we could have.

Interviewer

It doesn't matter.

This is a questionnaire that has got everyday words that are used in life, but the same words are use in….

Respondent (interrupts)

Science.

Interviewer (continues)

In Science

So I just sampled them, for example there's, the first word here they say "the soil contained a trace of potassium." Okay, then they say here it used to have some potassium, and (b) said it had plants which use potassium, and (c) had a very small amount of potassium and (d) had a large amount of potassium, and the majority of the people who responded they chose, used to have some potassium

Respondent

Arrr, because it's the word had.

Interviewer

Yes, maybe.

So that's what I wanted to find out from you, you said how you would understand a learner like that one who is answering like that?

Female Respondent

I would answer it as (c).

Interviewer

As (c)?

Respondent

It's got a small amount, yeah, of potassium.

Interviewer

Not necessarily they used to have some.

Respondent

No

Interviewer

What reasons can you give?

Respondent

I would take it as they're using past tense so, it had, as in they looked at it, it had some, they left and spoke about it. That's why they said had, instead of meaning it had a and now it's gone. So it's a more language, I don't know, I would say that as it had.

Interviewer

Ja, because the interest here was TRACE.

Respondent

Yeah, oh, okay.

Interviewer

The interest was is TRACE, not, they underlined the word TRACE.

Respondent

Oh, trace It would have a small amount of trace, a little amount.

Interviewer

Another word that we have is RETARD (spelt out as R.E.T.A.R.D). I hope I'm pronouncing it in a right way.

Respondent

RETARD (spelt out as R.E.T.A.R.D)

Interviewer

Yes, so it was constructed as follows "the pupil was trying to find a chemical that would RETARD the reaction. This means that the chemical would speed up the reaction, would make the reaction go the other way, or slow down the reaction or give maximum yield from the reaction.

So the responses that came was "It makes the reaction go the other way", another one it said, it would speed up the reaction. So I think ja, so that was the kind of some of the responses that came to that. So I wanted to see that how would you think of the person answering that. The word itself is RETARD.

Respondent

Ja, so they obviously not quite sure what retard means, in fact it would be to slow down surely, but ja, not a very good word to use in science, it's not a very scientific word in a way, is it? But ja, it's obviously they don't understand what is meant by the word retard, that sense to slow it down.

Interviewer

But it's used in everyday language

Respondent

You use it in everyday language but it's generally not a nice word and as referred to someone who's slower kind of a thing. But ja, I don't know.

Interviewer

So can that thinking of everyday language be applied in this regards?

Respondent

It could because it’s generally for someone slow but maybe they thought someone backwards and then they thought the reaction is gonna go backwards, I don’t know. It’s not understanding that word but ja, it could be linked.

Interviewer

Ja, the other word that we had was EFFECT (spelt out as E.F.F.E.C.T).They said if you were asked to find the effect of adding acid to a metal, this means that you would try to find (a) the reason for adding the acid, (b) the quantity of the acid used, and (c) how long the reaction took and (d) what happened?

Respondent

Okay

Interviewer

So most of the answers were rotating around the reason for adding the acid, so that’s what I want to learn from you, what would you think of the, of that kind of response.

Respondent

See again, it goes back to effect or effect it is how they use it in science it doesn’t necessarily link to how they use it in everyday life, cause I would have taken it as what would happen, but the effect you could say why did they do it so because, how do I word it. The effect of adding the base would give you what happened show you what would happen and then maybe they could say you did this because of this, this and this, I don’t know.

Interviewer

So the answer, there for reason for adding the acid in this case, how would it fit?

Respondent

I don’t get what, you see me I would have taken it as what you wanna see happened, what happened to see what happen but, ja, I don’t know if I’m answering your question.

Interviewer

Ja, ja, ja, you are answering the question, you are answering the question, okay. The last word I think was the word SENSITIVE. They said the beam balance is a very sensitive instrument, and they said this means that it can be used to weigh very small things, it can be used only by sensible people, and they said it is hard to understand how it works, and the last one it had it gets spoiled very easily, and most of the answers were rotating around, it gets spoiled very easily.

Respondent

Okay, see I would take it as (a) cause you can measure any small thing, because any small amount would change in measurement.

Interviewer

For the person who said it gets spoiled very easily?

Respondent

Ahh, well, ja.

Interviewer

Using the word sensitive

Respondent

Sensitive we use in everyday life to talk about someone who's sensitive or something sensitive, and then it means it breaks easily or the person gets hurt very easily. So you could see maybe why they thought it got spoiled because in everyday life, you generally refer to something being sensitive as something that can break easily. So, I don't know so.

Interviewer

Okay XXXX, I have some words that were in the questionnaire, but the students of course they did very well. Words like CONSERVE, SYSTEM, FACTORS, DEHYDRATE, LINEAR AND CONSTANT. These words they were very well performed. What could be, what's so significant about these words, generally?

Respondent

Well I think most of it you mentioned there were CONSERVE, SYSTEM, FACTORS, DEHYDRATE, all those words are more used, they are more used often in science. So you kind of get to an understanding of it from earlier on like linear, factors, conserve, we use in a lot of things in science and then also I think they link that you could use in everyday language in the same way you use it in science. They are used similarly where like retard was used completely different between everyday language and scientific language.

Interviewer

So these words they are like they are becoming science into the world?

Respondent

Yes

Interviewer

Not from the world into science?

Respondent

Yes, what conserve, it kind of mean the same thing in everyday language and in science. It means it stays the same, you're conserving it, where, I don't know, trace, it could be to trace a picture or a small amount, a base of few meanings in the everyday meaning and science. So I think that's why they perform better in that one, you know, ja.

Interviewer

So generally do you think these words, they are important in science learning, the way that they are displaying them, do you think they are important?

Respondent

Yes I think it's very important that they know both the everyday language and the science language and where the link comes in between them, because of you don't know what it means in science and you've got your own understanding in everyday language. You're not gonna be able to make the links so they could have made the link between science and everyday language and what they meant in the question for science. So yes, I think it's important that you do know what it means in science and also to make sure there is no misconception between the science language and the everyday language.

Interviewer

You yourself are going into the field now, you are going to teach physics.

Respondent

Hopefully

Interviewer

Hopefully, that's obvious, you'll do it, you'll do it, you'll do it. What would be the recommendation to maybe whether it's in high schools or the universities concerning the teaching of the science in regard with the language?

Respondent

Well, from Professor XXXX, I saw where you need to make that link, so if I were teaching it by myself I would, definitely. If there was a new word in science like linear, I would say here, in everyday language we use it like this, but in science it actually means this, and when we use it in this class we're talking about the science meaning not the everyday meaning. So I would make a clear distinction between both types of languages.

Interviewer

XXXX you yourself being an English speaking person, do you find these words like they are a bit tricky in terms of understanding in physics?

Respondent

Arrr, yeah, some of them. If you hadn't given me the options like, no, not really actually. Effect was probably the only one I would think a wee bit about, but it could be because I've done science throughout my entire school career and then university, and no, maybe I'm wrong, maybe when you look at it then it says no, but as far as I can tell, it kind of make sense when you gave the options which was the clear one.

Interviewer

No it was a questionnaire with options, so it was found that everyone was choosing according to his or her understanding.

Respondent

Ja.

Interviewer

Thank you very much, it was good that you turned up, and I was worried if you'd come cause I know that it's prac coming. So it wasn't that long of a thing so thank you very much.

……………………………….**END OF DISCUSSION**…………………………………………