A SYSTEMIC FUNCTIONAL LINGUISTIC ANALYSIS OF THE UTTERANCES OF THREE PIETERMARITZBURG PHYSICAL SCIENCES EDUCATORS

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ABSTRACT

In South Africa, Physical Sciences educators play a crucial role in contributing to equal life chances for Physical Sciences learners. This is because they have the opportunity to employ functional language features for increasing access to scientific literacy - a goal of the Physical Sciences National Curriculum Statement. However, no studies were found in the literature which explicitly explored this aspect of a Physical Sciences educator's pedagogical content knowledge in the South African context.

This study employs the sociocultural view of science as a language and the complementary theoretical framework of systemic functional linguistics to explore the nature of the utterances of three Pietermaritzburg Physical Sciences educators during Physical Sciences lessons. The focus is on the functional language features of nominalisation, lexical density, functional recasting, and lexical cohesion in terms of repetition and cohesive harmony index. Using a multi-case study methodology, pragmatic paradigm and mixed-methods approach, this study provides a sophisticated description of the utterances of Physical Sciences educators in language contexts characterised by varying proportions of English Second Language to total number of learners.

The results reveal that lexical cohesion, measured by the cohesive harmony index and proportion of repeated content words relative to total words, increased with an increasing proportion of English Second Language to total number of learners. Nominalisation and lexical density did not decrease with an increasing proportion of English Second Language to total number of learners. The functional recasting results provide insight into numerous types of functional recasting available to Physical Sciences educators. In addition, a model is proposed regarding how the outcomes to which the functional recasting types contribute, impact on movement towards the everyday or scientific registers of English. Furthermore, each individual Physical Sciences educator had a „signature' talk, unrelated to the language context in which they taught.

This study has significant implications for the development of pedagogical content knowledge in pre-service and in-service education and training of Physical Sciences educators. Training programmes need to place a greater emphasis on the functional use of language in order to empower Physical Sciences educators to adequately apprentice their learners into the use of the register of scientific English.

DECLARATION

M.Ed. Candidate

I, Kavish Jawahar, declare that 'A Systemic Functional Linguistic Analysis of the Utterances of Three Pietermaritzburg Physical Sciences Educators' is my own work and has not been submitted previously for any degree at any university. All sources that I have used have been indicated in the list of references.

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I hereby declare that this thesis has been submitted for examination with my approval.

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Chapter 1: Introduction and Rationale

1.1. Introduction

The purpose of this study is to explore and describe the nature of the utterances of South African Physical Sciences educators in different language contexts from the perspective of systemic functional linguistics. While the terms „educator' and „learner' are now commonly used in South Africa, the terms „teacher' and „student' are more common in international literature. „Educator' and „teacher' are thus used interchangeably in this thesis, as are „learner' and „student'. In this chapter, the major issues contributing to the rationale for the current study are introduced and discussed. Chapter 2 then presents a review of some literature involving the core concepts arising from Chapter 1. In Chapter 3, the theoretical framework and methodology for the current study are discussed. The results of the analyses carried out in this study are presented in Chapter 4 and discussed in Chapter 5. Chapter 6 contains the conclusions drawn from this study and recommendations arising from these.

An attempt has been made for this chapter to flow from issues that are peripheral but useful for a better understanding of the research problem and its background, towards those that are at its core. Thus, not all the topics raised here will receive equal attention or warrant it at all, in subsequent chapters. The implication of this approach is that this chapter concludes rather than begins, with the core issues constituting the rationale for the study. It is hoped that this will allow for better tracking of the central elements of the study as they weave through the subsequent chapters of this thesis.

This chapter will now present a description of education language policies and the domination of English in South Africa. Thereafter, it will highlight the attention given to scientific literacy in the Natural Sciences Revised National Curriculum Statement (Department of Education, 2002) and the Physical Sciences National Curriculum Statement (Department of Education, 2003). These curriculum statements are policy documents which provide a standard for the teaching of these subjects in all South African schools. This chapter will then describe language as a factor contributing to unequal access to scientific literacy and thus unequal life chances for learners of Physical Sciences, and subsequently discuss language use by teachers in relation to pedagogical content knowledge. Drawing from these issues, the rationale for a systemic functional linguistic analysis of the utterances of South African Physical Sciences teachers will be presented.

1.1.1. Education Language Policies and the Domination of English in South Africa

A child's initial language learning, constructs what is known as their basic interpersonal communication skills (BICS) which is foundational for their acquisition of further knowledge. Because BICS is developed socially and often informally, it is described as context-embedded and it is believed to take approximately two years for an individual to develop BICS in their mother-tongue. However, „to be fully literate and succeed academically we have to gain cognitive academic language proficiency (CALP)', which involves the ability to communicate more abstract ideas (Inglis, Thomson & Macdonald, 2000, p.44).

De Wet (2002) mentions that there is widespread agreement regarding the importance of children learning in their mother-tongue at least to the point of CALP, in order for them to develop systems of meaning which can then be employed within the framework of other languages. In essence, a learner should acquire home-language proficiency before being able or expected to acquire second-language literacy. Should this progression not occur, the learner's attempt at learning in a second language may be a traumatic experience, significantly or permanently delaying their academic development (De Wet, 2002).

According to Brock-Utne (2002), the use of a language of learning and teaching that is familiar to learners is not just important, but „œntral to learning', and there is consensus that students learn more effectively when they understand what their teacher is saying (Klaus, 2001). The claim that learners in such diverse countries as Mongolia, Korea, Japan, Finland, Norway, Sweden, Denmark and Italy, are advantaged over learners in countries such as South Africa is justified if one considers the different language demands made on these respective learners. In the former countries, formal education begins in the learners' mother-tongue, „the language they normally use with their parents and friends and hear all day', whereas in South Africa, a foreign language – English, enjoys elevated status over indigenous ones in various domains of everyday life, including education (Brock-Utne, 2002, p.7).

Education in the medium of mother-tongue is important not only for the academic development of children but also politically. An example of this is the empowering of previously disadvantaged groups, in which case a learner's education in the medium of their mother-tongue can be viewed as a basic human right. However, to fully understand the evolution and implications of the various language policies which South Africa has adopted over the years, the traditional argument that the retention of mother-tongue as the language of learning and teaching serves to achieve linguistic human rights, is insufficient. This is because the promotion of education in the medium of mother-tongue was used at different times in South African history for the achievement of very different and possibly even contrary, purposes (De Klerk, 2002).

During South Africa's apartheid regime, mother-tongue education was promoted as a means of reproducing social inequality and an aid to the construction of boundaries between various ethnic groups (De Klerk, 2002). After the election of the new South African government in 1994, national education reform ensued (Jansen & Taylor, 2003) and ever since, attempts have been made to employ the promotion of mother-tongue education for the purpose of empowering previously disadvantaged groups (De Klerk, 2002). Such attempts include the South African Constitution now providing a measure of protection for indigenous African languages through the raising of nine of them to the status of official languages, together with English and Afrikaans (Government of the Republic of South Africa, 1996). Furthermore, translating this to the level of the language of learning and teaching in schools, the Language in Education Policy promotes additive bilingualism and obliges each school to decide on its own language of learning and teaching from the eleven official languages (Department of Education, 1997).

While such initial displays of protecting and promoting indigenous languages were welcomed by the vast majority of South Africans, there was subsequently insufficient action taken by those in positions of power for materialising these goals – a characteristic criticism of many African leaders (Brock-Utne, 2002). In South Africa, evidence of this lack of concern manifested (and still manifests) in such forms as the lack of funding for the development of learner and teacher support materials in official languages other than English and the grade twelve final examinations being administered only in English and Afrikaans as described by Barry (2002). It is this disjuncture between the ideal and the implementation of measures for its achievement, which has provided grounds for the criticism that the recognition of eleven official languages as well as bilingual initiatives such as the language in education policy, are merely „symbolic' gestures (Barry, 2002, p.105; Probyn, 2006, p.391) which have failed to address the issue of educational equity in South Africa (Barry, 2002, p.105; Probyn, 2006, p.391; Brock-Utne, 2002; Gilmartin, 2004; De Wet, 2002; De Klerk, 2002).

Although the grade twelve examinations are administered in both English and Afrikaans, English is the language in which learner and teacher support materials are commonly available. This makes English as the language of learning and teaching, an attractive option both to schools and to English Second Language (ESL) learners despite the challenges which it presents to ESL learners. Furthermore, even in the event of the gradual development of learner and teacher support materials in official languages other than English, and the administering of the grade twelve final examinations in official languages other than English and Afrikaans, ESL learners together with their parents and teachers have been found to favour English as the language of learning and teaching for various other reasons (Barry, 2002; De Wet, 2002; Probyn, 2006). These reasons include the perception that English as the language of learning and teaching, is essential for economic empowerment (De Wet, 2002).

It thus appears that in South Africa, „discourses of language equality are now being replaced with discourses of utility' (Gilmartin, 2004, p.405) with the result that English „dominates the educational landscape in South Africa as „the language of access and power' (Probyn, 2006, p.391). This is problematic not only due to the lack of learner and teacher support materials in official languages other than English and the grade twelve final examinations only being administered in English and Afrikaans, but also due to the fact that in South Africa „a substantial number of teachers lack the necessary English language skills for effective teaching and learning' (De Wet, 2002, p.121).

In South Africa, the divide between the poor English proficiency of the majority of learners in township and rural schools, and the language demands of English as the language of learning and teaching has resulted in many teachers resorting to such teaching strategies as code-switching (Probyn, 2006). This is, however, not always beneficial to learners as evident in the example of the scientific terms „power', „force', „work' and „energy' - each having a specific meaning in scientific English, but all equating to a single term in isiZulu (Moji & Grayson, 1996). Hence, while code-switching may be useful as a pedagogic resource (Probyn, 2006), it could result in the loss of meaning in science subjects (Dempster & Reddy, 2007) such as Physical Sciences, negatively impacting on the quality of teaching and learning. The use of code-switching by science teachers, although not always successful, does serve to illustrate an idea central to this study as will become evident as we proceed – that if used in a particular way, language is a freely available pedagogical tool which can contribute to fixing the problems which it contributes to itself.

1.1.2. Scientific Literacy in the South African Natural Sciences and Physical Sciences Curriculum Statements

Other aspects of the education reform in South Africa following the election of the new South African government in 1994, include the highlighting of the importance of science (and mathematics) for the first time in South Africa in a White Paper on Education and Training (Department of Education, 1995) and new curriculum policy documents being written for school subjects which include the Natural Sciences and Physical Sciences. Physical Sciences is an umbrella subject in South Africa which encompasses both Chemistry and Physics. Natural Sciences is one of the compulsory learning areas covered from Grades one to nine and includes four strands – life and living, energy and change, matter and materials, and planet Earth and beyond. The Revised National Curriculum Statement for Natural Sciences foregrounds the promotion of scientific literacy (Department of Education, 2002), while the National Curriculum Statement for the Physical Sciences takes this a step further by declaring that the curriculum of Physical Sciences must „ensure increased access to scientific knowledge and scientific literacy' (Department of Education, 2003, p.9).

Such emphasis on the promotion of and increased access to, scientific literacy in the intended curriculum for Natural Sciences and Physical Sciences appears aligned to the thinking of curriculum implementers in that most science teachers agree that the purpose of school science is to develop learners' scientific literacy (Bybee, 1995). Miller (1983) presents a conceptual and empirical review of scientific literacy, in which he explains how confusion arises due to „literate' having two possible meanings – being learned, and being able to read and write. Miller's definition of scientific literacy in the „contemporary situation', includes three dimensions – understanding the nature of science, understanding science content knowledge and understanding and being aware of the impact of science and technology on society (Miller, 1983, p.31).

Laugksch (2000) provides a more recent conceptual overview of scientific literacy in which, in addition to Miller’s definition (Miller, 1983, p.31), he discusses such varying conceptions of scientific literacy as those of Pella, O' Hearn and Gale (1966), Branscomb (1981) and Shamos (1995). According to Pella *et al* (1966), a person who is scientifically literate understands the interrelationships of science and society, ethics that control the work of scientist, the nature of science, the difference between science and technology, basic concepts in science and the interrelationships of science and the humanities.

Branscomb (1981) turned to the Latin origins of the words „science’ and „literacy’, defining scientific literacy as the ability to read and write systematized human knowledge, as well as to understand it. Eight categories of scientific literacy are proposed by Branscomb (1981) – methodological, professional, universal, technological, amateur, journalistic, science policy and public science policy.

The three forms of scientific literacy proposed by Shamos (1995) are cultural, functional and true scientific literacy. According to this conception, cultural scientific literacy is the simplest form and is more passive than functional scientific literacy which requires a person to have a command of scientific vocabulary and be able to communicate and read coherently in a context which is non-technical but meaningful. True scientific literacy as proposed by

Shamos (1995) is unattainable by most people and includes, in addition to the aspects of the other two types, knowledge of the scientific enterprise.

While there may be overlaps between certain aspects of the different conceptions of scientific literacy, it is clear from the various conceptions that there is no consensus on what scientific literacy means, hence Laugksch (2000) stating that attempts at an explicit definition would be cause for controversy. Despite this, the advantages of scientific literacy are widely promoted (Laugksch & Spargo, 1999) and on a macro level are claimed to include such things as benefit to a country's economy, to the domain of science itself, to science policymaking, to democratic practices as well as to society in general (Laugksch, 2000). On a micro level the benefits of scientific literacy are claimed to include citizens being in an advantageous position to access high-paying technological and professional careers (Department of Education, 1995).

Laugksch and Spargo (1999) conducted a study to measure the scientific literacy of grade twelve South African learners, using a test of basic scientific literacy based on a report by the American Association for the Advancement of Science. They found that in South Africa, the subject Physical Sciences plays a significant role in improving scientific literacy (Laugksch & Spargo, 1999). Thus in terms of both the goals of policy and empirical evidence, the subject Physical Sciences in South Africa plays a crucial role in developing the scientific literacy of learners who choose to study this subject. However, there can only be equal opportunities for all Physical Sciences learners if they all have equal access to scientific literacy.

1.1.3. Language as a cause of Unequal Access to Scientific Literacy and thus Unequal Life Chances

The Constitution of the Republic of South Africa (Government of the Republic of South Africa, 1996) has anti-racism and anti-sexism as two of the five values on which it is based. It thus follows that there should be equal access to scientific literacy for South African Physical Sciences learners irrespective of their race or gender. However, in addition to racism and sexism, language is another avenue through which unequal access to scientific literacy may arise. In considering how language can result in unequal access to scientific literacy, two issues of concern are the „language of science' and the language of learning and teaching.

It can be argued that the language of science is the feature of science which most clearly separates it from other knowledge forms, and that „familiarity with the logical form and structure of the language of science' is one of the criteria for scientific literacy (Hodson, 2009, p.243). In fact, Wellington and Osborne (2001, p.139) assert that „knowing and understanding the language of science is an essential component of scientific literacy' and together with others such as Lemke (1990) suggests that it is also the biggest barrier. Halliday (Halliday & Martin, 1993, p.54) elaborates on the language of Physical Sciences, by explaining that scientific English is a „generalised functional variety' of language - a particular register of modern English. It becomes apparent why this register is problematic to learners when Fang (2004) mentions that the language of science is characterised by technicality, specialist grammar, high informational density, abstraction and authoritativeness.

The first characteristic - technicality, is „the most noticeable feature of scientific English' (O'Toole, 1996, in Mohan & Slater, 2005, p.156). Due to the language of science containing technical lexis, it is evident why understanding the specialised vocabulary of science is problematic for both English First Language (EFL) and ESL learners as mentioned by Wellington and Osborne (2001). However, considering that the learning of science subjects requires learners to be proficient in both the language of science and the language of instruction (Dempster & Reddy, 2007), ESL learners of Physical Sciences face additional challenges compared to their EFL counterparts in instances where English is the language of learning and teaching. For the reasons mentioned earlier, such instances are common in South Africa.

As Reddy (2006b, p.397) points out, although South Africa has numerous policies and programmes for improving the state of science education, „the ultimate indicator of success is the performance of learners'. South African learners achieved the lowest average score out of fifty countries participating in the Trends in International Mathematics and Science Study 2003 (TIMSS 2003) and also of all participating countries in the Third International Mathematics and Science Study 1995 (TIMSS 1995) and the Third International Mathematics and Science Study – Repeat 1999 (TIMSS-R 1999). Of all fifty countries participating in TIMSS 2003, the scores of South African learners also had the highest range (Reddy, 2006a) with learners from „African' schools achieving the lowest average scores and learners in the former „whites only' schools having the highest scores and an average close to the international average (Reddy, 2006a). This is convincing evidence that educational inequity still haunted South Africa almost a decade after the official end of apartheid, and may indeed still be haunting it almost two decades after the official end of apartheid.

Howie (2001, in Dempster & Reddy, 2007) and Reddy (2006a) point out that in the TIMSS 2003 study, the learners who did not learn in their mother-tongue performed significantly lower than those who did, and Dempster and Reddy (2007) found a relationship between the item readability of TIMSS 2003 questions and the achievement of learners. In addition to the evidence afforded by international studies such as TIMSS 1995, TIMSS-R 1999, TIMSS 2003, and results of education research, science learners themselves point to language as a factor impacting on their performance in the subject Physical Sciences. A recent South African study revealed that grade eleven Physical Sciences learners consider language to be a factor associated with poor performance in the grade twelve Physical Sciences examinations (Mji & Makgato, 2006). Barry (2002) sums up the effect of assessing of ESL learners in English as the already disadvantaged being further disadvantaged.

English as the language of learning and teaching for ESL Physical Sciences learners thus contributes to unequal access to scientific literacy and ultimately unequal life chances. Despite this, there is no indication that English will be replaced as the main language of learning and teaching in South Africa. The fact that English is likely to remain the main language of learning and teaching in South Africa and that the modelling and scaffolding of the use of scientific English by Physical Sciences teachers requires English proficiency, provide clear justification for the statement that training teachers on „how best to cope seems a matter of urgency' (Probyn, 2006, p.395).

Probyn (2006) reminds us of the need for teachers to understand the role which language plays in learning, in order to address the issue of equity and access. This is especially significant in countries such as South Africa where, as mentioned earlier, „a substantial number of teachers lack the necessary English language skills for effective teaching and learning' (De Wet, 2002, p.121). This provides a strong foundation for recommendations such as the one by Mawasha (1987, in De Wet, 2002) - that South African teachers, in addition to having a sound content knowledge base, should be required to be proficient in English.

In terms of the register of scientific English, both those who speak English as a second language and those who speak it as a first, are language learners. Abrams and Ferguson (2005, p.64) state that „language learners at all levels need specific scaffolding to build vocabulary and knowledge of language structures'. However, when English is the language of learning and teaching, a predominantly EFL class may require less language modelling and scaffolding compared to a predominantly ESL class due to differences in the overall English proficiency in these classes. Hence, the quality and quantity of scaffolding and modelling of scientific English occurring during Physical Sciences lessons can be expected to be strongly influenced by the language contexts of both the Physical Sciences teacher and the Physical Sciences learners.

1.**1.4. Language use by Teachers, and Pedagogical Content Knowledge**

Wellington and Osborne (2001) have asserted that giving greater attention to language is one of the most significant things that teachers can do for the quality of science education to improve. This supports Lemke's proposition that science teachers have the role of apprenticing learners into the use of science discourse (Lemke, 1990). Elaborating on the concept of apprenticeship of South African grade ten Physical Sciences learners, Gray (2007) discusses apprenticeship at the micro level of classroom interaction, apprenticeship and the role of the teacher and learner, apprenticeship and the regulation of the learner's behaviour, apprenticeship over time, and apprenticeship and the construction of the science learner. It is interesting to note that language plays a key role in all of these aspects of apprenticeship. Fang (2004, p.337) asserts that „learning the specialised language of science is synonymous with learning science'. This claim is supported by empirical evidence from the study by Mercer, Dawes, Wegerif and Sams (2004) which concluded that learners' use of language in particular ways enhances the learning of science.

In light of the above, it is evident that Physical Sciences teachers in South Africa can be viewed as teachers of scientific English. This places a huge responsibility on their shoulders considering that technicality often renders the language of science incomprehensible to learners, and that as mentioned earlier, a significant number of South African teachers are not sufficiently proficient in English for effective teaching and learning in this medium. The challenges which this poses to South African Physical Sciences teachers themselves and to those involved in their training and professional development, must be overcome since it is vital that learners be assisted in acquiring technical lexis, as „learning technical terms is central to success in much of academic discourse and schooling' (Mohan & Slater, 2005, p.156). In exploring what is needed in order for Physical Sciences teachers themselves as well as those involved in their training and professional development to improve access to scientific literacy in South Africa, it is useful to consider the types of teacher knowledge which literature reveals to be integral.

Zeidler (2002) mentions that a teachers' subject matter knowledge (SMK), pedagogical knowledge (PK) and pedagogical content knowledge (PCK) have been a central feature of education reform in science teacher education. According to Zeidler (2002, p.28), SMK can be described as „the quantity, quality, and organisation of information, conceptualisations, and underlying constructs in (the teacher's) major area of study'. PK refers to „a teacher's knowledge of generic instructional variables', while PCK „represents a teacher's ability to convey the underlying details and constructs in their field of specialisation in a manner that makes it accessible to their students' (Zeidler, 2002, p.28). While teachers require a strong command over other types of knowledge such as general cultural knowledge (GCK) and curricular knowledge (Shulman, 1986), „SMK, PK and PCK have remained at the forefront of what is essential to effective science teaching' (Zeidler, 2002, p.27) and of these three, it is PCK which has received increasing attention in recent years (Nakiboglu & Karakoc, 2005).

Zeidler's description of PCK (Zeidler, 2002) resonates with Shulman's notion of PCK making a subject „comprehensible' (Shulman, 1986, p.9). Such descriptions of PCK reveal it to be a form of knowledge crucial to South African Physical Sciences teachers for fulfilling their role in apprenticing learners into the use of scientific English. Wood, Bruner and Ross (1976) used the metaphor of „scaffolding' to describe the process in which the teacher aids learners who are attempting a task which originally appears beyond their ability to complete and Hodson (1999, p.247) refers to the „clear and skilful demonstration of expert practice' as modelling.

In South African Physical Sciences teaching then, PCK must involve a teacher both modelling the use of scientific English and scaffolding learners' attempts at constructing and deconstructing scientific English. Modelling is necessary for learners to gain exposure to the forms of scientific language used by the science discourse community and scaffolding is necessary for helping learners to work with such forms of language. Using the language of science entails, more specifically, writing and talking science (which in essence are processes associated with the „constructing' of science texts) and hearing and reading science (which in essence are processes associated with the „deconstructing' of science texts).

Seymour (2006, p.805) points out that the development of a teacher's PCK during the course of their teaching practice is „an often spoken claim that is not well documented or understood'. However, Seymour goes on to mention that classroom discourse analysis employing a branch of linguistics known as systemic functional linguistics can be used to provide evidence of a teacher's PCK (Seymour, 2006). The usefulness of employing a systemic functional linguistic perspective for a study such as the current one will be introduced in the rationale, before being discussed further in the literature review.

1.2. Rationale

A study exploring the nature of the utterances of South African Physical Sciences teachers will allow for more informed and thus meaningful pre-service and in-service development of PCK of Physical Sciences teachers in South Africa. This is critical for accomplishing the Physical Sciences National Curriculum Statement purpose of increased access to scientific literacy in order to contribute to equal life chances for all Physical Sciences learners.

Hodson (1999, in Roth & Barton, 2004, p.182) calls for science education to be „framed in socio-political terms if the science education community is to be successful in promoting a critically scientifically literate and just global society'. Systemic functional linguistics stems from sociolinguistics and „has been evolved as a tool for participating in political processes' (Halliday & Martin, 1993, p.22), enabling it to answer Hodson's call. In addition, the fact that it provides a model for the theory and practice of science in terms of language, makes it a well suited theoretical framework for this study.

Norris and Phillips (2003) refer to two „senses' of scientific literacy, reminding us of Miller's explanation from two decades earlier (Miller, 1983). The „fundamental sense' refers to the „ability to read/write science text' and the „derived sense' is explained as „knowledgeability about science'. The fact that the „derived' sense of scientific literacy relies on the „fundamental sense' is made clear when one considers that learners ideally progress from the „learning to read' stage to the „reading to learn' stage (Fang, 2006, p.491). The agreement of Blankley and Arnold (2001, p.69) with Fang (2006) as well as Norris and Phillips (2003), is evident in their recommendation that interventions aimed at improving scientific literacy „need to take into consideration the general lack of scientific vocabulary or scientific constructs that form the basis for the assimilation of scientific knowledge'.

In elaborating on the *functional* view of language, Fang (2004, p.336) mentions that scholars have shown language to be „an open-ended yet interlocking system of options' in which users make choices regarding the words and grammar used, based on their personal needs as well as the particular social context. Halliday (1993, in Fang, 2004, p.336) takes this further by stating that language is simultaneously „a part of reality, a shaper of reality, and a metaphor for reality'. This challenges the traditional, *formal* view of language which focuses on grammatical rules.

The perspective of systemic functional linguistics recognises the relationship between language and context, and it maintains that language itself is a tool for construing meaning (Halliday & Martin, 1993). Lemke (in Wellington & Osborne, 2001, pp.i-v) concurs by saying that „the forms of scientific language scaffold, support and channel our thinking, reasoning, insight and even our creative imagination'. This supports the claim that „learning the specialised language of science is synonymous with learning science' (Fang, 2004, p.337) and that Physical Sciences teachers in South Africa can be viewed as teachers of scientific English.

It is thus clear that South African Physical Sciences teachers play a crucial role in contributing to equal life chances for all Physical Sciences learners through the opportunity they have for employing the functional use of language to accomplish the Physical Sciences National Curriculum Statement purpose of increased access to scientific literacy. However, no published literature was found which explicitly explored this key aspect of a Physical Sciences teacher's PCK in the South African context. This provided a strong motivation for the undertaking of a systemic functional linguistic analysis of the utterances of South African Physical Sciences teachers.

Chapter 2: Literature Review

2.1. Introduction

The thread of concepts that are central to this study has emerged in the introduction and rationale chapter as follows:

- in order for all South African Physical Sciences learners to have equal life chances, the South African Physical Sciences National Curriculum Statement aim of increasing access to scientific literacy needs to be realised
- the challenges to achieving this include the domination of English in South Africa's linguistically diverse landscape while many South African teachers are not adequately proficient in this language
- while language gives rise to challenges, used functionally it becomes a freely available pedagogic tool for apprenticing learners into the discourse of science
- the modelling and scaffolding of scientific English is an aspect of the PCK of Physical Sciences teachers and so exploring it would be useful for both the professional development of existing Physical Sciences teachers and the training of future Physical Sciences teachers
- Systemic functional linguistics provides a useful framework for identifying the modelling and scaffolding of scientific English as part of the PCK of science teachers in practice

A review of some literature relevant to the core concepts will be presented in this chapter. The origin and evolution of the concept of scientific literacy will first be focused on before highlighting the link between scientific literacy and the South African Physical Sciences

National Curriculum Statement. Thereafter, different views on science education will be discussed before zoning in on sociocultural theory. An overview of sociocultural perspectives in science education and the link between sociocultural perspectives, systemic functional linguistics and scaffolding, follows. The chapter will conclude by discussing studies in science education employing systemic functional linguistics as a theoretical framework.

2.2. Origin and Evolution of the Concept of 'Scientific Literacy'

Paul Hurd was one of the first people to use the phrase „scientific literacy' (De Boer, 1991), in a publication proposing what it meant for American schools. Hurd wrote „the immediate problem is one of closing the gap between the wealth of scientific achievement and the poverty of scientific literacy' (Hurd, 1958, p.14). Scientific literacy is often regarded as being synonymous with „public understanding of science' and „stands for what the general public ought to know about science' (Durant, 1993, in Laugksch, 2000, p.71). In addition to the reasons mentioned earlier, conflict arises surrounding the definition of the term nowadays due to differing views about who „the public' is and what exactly they need to know about science (Laugksch, 2000).

Scientific literacy originally received much attention as the perceived solution to improved public support for science in order for America to compete in the space race. It was also perceived as having the ability to address concerns about whether American children were being adequately prepared for the increasingly scientific and technological world. The dual nature of its purpose spurred authors to promote various aspects associated with it, which in turn resulted in there now being various meanings attached to the term (Laugksch, 2000).

The numerous interpretations of scientific literacy resulted in it becoming „an umbrella concept to signify comprehensiveness in the purposes of science teaching in the schools' (Roberts, 1983, in Laugksch, 2000, p.73). Despite the diverse meanings attached to the term, there is now common acknowledgement that it involves the three dimensions proposed by Miller (1983): „an understanding of the norms and processes of science, an understanding of key scientific terms and concepts, and an appreciation of the impact of science and technology on society' (Laugksch & Spargo, 1999, p.427).

2.3. Scientific Literacy and the South African Physical Sciences National Curriculum Statement

It is appropriate at this point to shift focus to the Physical Sciences National Curriculum Statement. This is because, in addition to it declaring that the curriculum of Physical Sciences must „ensure increased access to scientific knowledge and scientific literacy' (Department of Education, 2003, p.9), there is a correlation between its learning outcomes and the three dimensions of scientific literacy. The Physical Sciences National Curriculum Statement has three focus areas identified in the scope of the document: „scientific inquiry and problem solving in a variety of…contexts', „the construction and application of scientific and technological knowledge' and „the nature of science and its relationship to technology, society and the environment' (Department of Education, 2003, p.10).

The focus areas of the Physical Sciences National Curriculum Statement are aligned to its three learning outcomes. Learning outcome 1 is „Practical Scientific Inquiry and Problem-solving Skills' and is orientated to the first dimension of scientific literacy - understanding the conventions and processes of science. „Constructing and Applying Scientific Knowledge' is learning outcome 2 and is orientated to the second dimension of scientific literacy - understanding the key terminology and concepts of science. Learning outcome 3 is „The Nature of Science and its Relationship to Technology, Society and the Environment' and is orientated to the third dimension of scientific literacy - appreciating the impact of science on technology and society (Department of Education, 2003, p.17).

Initially, it was believed that the overlap between the learning outcomes of the Physical Sciences National Curriculum Statement and the three dimensions of scientific literacy would have important implications for the methodology of the current study (Appendices 5 and 6). However, the learning outcomes of the Physical Sciences National Curriculum Statement arise from the lens of science as a process rather than science as a language. In a study of teacher talk and meaning making in science classrooms, Scott (1998, p.72) found that while some research studies do refer to particular instructional activities, „the way in which the teacher "talks around the activity" is at least as important as the activity itself'. Thus, since the current study is employing the lens of science as a language, the learning outcomes of the Physical Sciences National Curriculum Statement – due to their foundations in the view of science as a process, do not feature strongly in the methodology for this study.

2.4. Different views on Science Education

According to Piaget and those with related cognitive science perspectives, the successful prediction of learner responses to the teaching of science requires an understanding of the knowledge of learners' existing ideas. Such perspectives view the learning of science as essentially involving alteration of an individual's mental structures and can thus be referred to as individual views of learning (Leach & Scott, 2003). However, there has been a subsequent shift in focus evident in research on science teaching and learning, which has mirrored the changing focus in Psychology, from the individual view of learning to the construction of meaning as a product of social process between individuals or between individuals and cultural products available in such sources as books - the sociocultural view (Leach & Scott, 2003).

In a paper which considers how learning theories inform science teaching, Leach and Scott (2003) discuss how aspects of both major strands of learning theory – the sociocultural view as well as the individual view of learning in science education, can inform the study and practice of science teaching. Individual views on learning science afford us tools for exploring why students have difficulty internalising particular aspects of the social language of science and may be useful in the identification of new curricular aims for particular topics in science (Leach & Scott, 2003). Sociocultural views of science on the other hand, focus our attention on how scientific knowledge is „talked into existence' (Ogborn, Kress, Martins & McGillicuddy, 1996, in Leach & Scott, 2003) for illustrating how discourse on the social plane is controlled by science teachers in their classrooms and for considering how students learn in response to teaching (Leach & Scott, 2003).

Through the cognitive science lens, learner knowledge consists of mental objects referred to by researchers using different names for these mental structures, such as: conceptual structure, concept, phenomenological primitives, co-ordination class, conceptual ecology and initial and synthetic models (Leach & Scott, 2003). In explaining how these structures change, various conceptual change theories have been proposed but according to Leach and Scott (2003), individual views on learning such as those of Vosniadou and associates

(Vosniadou & Brewer, 1992; Vosniadou & Ioannides, 1998) are less suited for understanding the process of learning science in formal settings such as science classrooms, than in cultural settings.

Leach and Scott (2003) point out that in science education research there has a been movement away from studying learning separately from teaching and that it is necessary to employ sociocultural views in broaching the issue of how teacher behaviour impacts on student learning. Our attention is drawn to Bakhtin's approach to discourse analysis where the different modes of discourse used in different parts of society are referred to as social languages. Each social language is ‚a dialect used in a particular geographical area, or a particular form of professional jargon or indeed the way of talking about the natural world which is termed science' (Leach & Scott, 2003, p.99).

Furthermore, Leach and Scott (2003) mention that the scientific social language which is a particular way of talking and thinking as developed by the scientific community, needs to be internalised by science learners. In the process of internalisation, these learners will become adept in the individual use of conceptual tools they were first exposed to on the social plane. The internalisation process is followed by language providing the tools required for individual thinking. This resonates with the notion of fundamental and derived scientific literacy mentioned by Norris and Phillips (2003) and elaborated on by Fang (2006).

2.5. Sociocultural Theory

Emerson (1983, p.245) reminds us of the statement by Foucault, that „Language is no longer linked to the knowing of things, but to men's freedom', in a paper discussing some ideas of Bakhtin and Vygotsky on the internalisation of language. This reiterates that language is linked to empowerment and that the current concerns in South Africa over language and equal life chances mentioned in Chapter 1 are not entirely new or unique.

Foucault also described two seemingly opposing views of language – that it is a medium for deducing a metalanguage and for constructing statistical and mechanical models, and that it is a product of the individual psyche and also subject to psychic transformation (Emerson, 1983). A century later, these views were being re-evaluated due to de Saussure's contribution of the binary oppositions of langue and parole, with language moving „from the realm of naming to the realm of relationships (Emerson, 1983, p.246). Ferdinand de Saussure used „langue' for language as a system employed by a speech community and „parole' for language as the utterances of individuals (Jackson, 2007).

According to Emerson (1983, p.249), such researchers as Mikhail Bakhtin, Valentin Volosinov and Pavel Medvedev objected to the apparent opposition of the individual and social which was fundamental to the langue/parole schema. Their reasons for objecting are apparent in Bakhtin's description of transitions occurring „from "social intercourse" to "outer speech", and from "outer speech" to "inner speech" and to consciousness'. While Bakhtin was at odds with Freud's emphasis on searching within individuals for the answers to what both had observed, it was Lev Vygotsky who provided empirical, documented evidence of the social construction of language (Emerson, 1983). Vygotsky argued that a child's „Zone of

Proximal Development', where real learning occurs, is reached by posing challenges to the child which the child does not have the capacity to solve alone, and then making help available from those who are more knowledgeable (Emerson, 1983).

Vygotsky's conclusion about private and socialised speech, that „development in thinking' „is not from the individual to the socialised but from the social to the individual', was contrary to Piaget's assertion regarding the direction of development (Emerson, 1983). Furthermore, Vygotsky concluded that there is a dynamic interaction between speech and behaviour, with speech first accompanying action, later preceding it and finally displacing it (Emerson, 1983). For Vygotsky the idea that language is the greatest tool available to man for communication with the outside world and extracting from it, implied that it should be studied in authentic social contexts and for both Bakhtin and Vygotsky „the word…is a tool of pedagogy' (Emerson, 1983, p.257).

2.6. Sociocultural Perspectives in Science Education

In proposing a practical and holistic vision for twenty first century science education, Carter (2008) describes sociocultural influences on science education as innovations for contemporary times. Lemke (2001, p.296) elaborates on what a sociocultural perspective in science education involves: „viewing science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks'. According to sociocultural theory, interpersonal social reactions such as collaboration in a laboratory or the dialogue in a science classroom is only possible due to our growing up and living within larger-scale social organisations or institutions. Our lives within these institutions provide us with the tools for making sense both of, and to, the individuals around us. These tools – „our social semiotic resource systems' (which include such things as languages, pictorial conventions and specialised discourse) as a collective, with socially meaningful ways of operating them, together constitute what is known as the culture of a community (Lemke, 2001, p.296).

Science education together with all the social sciences in the late twentieth century, turned to linguistics. Researchers began exploring how we learn to talk and write the languages of science and effectively engage in science's wide range of „subculturally specific activities' such as experimenting and publishing as well as „signifying practices' such as data tabulation and graphing (Lemke, 2001, p.298). However, rather than the Chomskyan view of language as a machine for correct syntax, for researchers such as Halliday who were studying the functions of language in social contexts, the view that language is a „culturally transmitted resource for making meaning socially' began to emerge (Lemke, 2001, p.298).

Lemke (2001, p.298) also points out that language is only one possible tool since science and learning science are „best characterised by their richness of linguistic, mathematical, and visual representations'. While this may be true, it is important to note that the scaffolding provided by the teacher is most often in the form of talk and „the teacher's words support the learners' thoughts and actions' (Dawes, 2004). Howe (1996) points out that taking cognisance of the Vygotskian perspective impacts on the perceptions of the role language plays in teaching science. A sociocultural perspective „relies on language as a tool to support and promote thinking, using it as a means to stimulate pupils to reflect and explain in order to understand how their experiences and their context-bound knowledge fit into a larger structure' (Howe, 1996, p.47).

Lemke (2001, p.301) reminds us that not only are the tools for living obtained through social interactions, but the consequences of making decisions about the types of knowledge to be internalised are also social, since „in a community, individuals are not simply free to change their minds'. This highlights weaknesses in conceptual change theories and also a potential cause of learner difficulties in internalising the language of science (Lemke, 2001).

2.7. Sociocultural Perspectives, Systemic Functional Linguistics and Scaffolding

Since „human beings are quintessentially creatures who mean', it is natural that all learning by humans is basically semiotic (Halliday, 1993, p.93). Building further on this, Halliday (1993) points out the anomaly that while educational knowledge is largely dependent on verbal learning, this has not been taken into account in the theories of learning. This is because they have not been specifically based on results of studies into children's language development. Apart from the academic field of Linguistics, „language is not a domain of human knowledge…language is the essential knowledge of knowing, the process by which experience becomes knowledge' and this is the basis for Halliday (1993, p.94) proposing a language-based theory of learning.

The two constraints for a language-based theory of learning, arising from it viewing learning as being inherently a semiotic process, are that it should be based on natural and not empirical data and that it should not separate system and instance as embodied in such oppositional pairs as language and text, and langue and parole (Halliday, 1993). In suggesting considerations for such a theory, Halliday (1993) derives from research, twenty one features of child language development which he believes are critical to a language-based theory of learning. Among these, Halliday discusses the three metafunctional features of language which are expanded on later in this thesis: the interpersonal, ideational and textual functions, and proposes the adoption of a threefold perspective for learning - „learning language, learning through language and learning about language' (Halliday, 1993).

Halliday (1993, p.113) also mentions that the two unifying principles that need to be recognized for the threefold perspective are the developmental continuity over the stages in an individual's life and the „structural continuity running through all components and processes of learning'. We are told that these two continuities can be captured in a theory of learning by viewing learning in a semiotic way – that „learning is learning to mean, and to expand one's meaning potential' (Halliday, 1993, p.113).

Wells (1994) reveals that the two researchers who have had the greatest influence on his work on language and learning are Halliday and Vygotsky. Accepting an invitation to respond to Halliday (1993), Wells (1994, p.41) discusses „the complementary contributions of Halliday and Vygotsky to a language–based theory of learning'. By referring to relevant papers by Halliday and Vygotsky, Wells (1994) concludes that a comparison of their contributions shows them to be more aligned than different and not only compatible but also, due to the psychological orientation of Vygotsky and the linguistic orientation of Halliday, complementary in building a more comprehensive language-based theory of learning.

The sociocultural notion of scaffolding is unpacked by Sharpe (2006, p.211) who employed systemic functional linguistics to „articulate the kinds of discourse and multimodal strategies that constitute the nature of scaffolding'. In elaborating on the twofold nature of scaffolding, Sharpe (2006) distinguishes between the scaffolding which operates at a macro-level and the type which operates at a micro-level. The macro-level of „designed-in scaffolding' refers to such things as the overall design of the unit of work being taught and takes into account such things as the language demands of the tasks in the unit while the micro-level or „contingent scaffolding' refers to the strategies employed by the teacher at the point where they are needed by the learner(s) in a lesson and includes such things as recasting (Sharpe, 2006, p.213). Recasting will be discussed in detail further in this study. While constructing the zone of proximal development happens not only through the use of language but also through such semiotic modalities as body language and diagrams, „both designed-in and contingent (scaffolding) are based largely on language in its various modes' (Sharpe, 2006, p.213).

2.8. Studies in Science Education employing Systemic Functional Linguistics as a Theoretical Framework

Since this study aims to explore the utterances of science teachers from the perspective of systemic functional linguistics, literature surrounding similar studies was surveyed. In an attempt to maintain a coherent discussion here and prevent repetition between this chapter and Chapter 3, some of the concepts raised in this section will only be fully defined and elaborated on in Chapter 3. This sequence resembles more closely, the actual path followed in undertaking the current study as will now be outlined before discussing other relevant studies.

A preliminary literature survey provided a strong rationale for the current study which in turn provided grounds for an in-depth literature review. This review alerted the researcher to functional language features of particular usefulness in science education. The researcher subsequently reviewed further literature describing these in order to locate them in the broader systemic functional linguistics framework. Only then, were the particular systemic functional linguistic features employed in the analysis of the research data collected for this study in order to answer the current research questions.

Mohan and Beckett (2003) analysed the scaffolding of grammar by teachers for second language learners, using a systemic functional linguistic approach. Their study sheds light on recasts (instances where teachers employ different verbal representations) and grammatical metaphor (uncommon/unexpected forms), as well as on the relationship between these functional language features. Improving learners' ability to move between expected forms and grammatically metaphorical forms involves teachers appropriately modelling and scaffolding the usage and unpacking of the particular types of grammatical metaphor referred to as **nominalisation**.

Before looking further at recasts, an important property of text linked to nominalisation needs to be mentioned. Nominalisation impacts on the **lexical density** of a text that, according to Halliday and Martin (1993), refers to the density of information which can be measured as the number of lexical (content) words per clause. Although the lexical density may vary greatly from one clause to the next, there are general tendencies. The lexical density of informal verbal language is usually about two lexical words per clause, while language which is more formal and planned has a higher lexical density. The greater the lexical density, the greater the difficulty experienced by learners in understanding it (Halliday & Martin, 1993). Lexical density is thus an important aspect of the nature of language that characterises the verbal exchange between Physical Sciences teachers and their learners during Physical Sciences lessons.

In the study by Mohan and Beckett (2003), it was found that **functional recasting** plays a role in grammatical scaffolding, helping learners to move between expected or „congruent' forms of language and unexpected or „non-congruent' forms (Mohan & Beckett, 2003, p.87). Their study alerts us to two types of functional recasts - improvement recasts and repair recasts. Improvement recasts can be used by teachers to suggest less congruent (grammatically metaphoric) forms of language and to suggest more compact forms of language to construct abstraction and technicality. Repair recasts on the other hand, are aimed at correcting learners' incorrect attempts at constructing less congruent forms and may involve the teacher moving from the less congruent form to a more congruent form to de-construct abstraction and technicality.

Other studies illustrate that functional recasting also serves purposes other than those mentioned above. In a paper by Mohan and Slater (2006) which focused on using systemic functional linguistics for analysing the relationship between theory and practice in a high school science register, the researchers illustrate how functional recasting can be used to change learners' responses from ones which answer a practical question to one which answers a theory question - thereby constructing a theory/ practice relationship. Mohan and Slater (2005) focused on this relationship in a primary school. In describing their study, the researchers mention that it is important for teachers to construct the theory-practice relationship with learners. This is because „the theory-practice dynamic is a central process in research and in learning' and, especially for ESL learners, it is a challenge „relating hands-on-experience to minds-on-understanding' (Mohan & Slater, 2005, p.170).

The study by Mohan and Slater (2006) showed that the theory-practice relationship is also constructed through the functional language feature of **lexical cohesion.** In addition to functional recasting, the study by Green (2007) focused on lexical cohesion as a linguistic feature for developing learners' technical lexis. In a study discussing some central linguistic processes used in the teaching of science, Rodrigues and Thompson (2001) analysed the language used by two science teachers to identify textual cohesion during different pedagogical moves. Their study involved separating the words used by teachers into two groups: those which were related to each other through some category, and those which were not. They then used the **cohesive harmony index,** which is the proportion of words interacting together (relating to the topic or field of the text) to the total number of words, to measure the degree of cohesion.

Rodrigues and Thompson (2001) mention that both inadequate as well as excessive cohesion make text difficult to comprehend. Their conclusions include that excessive cohesion results in texts appearing pedantic while a lack of cohesion, particularly in the talk of science teachers, results in learners not understanding the science or the need for undertaking certain classroom tasks. The cohesive harmony index is thus another important aspect of the nature of language that characterises the verbal exchange between teachers and their learners during Physical Sciences lessons.

This review of literature describing studies involving systemic functional linguistics has identified nominalisation, functional recasting and lexical cohesion as functional language features which are significant to science education. They thus feature strongly in the research design and methodology for the current study, together with lexical density which is associated with nominalisation, and the cohesive harmony index which is associated with lexical cohesion.

Chapter 3: Theoretical Framework and Methodology

3.1. Introduction

The theoretical framework employed in this study is systemic functional linguistics as described by Halliday and Martin (1993), Martin and Rose (2007) and Eggins (2004). In this chapter, an attempt to integrate these complementary works as well as others, to construct an overview of the theoretical framework and then identify the relative location of the functional language features of nominalisation, functional recasting and lexical cohesion within it, is first presented. Drawing from the introduction and rationale, literature review and theoretical framework, the research focus will then be outlined and the research questions which the current study attempts to answer will be stated, together with the hypothesis and predictions. Research methodology will then be discussed and the rationale for employing the pragmatic paradigm and a mixed-methods approach will be presented. Next, the data collection, preparation and analysis will be described and lastly, research ethics will be discussed.

3.2. Systemic Functional Linguistics as the Theoretical Framework

3.2.1. Social Context and Language

According to Halliday and Martin (1993, p.23), systemic functional linguistics is orientated to „an elaborate model in which language, life, the universe and everything can be viewed in communicative terms'. In his model of the systemic functional linguistics perspective, Martin highlights the idea that social context is realised by language and that it is stratified, with ideology being realised through genre which itself is realised through register (Halliday & Martin, 1993). The levels of social context will be described individually, after considering their respective levels in the model of the stratification of social context illustrated in Figure 1.

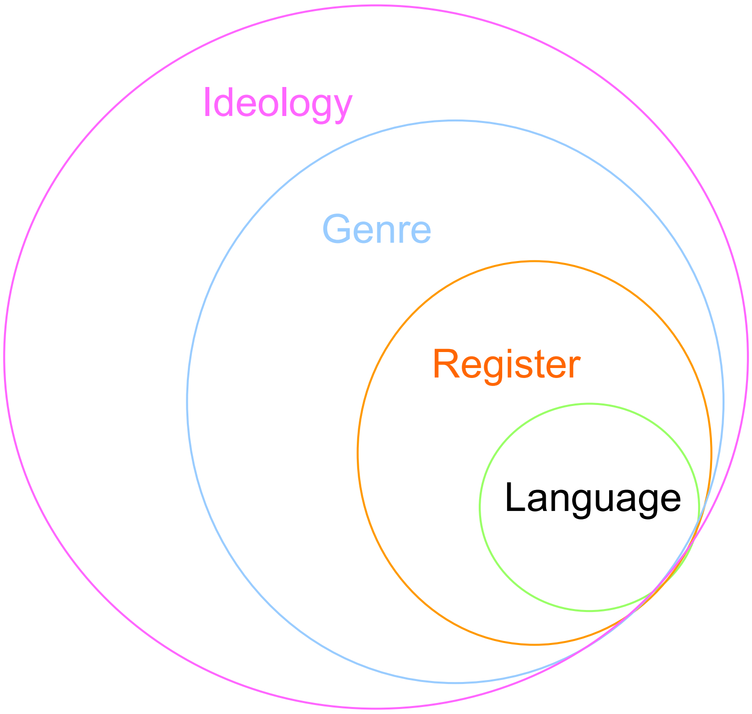

Figure 1: The stratification of social context (Halliday & Martin, 1993, p.38)

The concentric circles symbolise the notion of realisation between language and the ideology, genre and register levels of social context – that „language construes, is construed by, and (over time) reconstrues and is reconstrued by, social context' (Halliday & Martin, 1993, p.24). Martin and Rose (2007) describe realisation as a type of re-coding or symbolisation. Eggins (2004) elaborates further on the notion of realisation by indicating one way in which language and context are interrelated – context can be deduced from text.

3.2.2. Ideology

The ideology level of social context in the systemic functional linguistics model focuses on social subjectivity – the manner in which speakers are positioned in terms of meaning potential in their culture, by discourses such as those of class and ethnicity (Halliday & Martin, 1993). Our ideological positions refer to „the values we hold (consciously or unconsciously), the perspectives acquired through our path through the culture' (Eggins, 2004, p.10). Eggins (2004, pp.11, 23) points out that texts – defined as „authentic products of social interaction', are never ideology-free because „to use language at all is to use it to encode particular positions and values' and that increasing attention is being given to this higher level of social context, using systemic functional linguistics.

3.2.3. Genre

In systemic functional linguistics, genre is a level of social context which is less abstract than ideology but more abstract than register, and it refers to goal-orientated social processes which follow particular stages (Eggins, 2004; Halliday & Martin, 1993; Martin & Rose, 2007). The genre theory or concept is employed to describe how the *context of culture* impacts on language. An example of a genre is an academic thesis and while some additional stages are sometimes included or peripheral ones omitted, the common stages in the academic thesis genre as reflected in the current one are title, abstract, introduction and rationale, literature review, theoretical framework and methodology, results, discussion, conclusion and recommendations, and references. Being able to recognise genre has important implications for text analysis and it is usually problematic texts which cannot be attributed to a particular genre (Eggins, 2004).

3.2.4. Register and the Metafunctions

The lowest level of social context and thus the level with the least abstraction in the systemic functional linguistics model of social stratification, is register. Register refers to „a generalised functional variety' of language such as „scientific English' (Halliday & Martin, 1993, p.54). In contrast to genre theory, register theory is employed for describing the way in which aspects of the immediate *context of situation* impact on how language is used (Eggins, 2004). It is at the register level of social context that the current study is situated and it is thus aspects of register which feature strongly in the methodology. Register encompasses three metafunctions (Halliday & Martin, 1993) as illustrated in Figure 2.

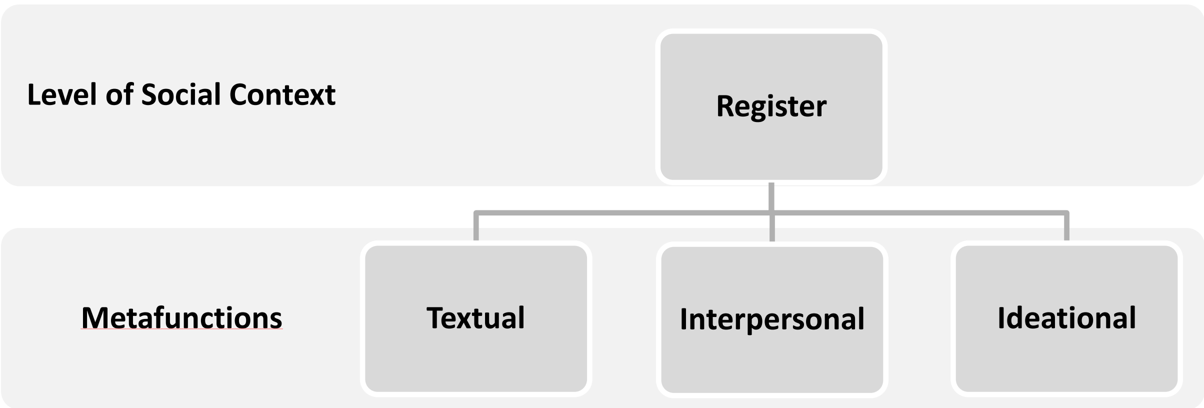

Figure 2: The three metafunctions of the register level of social context (Halliday & Martin, 1993)

The textual meaning (or mode) refers to the symbolic organisation of language and includes whether the language is written or spoken. The interpersonal meaning (or tenor) involves the role structure evident in the language and refers to the status of participants as well as the relationships between them. The ideational meaning (or field) is an indication of the particular social action which participants are engaged in, in which language is an essential component (Halliday & Martin, 1993). These three general social functions of language are interwoven to the extent that they are simultaneously achieved (Martin & Rose, 2007).

In systemic functional linguistics, texts include both spoken and written language. As mentioned earlier, texts are authentic products of social interaction. A property known as texture distinguishes between text and „non-text' and it involves the interaction between coherence and cohesion. Coherence refers to the relationship between the text and the social and cultural context of its occurrence, while cohesion refers to the way in which the different elements within a text tie it together to form a „unified whole' (Eggins. 2004, p.24).

Martin (in Halliday & Martin, 1993, p.266) suggests that „the texture of scientific discourse is orientated to field' and that field consists of lexis (a lexicon of technical terms) as well as grammar (logical sequences of logical reasoning). While everyday words or lexis, together with specialised lexis (which is found only in particular discourses) refer to concrete things, technical lexis refers to abstract concepts (Martin & Rose, 2003, in Mohan & Slater, 2005). This suggests that technical lexis is more difficult for learners to acquire. Like specialised lexis, technical lexis is accessible only to members of a particular discourse (Martin, 2006, in Green, 2007). Scientists and science teachers commonly have access to the technical lexis of scientific discourse, and science teachers can thus be likened to one of two gatekeepers of the language of science.

3.2.5. Discourse Systems of the Metafunctions

According to Martin and Rose (2007) there are six discourse systems – sets of meaning which serve the metafunctions of a register such as scientific English. These are shown in Figure 3.

Those interested in the textual and interpersonal metafunctions are referred to the work of Halliday and Martin (1993) and Martin and Rose (2007), as it is the ideational metafunction and the ideation discourse system in particular, which is relevant to this study and thus the focus of attention henceforth. The conjunction discourse system of the ideational metafunction focuses on how activities are interconnected and can be described as logical ideational meanings. The ideation discourse system of the ideational metafunction is concerned with the construal of experience and it focuses on *activity sequences* between the entities or participants of a field of experience, the *taxonomic relations* - chains of relations between words, and *nuclear relations* - the relationships between the words within a clause (Martin & Rose, 2007). These are illustrated in Figure 4.

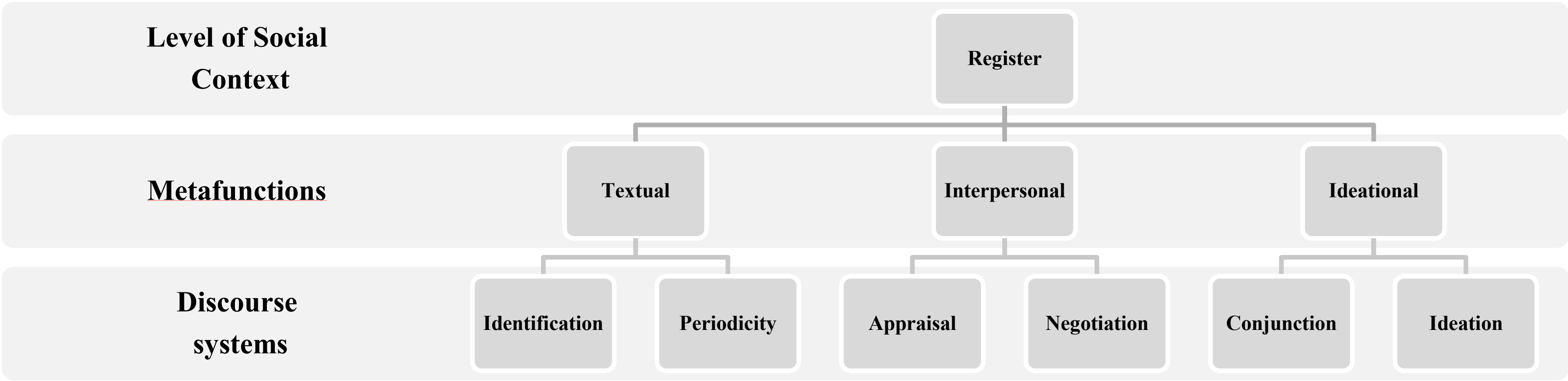

Figure 3: The discourse systems of the metafunctions of register (Martin & Rose, 2007)

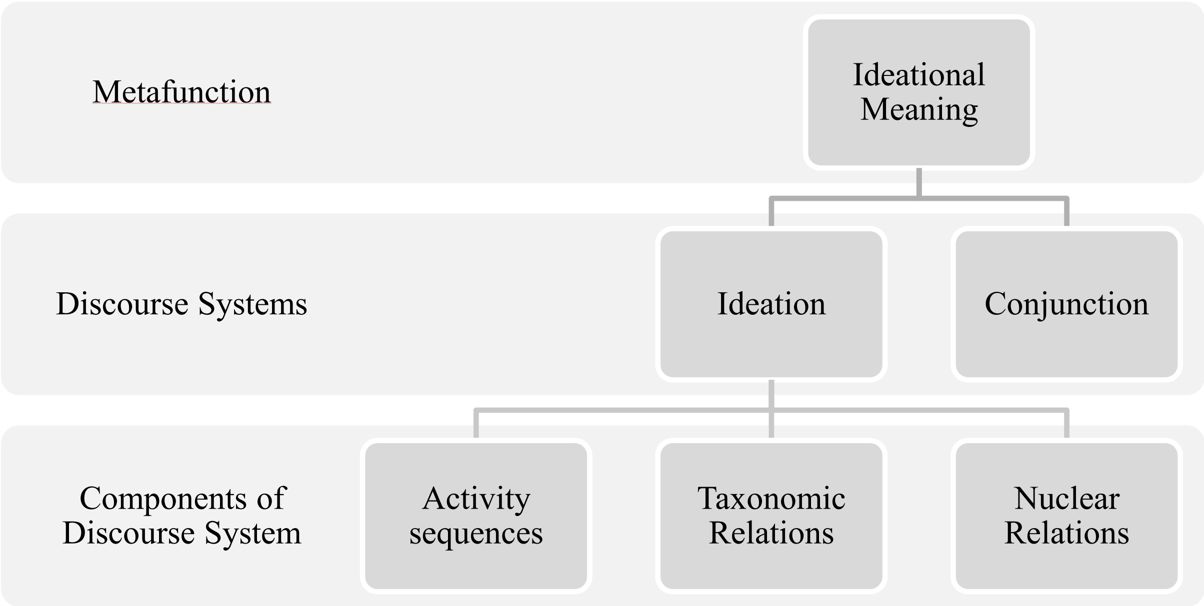

Figure 4: Components of the ideation discourse system of the ideational metafunction

(Martin & Rose, 2007)

Now that the theoretical framework has been outlined, the relative location of nominalisation, aspects of lexical cohesion, and functional recasting within the theoretical framework will be discussed.

3.2.6. Locating Nominalisation in the Systemic Functional Linguistics Framework

Nominalisation is an aspect of the activity sequences contributing to the ideation discourse system (Martin & Rose, 2007) and English nominalisations in science thus serves the field metafunction of scientific English. Nominalisation is the type of grammatical metaphor which involves substituting a more obvious grammatical structure (a congruent form) with another less obvious structure (a non-congruent form). An example of a congruent form is „he departed' while a non-congruent equivalent would be „his departure' (Halliday & Martin, 1993, p.79). In these examples, the action of departing has changed from the more expected structure of a verb - departed, to the less expected structure of a noun - departure.

Unsworth (1998) alerts us to the usefulness of grammatical metaphor as a significant resource in constructing technicality and in facilitating the development of chains of reasoning. It is thus evident why learners' ability to control non-congruence or grammatical metaphor is essential for the construction of both academic discourse and written language (Mohan & Beckett, 2003). However, despite its importance, the frequent use of grammatical metaphor is one of the most pervasive „problematic lexicogrammatical features of scientific English' (Halliday & Martin, 1993, p.79).

Nominalisation is the most extensively used type of grammatical metaphor in scientific writing and „involves actions, events and qualities being construed as nouns' (Parkinson & Adendorff, 2005, p.288). Fang (2004, p.339) explains that nominalisation is useful in scientific language as it „theorizes concrete life experiences into abstract entities, which can then be further examined and critiqued' but that it can create problems as „it tends to neutralize or obscure meanings'. Since grammatical metaphor is simultaneously useful and challenging, it is crucial for teachers to model the use of its most common manifestation – nominalisation, and to scaffold learners' attempts to work with nominalisation.

3.2.7. Locating Lexical Cohesion in the Systemic Functional Linguistics model

In elaborating on the concept of „text', Halliday and Hasan (1976) suggest that it is a semantic unit in which the parts are linked by cohesive ties. It is thus the cohesion aspect of texture, which defines a text as being a text (Witte & Faigley, 1981). In proposing a taxonomy of cohesive ties according to function, Halliday and Hasan (1976) highlight five main categories of cohesive ties. These are shown in Figure 5.

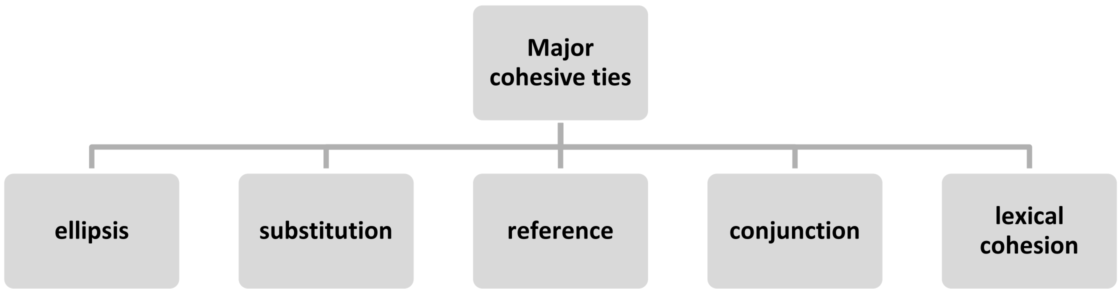

Figure 5: The five main categories of cohesive ties (Halliday & Hasan, 1976)

Ellipsis refers to the deletion of a word, phrase or clause and substitution refers to the replacement of one item with another item that is not a personal pronoun. Reference involves one element in a text referring to another for its interpretation. While conjunctive elements themselves are not cohesive, they „express certain meanings which presuppose the presence of other components in the discourse' (Halliday & Hasan, 1976). Lexical cohesion is the main tool for connecting sentences in discourse and consists of the subclasses of collocation, and reiteration, which itself is divided into subclasses. This is illustrated in Figure 6.

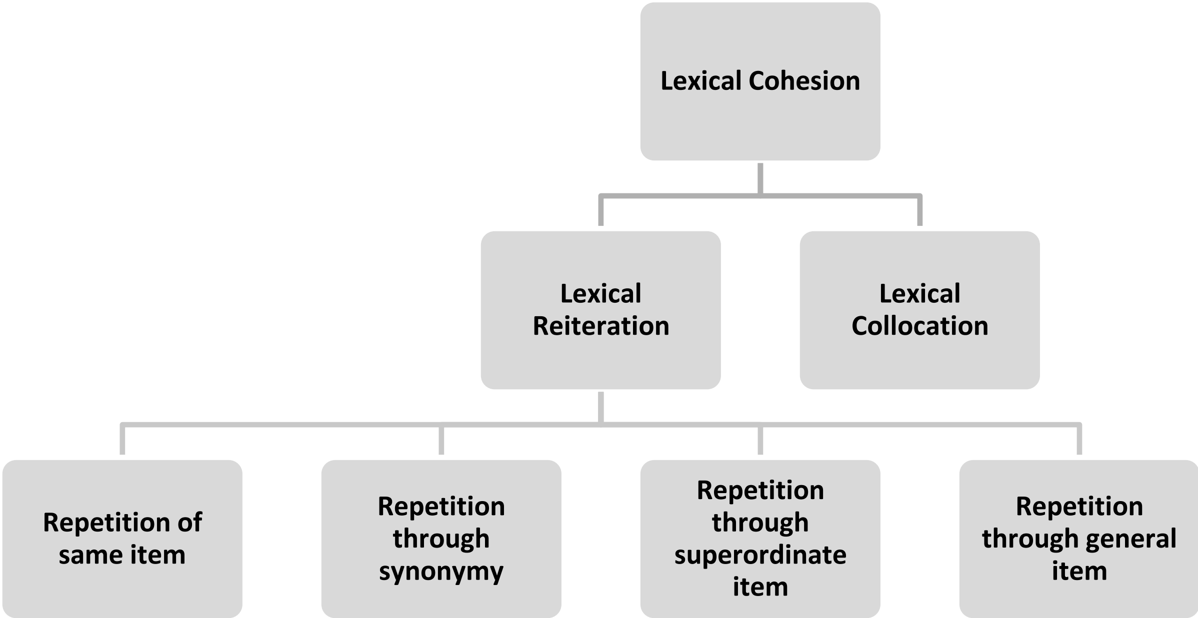

Figure 6: The subclasses of lexical cohesion and of lexical reiteration (Halliday & Hasan, 1976)

Lexical cohesion is a linguistic feature described by Halliday (1985) as continuity in text achieved through the particular choice of words used. Various types of repetition, synonymy and collocation are aspects of lexical cohesion (Halliday & Martin, 1993) which has been introduced earlier, in the literature review. Taxonomic relations contributing to ideation include repetition, while nuclear relations include collocation (Martin & Rose, 2007). Collocation involves the use of words which are related other than in those covered by synonymy (Halliday, 1985), and collocating items are those which „share the same lexical environment' (Halliday & Hasan, 1976).

The current study takes cognisance of the argument by Hasan (1984, in Cox, 1990), that the manner in which cohesion creates meaning is inadequately represented by merely counting repetitions. The current study thus includes a calculation of cohesive harmony index, based on the concept developed by Hasan (1984, in Cox, 1990), and introduced in Chapter 2.

3.2.8. Locating Functional Recasting in the Systemic Functional Linguistics Framework

Green (2007) elaborates on the field metafunction of language by explaining that it is composed of two components – lexicon (the words and meanings) and the logical sequences of logical reasoning (the grammar), and warns against viewing them as separate entities but rather as interacting together in constructing the discourse of science. Green further proposes two ways in which science teachers use grammar to construct technical lexis – lexical cohesion, which has already been introduced and discussed, and functional recasting, which is a functional language feature mediating between words and grammar and useful for constructing technicality.

Mohan and Beckett (2003, pp.423-424) alert us to two perspectives on recasts, those which „focus on form' and those which „focus on form and meaning'. A recast focusing on *form* would for example, involve the teacher paraphrasing a learner's statement to edit the grammar purely to ensure it conforms to the rules of grammar. A recast focusing on *form and meaning* on the other hand, would involve the teacher paraphrasing a learner's statement in order to edit the grammar to suit its function. The former type is referred to as *formal recasting* and is orientated to moving from non-conformance to conformance, to the rules of grammar. The latter is referred to as *functional recasting* and is orientated to improving learners' ability to use language as a resource for making meaning (Mohan & Beckett, 2003). Green (2007, p.4) describes functional recasting as involving the „incorporation and revision of the everyday or through drawing on specialised experiences in practical settings'.

3.3. Research Focus

Drawing from the rationale, literature review and theoretical framework for this study, the focus of this study is on exploring and describing the nature of the utterances of South African Physical Sciences teachers during Physical Sciences lessons in terms of the functional language features of nominalisation, functional recasting and lexical cohesion. Since nominalisation impacts on lexical density and the significance of lexical density has been established in Chapter 2, it is also focused on in the current study. The lexical cohesion analysis will be limited to a novel repetition analysis and a variation of the cohesive harmony index calculation employed by Rodrigues and Thompson (2001).

The reason for this study employing a refined definition of cohesive harmony index and the resulting variation in its calculation will be elaborated on later in this chapter. The repetition and collocation aspects of lexical cohesion occur at different levels within a text (such as within and between clauses, sentences, utterances and paragraphs). This complicates analyses involving these functional language features. It is thus no surprise that „lexical cohesion through collocation is the most difficult type of cohesion to analyse' (Witte & Faigley, 1981, p.193). This may warrant a complete, separate study focusing primarily on lexical collocation rather than it being a focus in a multi-faceted study such as the current one. It was thus not chosen as a focus in this study. To further focus this study, only the first type of lexical reiteration – repetition of the same lexical item, will be focused on. The novel repetition analysis employed in this study will be discussed further in this chapter.

In this study, an „utterance' refers to a unit of teacher talk within a lesson, undisturbed by the talk of others, such as learners. Since this study is more concerned with the *field* aspect of register rather than the mode or tenor, greater attention is given to the *teacher utterances* than to the learner utterances. However, the analysis of functional recasting includes both teacher and learner utterances since functional recasting sometimes occurs between learner and teacher utterances.

The researcher undertaking the current study is situated in the city of Pietermaritzburg in the province of KwaZulu-Natal in South Africa, and so for the purpose of convenience, the study focuses on teachers and thus schools within Pietermaritzburg. The sampling of schools within Pietermaritzburg however, is purposive, in order to cover the main Physical Sciences classroom language contexts (English first-language teacher with predominantly English first-language learners, English first-language teacher with predominantly English second-language learners and English second-language teacher with predominantly English second-language learners). This will be discussed further in the data collection section.

The generalisability of the results from this study is limited due to differences in the language profiles as well as other contextual factors among the nine provinces in South Africa. The current study is still useful due to its dual significance in allowing for a systematic and multi-faceted description of the utterances of Physical Sciences teachers in different classroom language contexts, and for constructing knowledge and developing understanding of how Physical Sciences teachers in South Africa are modelling and scaffolding scientific English.

3.4. Research Questions, Hypothesis and Predictions

The overarching research question „What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg?' is fairly broad. Drawing from the literature review and theoretical framework, specific systemic functional linguistic features have thus been employed in narrowing the focus so the study is more manageable. Thus, while in one sense there is only one research question in this study, it is subdivided according to specific systemic functional linguistic features as follows:

What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of:

1a) nominalisation?

1b) lexical density?

2) functional recasting?

3a) repetition?

3b) cohesive harmony index?

The discussion, conclusions and recommendations will be aligned to each of these questions individually.

The hypothesis for the current study is that the use of functional language features by Physical Science teachers is aligned to the language context. The predictions are that the amount of repetition, the cohesive harmony index and amount of functional recasting will increase as the proportion of ESL learners in the class increases, while the amount of nominalisation and the lexical density will decrease as the proportion of ESL learners in the class increases.

3.5. Method

3.5.1. Research Design

While some of the systemic functional linguistic features employed in this study lend themselves well to a quantitative research approach, others are aligned to a qualitative research approach. Thus, positioning this study traditionally into either a purely quantitative or purely qualitative approach would have been an inaccurate reflection of its nature, and so the literature was consulted.

In addition to qualitative and quantitative research designs, Creswell (2009) describes a third type: mixed-methods, which lies midway on the continuum between qualitative and quantitative approaches. The differences between these approaches arise from the various possible philosophical assumptions that could underpin research, and it is because such philosophical ideas *influence* research that they need to be identified. While some literature refers to these philosophical assumptions or ideas as worldviews, they are sometimes referred to as paradigms (Creswell, 2009) and so in this study „worldviews' and „paradigms' are used interchangeably.

McMillan and Schumacher (2010) describe various education research paradigms. According to the authors, each education research paradigm is associated with a different method of knowledge generation. The logical positivism paradigm advances „a single reality within known probability, objectivity, empiricism, and numbers' and is the foundation in which the scientific method is built. Later, logical positivism evolved into postpositivism which allowed for limitations to the rationalistic view of logical positivism and the consideration of contextual factors. In contrast to postpositivism, the interpretive or constructivist paradigm, while allowing the use of systematic procedures by researchers, advances „multiple, socially constructed realities' (McMillan & Schumacher, 2010, pp.5- 6).

Traditional quantitative methods are anchored in postpositivism while traditional qualitative methods are associated with interpretivism. Two more recent paradigms impacting on research are the transformative and pragmatic paradigms. The transformative paradigm advances that „social, political, cultural, gender, and ethnic factors' have significant implications for research design and the interpretation of results, and this paradigm is reflected in the feminist and critical theorist perspectives. The pragmatic paradigm involves viewing the scientific method alone as inadequate and requiring „common sense and practical thinking' for choosing the best research method, considering both the purpose of the research and the context (McMillan & Schumacher, 2010, p.6).

According to Creswell (2009, p.10), the focus of studies grounded in the pragmatic worldview is on the research problem, and solving it involves „using pluralistic approaches to derive knowledge about the problem'. Researchers employing the pragmatic worldview „do not see the world as an absolute unity' and so „look to many approaches for collecting and analyzing data rather than subscribing to only one way (e.g. quantitative or qualitative)' (Creswell, 2009, p.10). The pragmatic worldview affords a theoretical basis for mixed-methods studies (McMillan & Schumacher, 2010) but a rationale for the mixing of methods needs to be established (Creswell, 2009).

The aim of this study is to explore and describe Pietermaritzburg Physical Sciences teacher utterances during Physical Sciences lessons. Due to adoption of the sociocultural perspective on science education and the lens of science as language for this study, the scientific method alone is inadequate for effectively accomplishing the aim. The use of both qualitative and quantitative methods will generate more detailed descriptions of teacher utterances during Physical Sciences lessons. The theoretical framework of systemic functional linguistics has provided both quantitative and qualitative tools and so the use of mixed- methods in this study, is supported by the aim of this study as well as the theoretical framework being employed. This study is thus grounded in the pragmatic worldview, and there is a clear rationale for employing a mixed-methods research design.

3.5.2. Data Collection

In this section, the choice of case study methodology will be discussed, as well as the initially intended and actual cases studied. The recording of lessons will also be described.

3.5.2.1. Case Studies

The theoretical framework of systemic functional linguistics views language as being functional within social contexts, as explained earlier. The importance of the functionality of language within particular contexts was recognised via the use of case studies as each one „provides a unique example of real people in real situations' (Cohen, Manion & Morrison, 2000, p.181). Due to the different language contexts of South African learners, multiple case studies were carried out, to provide snapshots of the various language contexts. Despite some limitations of using case studies (which include results not being generalisable), they have noteworthy strengths such as their „being strong on reality' and „speaking for themselves' (Cohen *et al*, 2000, p.184). Furthermore, generalising was not a goal of the present research since the main aim was to provide a more complete description of the phenomenon and location being focused on.

3.5.2.2. The Initially Intended Cases for this Study

Due to the variations in South African Physical Sciences classroom contexts in terms of the mother-tongue language of learners and teachers, it was originally envisioned that this study would incorporate four case studies – each representing one of the four possible combinations shown in Table 1. The sampling was thus purposive since particular choices were made about the cases that would be included (Bertram, 2004). As mentioned in the research focus, the city of Pietermaritzburg was chosen as the location for convenience. Convenience sampling is commonly employed in studies as another aspect of purposive sampling (Bertram, 2004).

Table 1: Mother-tongue characteristics of the initially intended cases for this study

Case	**A**	**B**	**C**	**D**
Teacher	EFL	EFL	ESL	ESL
Learners	EFL	ESL	EFL	ESL

In reality, South African classrooms could not be categorised so distinctly in terms of the mother-tongue of learners since a continuum exists for the ratio of EFL to ESL learners. It was thus decided that in terms of the mother-tongue of learners, cases would be characterised by the proportion of ESL learners to total learners. Various schools along the continuum of the proportion of ESL learners to total learners were approached, and while the principals and heads of science departments at all these schools were eager to participate, there was hesitation on the part of some Physical Sciences teachers and others simply refused.

The difficulty in obtaining willing participants for this study is a reflection of one of the general challenges in conducting education research. Another difficulty encountered was that of one school agreeing to participate only if the researcher would sponsor items for their school laboratory – possibly due to their misconception that the researcher belonged to a science rather than an education faculty. The school was not included in this study. A third difficulty encountered, was of a teacher agreeing to participate on condition that there be no recording of the lesson with the researcher only being allowed to observe. Since this would not have provided useable data for the particular analysis intended for this study, the school was not included in this study.

3.5.2.3. The Actual Cases included in this Study

Eventually, some willing participants were found for three of the four intended cases, as a Physical Science class with the vast majority of students being EFL and their teacher being ESL could not be found in the Pietermaritzburg area. While this results in an apparent „gap' in terms of the different classroom language contexts covered in this study, it must be remembered that case studies are being employed in this study to gain insight into the phenomenon with real people and real situations. If in reality, only three cases could be found out of four planned ones, it may be acceptable to assume that these three cases reflect the common reality in the Pietermaritzburg area. The case numbers and their results will be presented in the order in which data was collected. The language contexts of the learners in the three cases focused on in this study are shown in Table 2.

Table 2: Language contexts of the learners in the three cases in this study

Case	Proportion of ESL learners to total number of learners (%)	Proportion of learners studying English at 'Home Language' * level (%)	Proportion of learners studying English at 'First Additional Language' ** level (%)
1	45	100	0
2	60	100	0
3	96	20	80

* In South African schools, learners are required to study one language at „Home-Language' level. „English Home-Language' is a subject designed for mother-tongue speakers of English.

** In South African schools learners are required to study a second language at „First Additional Language' level. „English First Additional Language' is a subject designed for non-mother-tongue speakers of English.

It is evident from Table 2 that case 3 has the greatest number of ESL learners and case 1 has the lowest. It is interesting to note that all the students in cases 1 and 2 studied English at home-language level while only 20% of students in case 3 studied English at home-language level with the remainder studying it at first additional language level.

The language contexts of the teachers in the three cases focused on in this study are shown in Table 3.

Table 3: Language contexts of the teachers participating in this study

Case	Teacher's Home Language	Other languages that teacher can speak	Other languages that teacher can read and write	Teacher's rating of their own English Proficiency
1	English	Afrikaans isiZulu French German	Afrikaans isiZulu French German	Good, to excellent
2	English	Afrikaans Hindi	Afrikaans	Good
3	Tshivenda	English Afrikaans isiZulu	English Afrikaans isiZulu	Good

English is the mother-tongue of the teachers in cases 1 and 2 and Tshivenda is the mother-tongue of the teacher in case 3. While there is significant variation in the language profiles of the three teachers in terms of the languages each can speak and write, all three teachers can speak and write Afrikaans and English and rated their own English proficiency highly. Out of the options: poor, adequate, good or excellent, the teachers in cases 2 and 3 rated their English proficiency as „good' with the teacher in case 1 mentioning it was „good, to excellent'. Other relevant characteristics of the teachers participating in this study are shown in Table 4.

Table 4: Age, qualifications and experience of the teachers participating in this study

Case	Teacher's age	Qualifications	Number of years of teaching experience	Number of years of Physical Sciences teaching experience
1	52	B.Sc., HDE	25	3
2	39	B.Sc., PGCE (currently)	12	12
3	39	B.Sc. (Hons.), UED	16	16

The teachers in case 2 and case 3 are of the same age and have both taught Physical Sciences for the duration of their teaching careers but have a difference of four years in their teaching experience with the teacher in case 3 having more teaching experience. The teacher in case 1 on the other hand, has had a considerably longer teaching career but much less experience in teaching Physical Sciences relative to the teachers in cases 2 and 3.

All three teachers had completed Bachelor of Science (B.Sc.) degrees as their initial qualification. In studying towards their B.Sc. degrees, the teachers in cases 1 and 2 have studied chemistry to third year level and physics at first year level while the teacher in case 3 studied both chemistry and physics up to third year level with her Honours degree covering chemistry.

The teachers in cases 1 and 3 then completed one year professional teaching diplomas. The teacher in case 1 obtained a Higher Diploma in Education (HDE) specialising in Physical Sciences and Economics education while the teacher in case 3 obtained a University Education Diploma (UED) specialising in Physical Sciences and Mathematics education. Unlike the teachers in cases 1 and 3, the teacher in case 2 has not completed any teaching qualification but is currently studying towards a Post Graduate Certificate in Education specialising in Physical Sciences and Mathematics education.

From Tables 3 and 4 it is evident that the teachers have similar qualifications and ratings of their English proficiency but different language profiles and years of teaching experience in general and of science in particular. In terms of the range of languages spoken and written, rating of English proficiency and experience in teaching Physical Sciences, the teacher in case 1 differed considerably from the teachers in cases 2 and 3.

All three cases involved grade ten Physical Sciences lessons in which English was the language of learning and teaching. The lessons in cases 2 and 3 involved the *mechanics* aspect of *physics* while those of case 1 involved the *elements and compounds* aspect of *chemistry*. Ideally the lessons used in this study should have focused on the same topic to contribute to a fair test, but due to the lack of a sufficient number of willing teachers, this option was not available. Each case involved observation of five lesson periods. Multiple observations aimed to improve the reliability of the data in two ways. Firstly, patterns of language feature usage by teachers may be more apparent over a series of consecutive lessons rather than within one lesson. Secondly, the effect of an outside observer being present in the classrooms may decrease over time, with the patterns of language feature usage by teachers more closely resembling their usual language usage within the classroom.

3.5.2.4. Recording of Lessons

The data was collected by the audiovisual recording of lessons. Since the focus was the actual utterances of the teachers, lesson observations alone would have been inadequate and during the video recording the video camera would need to be close to the teacher in order to record his or her utterances clearly. This would have required the researcher following the teacher around the classroom while recording the lessons. Apart from this being difficult in terms of physical obstacles in the classroom, it was feared this would unnecessarily emphasise the presence of the researcher to the teacher and learners and possibly reduce the trustworthiness of the data. Thus, the researcher video recorded each lesson from a stationary position, and the teacher was asked to carry a lightweight dictaphone. Teacher utterances unclear in the video recording were verified using the audio recording in order to enhance the accuracy of the transcription of the recordings during the data preparation phase.

3.5.2.5. Summary of the main resources employed in and products of, the data collection phase

The main resources used for the data collection were a video recorder and a dictaphone. The products of the data collection phase were fifteen electronic audiovisual recordings (one for each of the five consecutive lessons in each of the three cases), as well as fifteen electronic audio recordings of teacher utterances (one for each of the five consecutive lessons in each of the three cases).

3.5.3. Data Preparation

3.5.3.1. Challenges to obtaining reliable transcripts, and attempts to overcome them

The data preparation phase firstly required the transcribing of each of the fifteen recordings. In discussing issues of representation when transcribing talk, Roberts (1997) mentions that the transcriber's personal language ideology influences the transcription process. Furthermore, we are reminded that because of this, „all transcription is representation, and there is no natural or objective way in which talk can be written' (Roberts, 1997, p.168).

Green, Franquiz and Dixon (1997, p.172) concur, in describing the idea of an objective transcript as a myth. This is because transcribing is a situated act within research, „embedded in a conceptual ecology of a discipline' (Green et al, 1997, p.172). Green et al (1997, p.174) discuss the two issues of transcribing as an interpretive process and a representational process and remind us that „a transcript is shaped by and, in turn, shapes what can be known'.

The literature reveals that there are many challenges in obtaining reliable transcripts and that „no generalised method is available to produce the perfect transcript'. However, it is also revealed that „informed ways do exist to go about the work of transcription that contribute to the credibility of research outcomes' (Tilley & Powick, 2002, p.306) and literature also provides guidelines for this purpose. According to Gill (2000, p.177) „a good transcript should be as detailed a record as possible, of the discourse to be analysed. A transcript should not summarise speech, nor should it "clean it up" or correct it; it should record verbatim speech with as many features of the talk as possible'. The initial transcription process thus captured verbatim, both the teacher and learner talk from the video recordings of each lesson into Microsoft Word documents.

Data reduction refers to „the process of selecting, focusing, simplifying, abstracting and transforming the data' (Bertram, 2004, p.145). While it is an aspect of data analysis (Bertram, 2004, p.145), mentioning it in the discussion of data preparation is justified since the data preparation needs to be informed by and aligned to, the data analysis. One of the challenges to producing accurate transcripts described by Roberts (2007) is transcribing from more complex data such as video recordings as opposed to audio recordings. This requires a greater amount of data reduction and thus requires more decisions to be made on the part of the transcriber – possibly impacting negatively on reproducibility and repeatability. Since this study focused on actual teacher utterances, additional data provided by audiovisual recordings compared to audio recording was not required. Hence the data reduction in this instance impacted less negatively on reproducibility and repeatability.

A second challenge, arising from transcribing the lessons without correction to any of the talk, was that subsequent reading of the transcripts without the accompanying lesson video revealed both *actual* transcription errors as well as *apparent* transcription errors. The actual errors refer to instances where one or more sections of the lesson videos were incorrectly transcribed due to human error on the part of the transcriber. The apparent errors included such things in the transcript as repeated words or sentences not conforming to the rules of English grammar on the part of the teacher and learners being recorded, and not due to human error on the part of the transcriber.

Because this study involved quantitative aspects including counting the number of words in each teacher utterance, it was important to remove as many actual transcription errors as possible whilst not removing the apparent errors. The original transcripts of the lesson videos were cross-checked against the dictaphone audio recording of the teacher utterances to improve the reliability of the transcripts. While this did not allow for checking of the learner utterances, it was the teacher utterances that are the main focus of this study as mentioned previously. Furthermore, this reduced the quality concerns arising from the data reduction necessary in transcribing video as opposed to audio recordings.

A third challenge arose from the shorthand sometimes employed for the sake of more efficient transcribing, which included instances of writing numbers as numerical digits instead of in word form. Such instances were unintentional, and possibly due to fact that attempts at detailed transcribing are time-consuming, causing the transcriber to subconsciously resort to shorthand at times, as a time-saving strategy. While unintentional, this was problematic for the reason mentioned earlier, of the quantitative aspects of this study requiring the counting of actual words in the teacher utterances. The threat to reduced reliability of the original transcripts due to this challenge was overcome by carefully revising them so that the final transcripts contained no shorthand.

Initially, it was planned that only substantive sequences of talk (those related to learning and teaching – for example teacher explanations) would be analysed, after having identified and removed the non-substantive sequences (those unrelated to the learning and teaching – for example discipline and administration issues). However, it was later decided that this is contrary to the rationale for using case studies mentioned earlier, of their being strong on reality. Removing the non-substantive utterances would have resulted in transcripts that more closely resemble the language in written texts such as textbooks. This in turn, is contrary to the focus of the study and the recognition given by the theoretical framework, to context. Furthermore, reproducibility might have been reduced since there may have been utterances which could not easy be classified as purely substantive or non-substantive, or in which one type was embedded in the other. It was thus decided that all the teacher utterances would be retained in the transcripts for analysis.

3.5.3.2. Case, Lesson and Utterance Labelling

The original transcripts included all the talk occurring during the lessons – both teacher and learner utterances. In preparing the final transcripts for all analyses except the analysis of functional recasting, learner utterances were removed. This was another aspect of data reduction employed in this study.

In the data preparation for this study, the actual lines of text in the Microsoft Word transcript documents were not numbered as is the traditional method for breaking down transcripts into smaller units. This is due to changes in the electronic transcript font type or size impacting negatively on the reproducibility of such a labelling method. It was decided that utterances would be labelled instead, since utterance numbers are unaffected by choice of font type or size. Furthermore, the same number would be allocated to a particular utterance irrespective of the person performing the transcribing or the word processing software being employed.

Once the final transcripts were prepared, each teacher utterance was assigned a unique code where the first number referred to the particular case, the second number referred to the lesson number and the third number referred to the utterance number within that particular lesson. For example, the code 2.4.18 refers to the eighteenth utterance of lesson number four for case number two.

3.5.3.3. Summary of the main resources employed in and products of, the data preparation phase

The main resource used for the data preparation was a laptop for replaying the electronic audiovisual and audio recordings and typing the teacher and learner utterances into Microsoft Word format. The products of the data preparation phase were fifteen electronic texts (one for each of the five lessons of each of the three cases) where each text is the transcript of the verbal exchange taking place within one lesson period. In each text, each teacher utterance had been allocated a unique double decimal number for easy identification.

3.5.4. Data Analysis

For reasons discussed in the section on Case, Lesson and Utterance Labelling, the lowest level of analysis in this study was teacher utterances, wherever possible. Where utterances were not a possible level of analysis, lessons were used as the level of analysis. The justification for using utterances rather than lines of text in the Microsoft Word transcripts has already been given. The fact that lessons were the units of text as per the definition of text provided earlier, justifies this choice of level of analysis. Utterances and lessons were thus the levels of analysis in this study.

The data analysis can be described as textual as the data was in the form of Microsoft Word documents. The actual data analysis techniques employed, differed for each of the functional language features with some being novel and others being variations of the techniques described in the literature. The data analysis will now be described separately for each functional language feature.

3.5.4.1. Nominalisation Analysis

For this quantitative analysis, the fifteen transcripts of teacher utterances were imported into NVivo 8 software as separate source documents. For each transcript, the individual nominalisations in the teacher utterances were coded in a particular node. A node in NVivo 8 software can be thought of as a folder which can be labelled, and into which particular words from the transcript can be copied. For example, a node labelled *Case1Lesson1Nominalisation* during the NVivo 8 coding for the nominalisation analysis in this study is the folder into which the nominalisations of teacher utterances in lesson 1 of case 1 appeared, once they were coded. According to the definition provided earlier, nominalisation is the type of grammatical metaphor which involves substituting a more obvious grammatical structure (a congruent form) with another less obvious structure (a non-congruent form). The coding of nominalisations is illustrated in the following teacher utterance, where the nominalisations have been indicated in bold text.

… You have an idea of some of the vectors and some of the, scalar quantities. You know the **definitions**. You've also seen the **definitions** of speed. Speed is basically the change in the **distance** over the change in the time. Or we use the same formula for velocity but we add, **direction**. Velocity we said, is the rate of change of **displacement**. Either delta X over delta S, over time and we also looked at the **difference** between **distance** and **displacement**.

NVivo 8 software allows items highlighted (as belonging to a particular node) from a particular source text, to be viewed together (in the node under which they were coded) and for queries to be performed on the data within nodes. For the nominalisation analysis, the queries performed for each node were for the purpose of obtaining an alphabetical list of the individual nominalisations with the frequency of occurrence of each (the percentage of the total number of words in that lesson transcript of teacher utterances, which that particular nominalisation constituted). An example of the data obtained through such a query, is illustrated in Table 5.

Table 5: An excerpt of a query performed in NVivo 8 during the nominalisation analysis

Nominalisation	**Count**	**Percentage**
addition	1	0.03
definition	5	0.16
displacement	38	1.18
multiplication	2	0.06

This excerpt shows some of the nominalisations which were spoken by the teacher during one lesson, the number of times each occurred and the proportion of the total text which each constitutes. For example, the nominalisation „addition' was spoken once during the course of the lesson by the teacher and this constituted 0.03% of the total number of words spoken by the teacher in that lesson.

The fifteen queries were then exported into a Microsoft Excel document where the proportion of nominalisation words relative to the total number of words was calculated for the teacher utterances of each lesson. This was done by summing the percentage contributions of each particular example of nominalisation within that text (indicated by the „Percentage' column heading in Table 5). For the excerpt in Table 5:

Proportion of nominalisation words relative to the total number of words

= 0.03 + 0.16 + 1.18 + 0.06

= 1.43%

The mean proportion of nominalised words to the total number of words was also calculated across all five texts for each of the three cases, to obtain a mean value for each case. These results are presented in Chapter 4.

3.5.4.2. Lexical Density calculation

For this quantitative analysis, the fifteen transcripts of teacher utterances were again imported into NVivo 8 software, as separate source documents. The texts imported into NVivo 8 as source documents for the nominalisation analysis could not be re-used as coding in NVivo 8 can only be done in one colour and so the coding for different language features would not be distinct and thus of little value. The individual *science content words* were coded in a particular node (for example Case1Lesson1ContentWords). This coding will now be illustrated for one teacher utterance, where the science content words have been underlined.

T:	I am just gonna recap what we have done, and we gonna go back to the example we have done the other day. So far you know, you been introduced to a vector quantity; you've been introduced to a scalar quantity, okay. You have an idea of some of the vectors and some of the, scalar quantities. You know the definitions. You've also seen the definitions of speed. Speed is basically the change in the distance over the change in the time. Or we use the same formula for velocity but we add, direction. Velocity we said, is the rate of change of displacement. Either delta X or delta S, over time and we also looked at the difference between distance and displacement. Now what we gonna look at today, is going back to your notes, we looking at page 3. We looking at the problem of the student. Remember the student?

The ratio of *science content words* to *total number of words* was then calculated *per teacher utterance*. For example, the teacher utterance above contains twenty nine content words out of a total of one hundred and fifty two words. The lexical density calculation is thus:

$$Lexical\ Density = \frac{science\ content\ words}{total\ words} = \frac{29}{152} \times 100\% = 19\%$$

The mean lexical density of the utterances in each transcript was then calculated to obtain a mean value for each lesson. The mean lexical density of the five lessons in each case was also calculated, in order to obtain a mean value for each case. These results are presented in Chapter 4.

Halliday and Martin (1993) describe lexical density as the number of *content carrying words* per *clause*. The lexical density calculation technique employed in the current study is thus a variation from the traditional method described, in three ways. Firstly, the lexical density calculation was performed only for the teacher utterances as this study is concerned with the nature of teacher utterances rather than learner utterances or tenor, as mentioned in the research focus. Secondly, the reason for calculating the lexical density per utterance rather than per clause or per sentence, is that the teacher talk in all three cases did not conform to the rules of English grammar in terms of clause or sentence construction. The calculation would thus not be performed reproducibly if calculated per clause or per sentence, since what constituted a clause or sentence in the audiovisual and audio recordings would be dependent on the transcriber. Thirdly, the reason for the lexical density calculation being restricted to the number of science content words (as opposed to English content-carrying words in general) is that the focus of this study is on the field of Physical Sciences and not English linguistics.

The refining of the lexical density definition and thus calculation for this study has implications for the cohesive harmony index definition and calculation. These will be discussed in the section outlining the cohesive harmony index calculation.

3.5.4.3. Functional Recasting Analysis

Since the primary functional recasting analysis was qualitative, the use of NVivo 8 was not necessary and the analysis was performed directly on the fifteen Microsoft Word transcripts containing both teacher and learner utterances. The focus of this study is on systemic functional language features and so *functional* rather than *formal* recasting, was analysed. To illustrate the distinction between formal recasting and functional recasting, an example of each is shown below.

An example of functional recasting:

L:	Sir, a quantity that has both magnitude and signs
T:	Alright, a physical quantity that has both magnitude and direction.

An example of formal recasting:

L:	It's different by the direction…
T:	It's a poor use of, uh, language there, that's what I'm actually saying. So if I was writing that what, what must I change? Which word must I change?
L's:	By
T:	By. What must I write in place of by?…Alright, there's a difference in the direction. Ok, so we have to change the word „by' to „in the direction'. …

As mentioned in the research focus, this aspect of the analysis included both the teacher and learner utterances since functional recasting occurs in the interaction between the two. However, instances of the teacher recasting both within and between their own utterances were also identified in this study. Once all the instances of functional recasting had been identified and highlighted, functional recasting types were identified. This is another aspect of data reduction in qualitative analysis, but in this case it involved „organising and sorting data into codes or categories and then looking for patterns or relationships between these categories' (Bertram, 2004, p.145). The categories of functional recasting identified from the current study, as well as of the outcomes which the functional recasting types contributed to, are presented in Chapter 4. A model of the functional recasting outcomes emerging from the teacher talk in the three cases of this study is presented in Chapter 5. After the qualitative analysis of functional recasting, a quantitative analysis was also carried out in order to calculate the proportion of functional recasts contributing to each outcome, for each of the three cases. These quantitative results are also presented in Chapter 4.

3.5.4.4. Lexical Cohesion analysis: Repetition Calculation

The repetition „calculation' described here was devised especially for this study as no specific calculations describing this aspect of lexical cohesion could be found in the literature reviewed. The query results obtained from the NVivo 8 nodes containing the content words of the teacher utterances from each text (constructed during the lexical density calculation) were used. For each transcript of teacher utterances, the total number of teacher's content words (initial and repeated) was calculated by adding together the number of times each teacher content word occurred. This was obtained from the NVivo 8 query.

While the actual analysis was done using query results from NVivo 8 as will now be illustrated, the technique will also be illustrated working directly from an utterance (using the utterance below), in which all the content words are underlined and the repeated content words are bracketed.

T:	I am just gonna recap what we have done, and we gonna go back to the example we have done the other day. So far you know, you been introduced to a vector quantity; you've been introduced to a scalar (quantity), okay. You have an idea of some of the (vectors) and some of the, (scalar) (quantities). You know the definitions. You've also seen the definitions of speed. (Speed) is basically the change in the distance over the (change) in the time. Or we use the same formula for velocity but we add, direction. (Velocity) we said, is the rate of (change) of displacement. Either delta X or (delta) S, (over) (time) and we also looked at the difference between (distance) and (displacement). Now what we gonna look at today, is going back to your notes, we looking at page three. We looking at the problem of the student. Remember the student?

An excerpt of a query performed in NVivo 8, used in the quantitative repetition analysis for the above utterance, is shown in Table 6.

Table 6: An excerpt of a query performed in NVivo 8 as a part of the repetition analysis

	Content Words	Count
1	vector	2
2	quantity	3
3	scalar	2
4	speed	2
5	change	3
6	distance	2
7	over	2
8	Time	2
9	formula	1
10	velocity	2
11	direction	1
12	rate	1
13	displacement	2
14	delta	2
15	X	1
16	S	1

The total number of content words for an utterance is the sum of the counts for each particular content word. Thus, for the utterance analysed in Table 6, the total number of content words is twenty nine (the sum of numbers in the „count' column). To calculate the number of repeated words, the first instance of use of each content word was subtracted from the total number of content words. The number of first-time uses of content words is given by the first column of the table as it corresponds to the actual number of different content words (without repetition). The calculation of the number of repeated content words is shown below:

Number of repeated content words $= total\ number\ of\ content\ words\ occurring - initial\ use\ of\ each\ content\ word$

$= 29 - 16$

$= 13$

While the above calculation provides a simple method to calculate the number of repetitions using the NVivo 8 query, it is also useful to view the calculation in terms of the actual utterance. In terms of the brackets and underlining in the utterance excerpt, the number of bracketed underlined words (repeated content words) in the utterance is equal to the total number of underlined words (total number of content words) minus those with no brackets (the initial use of each content word).

To permit comparisons within and among cases, for each transcript of teacher utterances the proportion of repeated content words *relative to the total number of content words* was calculated per lesson. For the above utterance, this would be $13 \div 29 \times 100\% = 44\ \%$. Thus, 44% of the content words were repetitions. The mean values for the five lessons of each case were also calculated.

For each transcript of teacher utterances, the proportion of content word repetitions *relative to the total number of words* was also calculated per lesson to obtain a measure of the use of repetitions by the teacher. For the above utterance, this would be $13 \div 152 \times 100\% = 9\ \%$. The mean values for the five lessons of each case were also calculated.

The results of these repetition analyses are presented in Chapter 4.

3.5.4.5. Lexical Cohesion analysis: Cohesive Harmony Index Calculation

The cohesive harmony index was defined as the percentage of *words interacting together relative to the total number of words* (Rodrigues & Thompson, 2001). The current study uses a refined definition of the cohesive harmony index, resulting in a variation in its calculation. The need for the refinement arose from the refining of the lexical density definition for this study, causing it to closely resemble the traditional cohesive harmony index definition. In this study, the cohesive harmony index is defined as the percentage of *science content words interacting together relative to the total number of words*. This can be understood as the calculation now providing a measure of the cohesion for the particular science topic being covered during a particular lesson, rather than for cohesion in general.

As in the case of the nominalisation, lexical density and repetition analyses, the teacher utterances were the focus. The analysis of the cohesive harmony index was thus performed directly on the fifteen Microsoft Word transcripts of the teacher utterances. The individual *science content words interacting together* were counted, for each utterance. The proportion of *science content words interacting together* relative to the *total number of words* was calculated *per teacher utterance.* The mean cohesive harmony index per lesson and case was also calculated. These results appear in Chapter 4.

3.6. Research Ethics

Creswell (2009) mentions that ethical issues stem from discussions about codes of professional conduct for researchers and McMillan and Schumacher (2010) point out those ethical considerations are one of the constraints on educational research. This is because educational research often relies on professional practitioners such as teachers. However, it may also involve learners, for example in the case of interviewing them or in studies such as the current one, video recording lessons. Many educational institutions now require that an application for ethical clearance be made, before any research is conducted under the auspices of the institution. This is also true for the current research study.

The three teachers from the three cases in this study, as well as the three principals of the schools to which each of the cases belongs, agreed to participate in this study and signed the Informed Consent documents (Appendices 1 and 2). The ethical clearance number awarded by the university Ethics Committee for this study as per the approval letter (Appendix 3) is **HSS/0465/08M**. Ethical clearance was also obtained from the KwaZulu-Natal Department of Education.

In addition to including proof of ethical clearance in theses such as the current one, it is also becoming common practice to include proof of an originality check by software such as Turnitin. A printout from Turnitin is included in this thesis (Appendix 4), and indicates a similarity index of 16%. This indicates that 84% of this thesis is „original'.

Chapter 4: Results

4.1. Introduction

Since this study employed mixed-methods, both quantitative and qualitative results are presented in this chapter. The quantitative results do not include statistical calculations other than for mean, standard deviation, standard error and range (highest value minus the lowest value). This is due to the sample size in terms of cases and lessons within each not being high enough to justify the use of such statistics as tests for outliers, analysis of variance and correlation. Given the large number of utterances, mean values for utterances within lessons or total values per lesson are reported. In addition to this level of reporting results, summary results at the level of case are reported in order to better comment on the hypothesis and predictions. A discussion of the results presented here, can be found in Chapter 5.

4.2. Nominalisation Results

Table 7 shows the results of the nominalisation analysis for the three cases. The results are shown per lesson for each case, together with the mean and standard deviation for the five lessons of each case. These results will enable the answering of research question 1a: What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of nominalisation?

Table 7: The nominalisation results for the three cases

Case	Lesson	Proportion of Nominalisation words relative to Total Words (%)	Mean Proportion of Nominalisation relative to Total Words ± SD (%)
1	1	1.50	0.91 ± 0.42
	2	1.11	
	3	0.37	
	4	0.74	
	5	0.81	
2	1	3.08	3.82 ± 0.81
	2	3.27	
	3	4.88	
	4	4.50	
	5	3.39	
3	1	2.77	3.34 ± 0.49
	2	3.93	
	3	2.92	
	4	3.41	
	5	3.65	

The range of the mean proportion of nominalisation words relative to total words for the three cases is 2.91%. The value is the lowest for case 1 and the highest for case 2. The values for cases 2 and 3 are similar and they are also considerably higher than the value for case 1. The low standard deviations for the proportion of nominalisation words relative to total words in the lessons of all three cases indicate a fair degree of consistency between the lessons within each case for this functional language feature.

4.3. Lexical Density Results

Table 8 shows the results of the lexical density analysis for the three cases. The mean and standard deviation are shown for the lexical densities of utterances within the lessons and the mean and standard error are shown for the lexical densities of lessons within the cases. These results will enable the answering of research question 1b: What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of lexical density?

Table 8: The lexical density results for the three cases

Case	Lesson	Number of Utterances	Mean Lexical Density of utterances ± SD (%)	Mean Lexical Density of lessons ± SE (%)
1	1	145	25.50 ± 22.35	23.68 ± 6.02
	2	158	13.15 ± 19.11	
	3	160	26.12 ± 27.58	
	4	221	28.43 ± 26.27	
	5	172	25.19 ± 24.19	
2	1	60	11.52 ± 13.20	11.88 ± 1.88
	2	256	11.92 ± 15.94	
	3	97	13.68 ± 18.06	
	4	133	13.36 ± 17.64	
	5	199	8.94 ± 14.60	
3	1	136	19.71± 20.70	29.66 ± 6.15
	2	82	28.79 ± 21.86	
	3	119	34.43 ± 25.56	
	4	150	34.97 ± 27.83	
	5	100	30.41 ± 20.24	

For the three cases, the range for the mean lexical density of lessons is 17.78%. The value is the lowest for case 2 and the highest for case 3. The values are similar in cases 1 and 3 but considerably lower in case 2. There is a consistently higher standard deviation between the lexical densities of utterances within lessons, than standard error between the lexical densities of lessons within each case. As in the case of nominalisation, this indicates a fair degree of consistency between the lessons within each case for this functional language feature, but a high degree of variation between utterances. While the values for lesson 2 of case 1, lesson 5 of case 2 and lesson 1 of case 3 may appear to be outliers, this could not be confirmed due to the small sample size, and the values were thus retained.

4.4. Functional Recasting Results

Functional recasting was found to occur regularly within each lesson of each case. The instances reported on here included the teacher's functional recasting of learner utterances (which mostly served to scaffold or correct the learners' attempts) as well as of their own utterances (which mostly served to model movement from the register of everyday English to the register of scientific English or to correct their own attempts). Each of the functional recasting examples identified in this study were found to belong to one of the following 19 functional recasting types:

1. Replacement
2. Inclusion
3. Correction
4. Omission
5. General to specific
6. Specific to general
7. Everyday to technical
8. Condensed/concise form
9. Technical to everyday
10. Expanded form
11. Elaboration
12. Incorporation of everyday
13. Focusing questions
14. Quantity and formula
15. Quantity/unit and symbol
16. Quantity and value
17. Synonyms

18. Paraphrasing

19. Multiple representation

These functional recasting types will now be briefly described, and highlighted using an example of each from the research data.

1. Replacement

This type of functional recasting involved the teachers replacing one word with another, *increasing accuracy*.

L:	Sir, a quantity that has both magnitude and signs
T:	Alright, a physical quantity that has both magnitude and direction.

2. Inclusion

In this type of functional recasting, the teachers repeated a previous statement but with something added, *increasing accuracy*.

T:	Okay, so his displacement
L:	Its zero
T:	Is zero meters. I wanna emphasise the units. Are you'll okay with that?

3. Correction

This functional recasting type involved the teachers recasting a statement into a more correct form, *increasing accuracy*.

T:	So, it's the shortest distance between the starting point and the end point in a certain direction. There is only one problem I have with that. It's a bit too difficult to define a vector using a scalar quantity. So maybe, uh, a better definition would be, it's a straight line path from the starting point to the end point and it's a quantity that has direction.

4. Omission

In this type of functional recasting the teachers omitted something from a previous statement of their own or of a learner. These recasts were perhaps unintentional, as they resulted in *decreasing accuracy*. In the example below, the recasting involves the omission of units.

T:	See my second diagram? From B to C he covered hundred and forty meters.
L:	Yes.
T:	So there should be one forty.

5. General to Specific

This functional recasting type involved the teachers recasting from a more general form to a more specific form which was usually a type or example, *increasing specificity*.

T:	This is used to separate one liquid, which is dissolved in another like alcohol and water.

6. Specific to General

In this type of functional recasting, the teachers recasted from a more specific form (which was usually a type or an example) to a more general form, *decreasing specificity*.

T:	Hydrogen is a strange one, okay? It behaves like a metal although it's a gas.

7. Everyday to Technical

This type of functional recasting involved the teachers recasting from the everyday word/description or representation of an object or phenomenon to a more technical one, *increasing technicality*.

T:	He starts off at his home which is, I'm calling it point A and he ends off at his school which is point B….

8. Condensed/Concise form

In this type of functional recasting, the teachers recasted from a more expanded form or a definition to a shorter form such as an acronym, technical term or simply a shorter form of reference such as in the following example, *increasing technicality*.

T:	He starts off at his home which is, I'm calling it point A and he ends off at his school which is point B. Right let's say, the distance between A and B, okay let's just use a different figure.

9. Technical to Everyday

This type of functional recasting involved the teachers recasting from a more technical word/description or representation of an object or phenomenon, to a more everyday form, *decreasing technicality*.

T:	…H, is the home and the W stands, is, uh, basically, uh, basically a representation for the shops.

10. Expanded Form

In this type of functional recasting, the teachers recasted from a more concise/condensed form, term or an acronym to an expanded form such as a definition or whole-word reference, *decreasing technicality*.

T:	No, the unit. Like meters, kilometres, metres per second, things like that. S.I stands for System International….

11. Elaboration

This type of functional recasting involved the teachers recasting an action, decision or process with an explanation for it that employed different words, *decreasing technicality*.

T:	Alright, because she's moving East we write it as a plus twenty nine metres. I want you to understand something. With, uh, mechanics, especially with vectors, what I've actually done is, I've replaced the direction with a sign.

12. Incorporation of Everyday

In this type of functional recasting, the teachers recasted from an abstract or technical form to a more everyday form or example, *decreasing technicality*.

T:	… which is basically the perimeter of a circle. It's like if I am putting a fence around the circle…

13. Focusing Questions

This type of functional recasting entailed the teachers recasting a question which may have been vague, general or not eliciting a response from students, into a more specific one, *decreasing technicality*.

T:	That's right, but this one here – compounds are combinations of two or more? …What's a compound made out of? Like water's a compound. What's water got in it - molecules or atoms?

14. Quantity and Formula

In this type of functional recasting, the teachers recasted between a physical quantity and the formula for calculating it, providing an *alternate representation*.

T:	…We said speed is distance over time. Velocity is displacement over time.…

15. Physical Quantity or its Unit, and Symbol

This type of functional recasting involved the teachers recasting between a physical quantity or its unit, and the symbol representing it, providing an *alternate representation*.

T:	D, I am writing diameter. That's all I am actually doing, there's no magic. I've just simply, I replaced the two and the letter r by another letter called d - the diameter. But that is because a diameter consists of two radii. You all agree?

16. Physical Quantity and its Value

In this type of functional recasting, the teachers simply recasted between a physical quantity and its numeric value, providing an *alternate representation*.

T:	To his school and it's a distance of six hundred metres and he does this in a time of we said ten minutes.

17. Synonyms

This type of functional recasting involved the teachers recasting between synonymous words, providing an *alternate representation*.

T:	Alright, if that is the size or the magnitude, what have you not told me as yet?

18. Paraphrasing

In this type of functional recasting, the teachers stated something in a different way, as an *alternate representation*.

T:	I initially said, my cyclist starts at point A and he goes all the way back to point A. He covers one lap around the circular track

19. Multiple Representations

This type of functional recasting entailed the teachers recasting between different forms/ representations for such things as direction and variables, providing an *alternate representation*.

T:	Or we can also write it as change in X over change in time. …In the old, uh, manner that we used to write this we should write S over T, or delta S over delta T…

Each of the nineteen functional recasting types was found to contribute to a particular outcome. Some types achieved the same outcome, allowing them to be grouped. Table 9 which is a composite of the qualitative functional recasting results from the analysis of all three cases, shows the seven outcomes achieved by the nineteen functional recasting types.

Only one functional recasting type was identified for each of the decreased accuracy, increased specificity and decreased specificity outcomes. Two functional recasting types were identified which contributed to increased technicality and three types which contributed to increased accuracy. The decreased technicality and alternate representations outcomes had the highest numbers of functional recasting types with five types contributing to decreasing technicality and six types contributing to alternate representations.

Table 9: Functional recasting outcomes contributed to by the respective functional recasting types

Functional Recasting Outcome	Functional Recasting Type/s
1. Increased Accuracy	Replacement Inclusion Correction
2. Decreased Accuracy	Omission
3. Increased Specificity	General to Specific
4. Decreased Specificity	Specific to General
5. Increased Technicality	Everyday to technical Condensed/concise form
6. Decreased Technicality	Technical to everyday Expanded form Elaboration Incorporation of everyday Focusing questions
7. Alternate Representations	Quantity and formula Quantity/unit and symbol Quantity and value Synonyms Paraphrasing Multiple representation

A quantitative analysis of the proportions of functional recasts out of the total number, serving each outcome for each case yielded the results shown in the Table 10.

Table 10: Proportions of functional recasts out of the total number, serving each outcome for each case

Case	**Total number of functional recasts**	**Increased Accuracy (%)**	**Decreased Accuracy (%)**	**Increased Specificity (%)**	**Decreased Specificity (%)**	**Increased Technicality (%)**	**Decreased Technicality (%)**	**Alternate Representation (%)**
1	439	2.28	0	8.43	5.47	5.47	28.25	50.11
2	362	9.67	1.93	0.83	0.55	14.36	33.43	39.22
3	514	4.67	0.39	5.64	1.56	2.14	31.71	53.89

The teacher in case 3 employed functional recasting the most, while the teacher in case 2 employed it the least. More than half of the functional recasts of the teachers in cases 1 and 3 contributed to alternate representation, with case 3 having the highest proportion of these recasts. While the value was smaller for case 2, alternate representation was also the outcome which the highest proportion of functional recasts contributed to in this case.

For all three cases, the outcome which the second-highest proportion of functional recasts contributed to, was decreased technicality. Case 2 had the highest proportion of functional recasts contributing to decreased technicality and case 1 the lowest, with cases 2 and 3 having similar proportions contributing to decreased technicality. Case 3 had the lowest proportion of functional recasts contributing to increased technicality and case 2, the highest. In all three cases, there were smaller proportions of functional recasts contributing to increasing technicality than to decreasing it.

Case 1 had the highest proportion of recasts contributing to increased and decreased specificity and case 2 had the lowest (less than 1% each). In contrast to technicality, in all three cases there were smaller proportions of functional recasts contributing to decreased specificity than to increased specificity.

For all three cases, there were higher proportions of functional recasts contributing to increased accuracy than to decreased accuracy. Relative to the other cases, case 2 had the highest proportions of recasts contributing to increased and decreased accuracy and case 1 had the lowest, with no instances of decreased accuracy. For cases 1 and 3 the outcome which the smallest proportion of functional recasts contributed to, was decreasing accuracy. This was different for case 2, where a higher proportion of functional recasts contributed to decreased accuracy than to increased or decreased specificity.

4.5. Lexical Cohesion: Repetition Results

Table 11 shows the results of the repetition analysis for the three cases. The mean ± standard deviation of the repeated content words relative to the *total content words* is shown for each case. The mean ± standard deviation of the repeated content words relative to the *total words* per teacher utterance is also shown for each case. These results will enable the answering of research question 3a: What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of repetition?

Table 11: Repetition results for the three cases

Case	Lesson	Total Number of Content Words	Repeated content words relative to total number of content words (%)	Mean ± SD of repeated content words relative to total content words (%)	Total Number of Words	Repeated content words relative to total number of words (%)	Mean ± SD of repeated content words relative to total words (%)
1	1	916	30.50	19.35 ± 6.99	5535	11.69	13.20 ± 1.59
	2	845	17.17		6053	11.88	
	3	739	21.49		4409	13.43	
	4	1093	13.70		6200	15.65	
	5	983	13.91		6448	13.34	
2	1	828	14.04	12.25 ± 3.00	4425	16.61	16.68 ± 4.14
	2	583	16.24		4767	10.38	
	3	750	11.96		4443	15.73	
	4	1195	8.58		5590	21.14	
	5	1375	10.44		6414	19.52	
3	1	649	17.76	12.73 ± 4.64	3866	14.61	21.28 ± 5.03
	2	620	17.55		2959	17.30	
	3	1263	10.43		4789	23.68	
	4	1226	10.33		4485	24.57	
	5	1145	7.59		4042	26.22	

The range of the mean proportion of repeated content words relative to total content words, for the three cases is 7.10 %. The value is the lowest for case 2 and the highest for case 1. The mean values are similar in cases 2 and 3 but considerably higher in case 1. The proportion of repeated content words to total content words was fairly consistent for lessons within each case, as evident from the low standard deviations.

The range of the mean proportion of repeated content words relative to total words, for the three cases is 8.08 %. The value is the lowest for case 1 and the highest for case 3. The proportion of repeated content words out of the total number of words was also fairly consistent for lessons within each case as evident from the low standard deviations. While case 1 had the highest mean proportion of repeated content words out of total content words, it had the lowest mean proportion of repeated content words out of total words. Case 3 has the highest mean proportion of repeated content words out of the total number of words.

4.6. Lexical Cohesion: Cohesive Harmony Index Results

Table 12 shows the results of the cohesive harmony index analysis for the three cases. The mean cohesive harmony index ± standard deviation is shown for each lesson as well as for each case. These results will enable the answering of research question 3b: What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of cohesive harmony index?

Table 12: Cohesive harmony index results for the three cases

Case	Lesson	Mean CHI ± SD of utterances (%)	Mean CHI ± SE of lessons (%)
1	1	9.53 ± 12.36	8.58 ± 2.21
	2	8.76 ± 13.12	
	3	11.58 ± 17.37	
	4	7.18 ± 9.50	
	5	5.83 ± 9.93	
2	1	7.41 ± 15.31	9.48 ± 3.40
	2	7.30 ± 10.95	
	3	14.94 ± 24.33	
	4	7.05 ± 14.23	
	5	10.71 ± 11.89	
3	1	12.25 ± 15.45	16.55 ± 2.62
	2	18.87 ± 16.30	
	3	17.06 ± 14.93	
	4	16.21 ± 17.90	
	5	18.36 ± 15.25	

The range of the mean cohesive harmony index for the three cases is 7.97 %. The value is the lowest for case 1 and the highest for case 3. The values are similar in cases 1 and 2 but considerably higher in case 3. The cohesive harmony index of utterances within each lesson is variable, as indicated by the high standard deviation relative to mean for each lesson.

Chapter 5: Discussion

5.1. Introduction

The research questions for this study require descriptive discussions as presented in this chapter. For ease of reference, the results will be discussed here in the same order that the research questions have been presented. To further facilitate the discussion of the results in relation to the relevant research questions, a summary of the results is shown in Table 13.

An interesting fact which warrants mention at this point is that no practical work was covered in any of the five lessons of each of the three grade 10 Physical Sciences cases in this study. This is evidence that while language may not be the sole tool employed in the teaching and learning of Physical Sciences in Pietermaritzburg, it is a commonly used one. Furthermore, this provides justification for the sociocultural view of science as a language as described by Dawes (2004), Halliday (1993), Howe (1996) and Lemke (2001) and adopted in this study as mentioned earlier, as opposed to the view of science as a process, which if employed would have provided grounds for greater focus on the learning outcomes of the Physical Sciences National Curriculum Statement.

Table 13: Summary of all quantitative results and cases with expected and actual highest and lowest values

Research Question	Main Functional Language Feature	Aspect of Main Functional language Feature	Description/ Unit of value reported for the three cases	Case 1 (EFL teacher and 45% ESL learners)	Case 2 (EFL teacher and 60% ESL learners)	Case 3 (ESL teacher and 96% ESL learners)	Range	Case expected to have the highest value	Actual Case having highest value	Case expected to have the lowest value	Actual Case having lowest value
1a	Nominalisation		Mean Nominalisation relative to Total Words ± SD (%)	0.91 ± 0.42	3.82 ± 0.81	3.34 ± 0.49	0.03	1	2	3	1
1b	Lexical Density		Mean Lexical Density of lessons ± SE (%)	11.88 ± 1.88	23.68 ± 6.02	29.66 ± 6.15	0.18	1	3	3	1
2	Functional Recasting	Total number of instances identified		439	362	514	152.00	3	3	1	2
		Increased accuracy	Proportion of functional recasts out of total number (%)	2.28	9.67	4.67	7.39		2		1
		Decreased accuracy		0	1.93	0.39	1.93		2		1
		Increased specificity		8.43	0.83	5.64	7.60		1		2
		Decreased specificity		5.47	0.55	1.56	4.92		1		2
		Increased technicality		5.47	14.36	2.14	12.22		2		3
		Decreased technicality		28.25	33.43	31.71	5.18		2		1
		Alternative representation		50.11	39.22	53.89	14.67		3		2
3a	Repetition		Mean ± standard deviation of repeated content words relative to total content words (%)	19.35 ± 6.99	12.25 ± 3.00	12.73 ± 4.64	7.10	3	1	1	2
			Mean ± standard deviation of repeated content words relative to total words (%)	13.20 ± 1.59	16.68 ± 4.14	21.28 ± 5.03	8.08		3		1
3b	CHI		Mean CHI ± SE of lessons (%)	8.58 ± 2.21	9.48 ± 3.40	16.55 ± 2.62	7.97	3	3	1	1

5.2. Answering Research Question 1a:

What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of nominalisation?

Based on the literature describing similar studies, the use of nominalisation by the teachers in the three cases of this study was expected. However, the results of the nominalisation analysis in this study summarised in Table 13, are contrary to the initial prediction. The range of 2.91 % was lower than expected considering the proportion of ESL learners to total number of learners, in the three cases ranged from 45% to 96%.

It was anticipated that case 1 (45% ESL learners) would have the highest value and case 3 (96% ESL learners) the lowest, with case 2 (60% ESL learners) having a value lying in between. The results were not aligned to this, with case 2 having the highest value, case 3 having the second highest and case 1 having the lowest. The prediction that the proportion of nominalisation words relative to the total number of words in teacher utterances would decrease as the proportional of ESL learners increases, is thus incorrect, for the cases in this study.

The use of nominalisations is fairly consistent within each of the three cases in this study, as evident from the low standard deviations in Table 7. This supports the possibility that the amount of nominalisation occurring in each of the 15 lessons in this study is not random, but a characteristic of individual teachers teaching those lessons. The implications of this will be mentioned in the recommendations. Since the quantitative analysis of nominalisation employed in this study is a novel one, the nominalisation results from this study could not be compared to the nominalisation results in other published research.

5.3. Answering Research Question 1b:

What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of lexical density?

It is evident from Table 13, that although the lexical density was higher in case 3 (96 % ESL learners) than in case 2 (60 % ESL learners), as with the nominalisation results, the lexical density in cases 2 and 3 are similar. Here again, the values for cases 2 and 3 are considerably higher than the value for case 1 (45% ESL learners). The implication of the lexical density calculation technique employed in the current study being a variation from the traditional method described for example, by Halliday and Martin (1993), is that it is not possible to compare the lexical densities calculated in this study to those described in the literature.

However, since lexical density is associated with difficulty in learners understanding (Halliday & Martin, 1993), as in the case of nominalisations, it was predicted that the lexical density would decrease as the proportion of ESL learners increased. It was thus anticipated that case 1 would have the highest value and case 3 the lowest, with the value for case 2 lying in between. The results were contrary to this for cases 1 and 3, with case 1 having the lowest lexical density and case 3 having the highest. The original prediction is thus incorrect. The range of 17.78% for lexical density is higher than the range of 2.91% for the nominalisation analysis. This indicates little correlation between nominalisation and lexical density for the cases in this study and is contrary to what was expected from the literature (Halliday & Martin, 1993, p.79). However, due to the small sample size this lack of correlation cannot be confirmed statistically. A possible reason for the apparently low correlation between nominalisation and lexical density is that there are significant factors other than nominalisation which also impact on lexical density.

As with the nominalisation results, the lexical density is fairly consistent between the lessons within each of the three cases in this study. This is evident from the low standard deviations shown in Table 8. Three possible outlier values were identified - one for each case, where an unusually low lexical density value was calculated. As evident from Table 8, the apparent outliers are:

1. Lesson 2 of case 1,

2. Lesson 5 of case 2 and

3. Lesson 1 of case 3.

These can be explained as follows:

1. This lesson involved individual learners attempting to answer questions on the chalkboard and then receiving feedback from other learners and the teacher. The lesson was thus significantly different from the other four in terms of the amount and characteristics of teacher talk taking place.

2. The teacher discussed the answers to a test which the students had written previously and also addressed marking errors and changes in recorded marks for a significant portion of the lesson.

3. The teacher reminded the learners „to behave as if everything is normal' as soon as the lesson recording began, possibly emphasising the presence of the researcher both to the teacher and the students.

The significance of this is that deviations from the normal, apparently „signature' talk of individual teachers can apparently be accounted for. As with nominalisation, lexical density appears to be a characteristic of an individual teacher's talk rather than related to the language context of the particular class of learners.

5.4. Answering Research Question 2:

What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of functional recasting?

The functional recasting instances identified in the three cases were grouped into 19 types as described and illustrated in Chapter 4, with the 19 types in turn being grouped according to the outcome they contributed to. The results of the functional recasting analysis in this study provide more detail about its occurrence in science lessons than the study by Mohan and Beckett (2003) which categorised functional recasting examples into the broad categories of improvement or repair recasts. The functional recasting outcomes identified in this study are modelled in Figure 7.

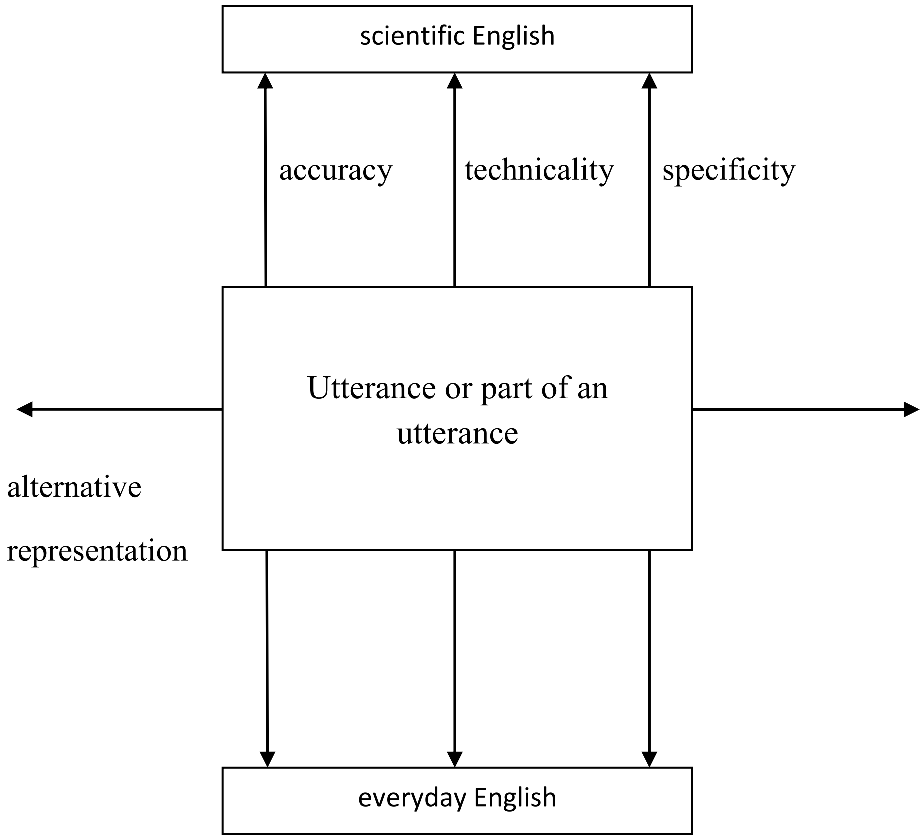

Figure 7: Model of functional recasting outcomes emerging from the teacher talk in the three cases of this study

The above model situates the possible functional recasting outcomes for an utterance or a part of an utterance during Physical Sciences lessons in relation to movement towards the registers of everyday or scientific English. One or more of the 19 functional recasting types identified in the current study, contribute to the outcomes of increased or decreased accuracy, technicality or specificity in order to move towards the everyday or scientific register of English. Upward arrows refer to an increase in accuracy, technicality or specificity while downward arrows refer to a decrease in these. There are also various functional recast types for achieving movement between alternate representations of a concept/statement/idea. Since these types of recasts do not increase or decrease accuracy, technicality or specificity and thus do not cause any shift towards the everyday or the scientific register of English, they are represented by horizontal arrows.

None of the cases in this study contained examples of functional recasting for movement between congruent (common/expected) and non-congruent (grammatically metaphoric) forms which was a possibility revealed in the study by Mohan and Beckett (2003). Furthermore, none of the teachers in this study employed functional recasting for constructing a theory/ practice relation which was a possibility revealed in the studies by Mohan and Slater (2005, 2006). This may be due to the absence of practical work in the lessons employed in this study but since practical examples could at least have been alluded to, it is nonetheless significant as it reveals that the teachers in the three cases of this study did not utilise functional recasting as effectively as they could have.

As evident from Table 10, the expectation that case 3 (96% ESL learners) would have the highest number of functional recasts was correct but the expectation that case 1 (45% ESL learners) would have the lowest number was incorrect, since case 2 (60% ESL) had the lowest number. Since the seven outcomes which the functional recasting types contribute to, only emerged during the analysis, there were no original predictions about which cases would have the highest and lowest number of each of these. However, drawing from Table 13, there is a trend for the cases having the lowest and highest proportions of functional recasts contributing to the outcomes. The results for the highest and lowest values are consistent for the functional recasting outcome *pairs* involving accuracy, specificity and technicality. For example, the case having the highest value for *increased accuracy* also had the highest value for *decreased accuracy* and the case having the lowest value for *increased specificity* also had the lowest value for *decreased specificity*. The only exception was that case 3 had the lowest value for *increased technicality* while case 2 had the highest value for *decreased technicality*.

As with the nominalisation and lexical density results, this indicates that Physical Sciences teachers' use of functional recasting represents individual styles of talking, contributing to the „signature' talk apparently unaffected by the overall language context of the learners in the classroom.

5.5. Answering Research Question 3a:

What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of repetition?

Table 13 shows that the expectation that case 3 (96% ESL learners) would have the highest repetition value and case 1 (45% ESL learners) would have the lowest repetition value, was confirmed for the mean ± standard deviation of repeated content words relative to *total words* but not supported for the mean ± standard deviation of repeated content words relative to *total content words*. To illustrate how the two repetition calculations complement each other, let us consider the summary of repetition results shown in Table 13.

While case 1 had the highest proportion of repeated content words out of *total content words*, it had the lowest proportion of repeated content words out of *total words*. This indicates that the teacher in case 1 used relatively fewer content words than the teachers in cases 2 and 3, but repeated those content words quite frequently. This is what was expected for case 3 and not case 1, since case 3 had the highest number of ESL learners and case 1 had the lowest.

Case 3 had the highest proportion of repeated content words to *total words* and had almost the lowest proportion of repeated content words to *total content words*. This indicates that there was a relatively high number of different content words used, which were not repeated often. This is contrary to what was expected, considering that case 3 had the highest proportion of ESL learners. While cases 2 and 3 were very similar in terms of the proportion of repeated content words to *total content words*, case 3 had a higher proportion of repeated content words to total words than case 2. Thus, while both teachers repeated content words to the same extent, the teacher in case 2 used relatively fewer content words. This is also unexpected, since case 2 had a smaller proportion of ESL learners.

The proportion of repeated content words out of total content words was fairly consistent for lessons within each case, as evident from the low standard deviations. In addition, the proportion of repeated content words out of the total number of words was also fairly consistent for lessons within each case as evident from the low standard deviations. This is further evidence of signature talk by each teachers participating in this study.

5.6. Answering Research Question 3b:

What is the nature of the utterances of Physical Sciences teachers in three different language contexts in Pietermaritzburg in terms of the cohesive harmony index?

Table 13 shows that the cohesive harmony index value for case 3 (96% ESL learners) was considerably higher than for case 2 (60% ESL learners) or case 1 (45% ESL learners). The expectation that case 3 would have the highest value and case 1 would have the lowest, was confirmed and so the initial prediction is correct. Since the current study uses a refined definition of the cohesive harmony index and thus a variation in its calculation, these results cannot be compared to those of Rodrigues and Thompson (2001).

For case 3, the lesson with the lowest cohesive harmony index is also the lesson with the lowest lexical density, indicating a possible correlation. Here again, due to the small sample size, the correlation could not be confirmed statistically. As with nominalisation, lexical density and repetition, the values for the mean cohesive harmony index of utterances within the lessons of each case are less consistent than the values for the mean cohesive harmony index between the lessons within each case as indicated by the low standard errors.

The results from the analysis of the various functional language features have consistently provided evidence that each of the teachers participating in this study has a signature talk. The signature talk of the teachers in all three cases, does not appear to be aligned to the language context of the learners in that case. The hypothesis for the current study is thus not supported.

Chapter 6: Conclusions and Recommendations

6.1. Conclusions

The purpose of this study was to explore and describe the nature of the utterances of Pietermaritzburg Physical Sciences teachers in different language contexts from the perspective of systemic functional linguistics. This study employed the lens of science as a language rather than science as a process. The fact that none of the five lessons of each of the three cases involved practical work affirms the choice of science as a language rather than science as a process for this study, as well as the use of systemic functional linguistics as the theoretical framework.

One drawback to this study using refined definitions for lexical density and cohesive harmony index and as a result, novel analysis techniques for these and also for nominalisation and repetition, is that the results for these analyses cannot be compared to those of other studies described in the literature. However, the advantage of the refined definitions and novel analysis techniques is that the study is more grounded in the field of Physical Sciences education. It is thus well-situated for meaningfully addressing the research questions.

Due to grammatical metaphor being a simultaneously useful (Unsworth, 1998) and problematic (Halliday & Martin, 1993) feature of the register of scientific English, it has been woven into this study. In the systemic functional linguistic framework, nominalisation is an aspect of the activity sequences component of the ideation discourse system of the ideational metafunction (Martin & Rose, 2007). Since nominalisation - which entails actions, events and qualities being substituted by nouns, is the most common type of grammatical metaphor in science (Parkinson & Adendorff, 2005), it was chosen as the focus in the current study. Due to nominalisation impacting on textual information density, referred to as lexical density in the systemic functional linguistics framework, and due to higher lexical densities being problematic to learners' understanding (Halliday & Martin, 1993), lexical density was included as another focal point in this study.

There was no apparent correlation between nominalisation and lexical density although a correlation was expected based on the literature (Halliday & Martin, 1993). This may be due to the teachers in this study insufficiently scaffolding learners' abilities to construct technicality by moving from congruent to non-congruent forms of language. Another possible reason for the apparently low correlation between nominalisation and lexical density is that there may be significant factors other than nominalisation, which also impact on lexical density.

The prediction that the proportion of nominalisation words relative to the total number of words in teacher utterances would decrease as the proportion of ESL learners to total learners increased, is incorrect. The prediction that the lexical density of the teacher utterances would decrease as the proportion of ESL learners to total learners increased is also incorrect.

According to Green (2007), functional recasting is a functional language feature mediating between words and grammar and useful for constructing technicality. It is described as incorporating and revising the everyday or drawing on specialised experiences in practical settings. Mohan and Beckett (2003) point out that functional recasting is orientated to improving learners' ability to use language as a resource for making meaning. There was thus strong justification for including it as one of the focal points of this study. From the functional recasting analysis in this study, nineteen functional recasting types were identified into which the various instances of functional recasting in the three cases could be categorised. Furthermore, it was found that one or more of these functional recasting types contributed to seven particular outcomes.

The replacement, inclusion and correction functional recasting types contributed to increased accuracy while the omission type of functional recasting contributed to decreased accuracy. The general to specific functional recast type contributed to the outcome of increased specificity while the specific to general functional recast type contributed to decreased specificity. Everyday to technical functional recasting together with the condensed/concise form type, contributed to the outcome of increased technicality while the technical to everyday, expanded form, elaboration, incorporation of everyday, and focusing question types of functional recasting contributed to the decreased technicality outcome. The quantity and formula, quantity/unit and symbol, quantity and value, synonyms, paraphrasing and multiple representation types of functional recasting contributed to the outcome of alternate representations.

While the results from this study confirm the description by Green (2007) regarding the increasing technicality outcome and incorporation of everyday type of functional recasting, it expands on it through the numerous other types and outcomes of functional recasting it has brought to the fore. The results from the current study also highlight the usefulness of functional recasting as mentioned by Mohan and Beckett (2003), of it being a resource for meaning-making.

The functional recasting results from this study reveal an interesting model of how it is used in Physical Sciences classrooms to move towards the register of everyday or scientific English, and for alternative representations. However, it was not used as fully as possible since there were no instances of it being used to move from congruent to non-congruent forms – a possibility revealed from the study by Mohan and Beckett (2003). In addition, no instances were identified in any of the three cases, where functional recasting was used to construct a theory-practice relationship as revealed to be possible in the studies by Mohan and Slater (2005, 2006). While this incomplete use of functional recasting may be due to the absence of practical work, since practical examples could at least have been alluded to, it can be commented that the teachers in the three cases of this study did not utilise functional recasting as effectively as they could have.

A troubling find in the results of the functional recasting analysis in this study was that two of the teachers, even if unintentionally, recasted functionally in a way that reduced accuracy. This emphasises the need for Physical Sciences teacher training in the functional use of language not only to engage with it (as it may currently already be in use by teachers whether they are aware of it or not and to varying degrees), but to do so constructively rather than destructively. The prediction that the amount of functional recasting would increase as the proportion of ESL learners to total learners increases is incorrect.

Halliday and Hasan (1976) suggest that text is a semantic unit in which the parts are linked by cohesive ties. This explains why Witte and Faigley (1981) point out that it is the cohesion aspect of texture which defines a text as being a text. Halliday and Hasan (1976) highlight five main categories of cohesive ties with lexical cohesion being one of them. Lexical cohesion is the main tool for connecting sentences in discourse and is a linguistic feature described by Halliday (1985) as continuity in text achieved through the particular choice of words used.

Lexical cohesion consists of the subclasses of collocation and reiteration. Collocation involves the use of words which are related in ways other than in those covered by synonymy (Halliday, 1985), and the subclasses of reiteration include repetition of the same lexical item. Collocation is one of the nuclear relations contributing to the ideation discourse system of the ideational metafunction of language while repetition is one of the taxonomic relations contributing to the ideation discourse system (Martin & Rose, 2007). Since it is the ideation discourse system of the ideational metafunction of language which was focused on in this study, collocation and repetition were originally considered as focal points.

However, the caution of Witte and Faigley (1981, p.193) that collocation is the most difficult type of lexical cohesion to analyse, warrants a study focusing primarily on lexical collocation rather than it being one of many focal points in a multi-faceted study such as the current one. Collocation was subsequently rejected as a focus of this study, and only repetition of the same lexical item was identified, with a novel method of analysis having been employed for quantifying it. The current study took cognisance of the argument that cohesion is inadequately represented by counting repetitions (Hasan, 1984, in Cox, 1990) by including calculations of the cohesive harmony index, based on the concept developed by Hasan (1984, in Cox, 1990).

The prediction that the degree of lexical cohesion in each case in terms of repetition would increase as the proportion of ESL learners to total learners increased, is incorrect for the mean ± standard deviation of repeated content words relative to total content words (%). However, the prediction is correct for the mean ± standard deviation of repeated content words relative to total words (%).The prediction that the degree of lexical cohesion in each case in terms of cohesive harmony index would increase as the proportion of ESL learners to total learners increased, is correct.

The nominalisation, lexical density, functional recasting and lexical cohesion results from this study, provide evidence of signature trends in grade ten Physical Sciences teacher utterances. This is supported by considerable consistency at the level of mean value for lessons within each case as indicated by the low standard deviations or standard errors for the mean values of the lessons within each case. The trends have been described as „signature' ones since the consistency is more strongly apparent within each case than between cases. The consistency within cases however, becomes apparent at the level of case rather than lesson.

Case 1 involved an EFL teacher and 45% of the class being ESL learners. The teacher in this case had the lowest mean proportion of nominalisation words relative to total words (0.91 ± 0.42). This is contrary to what was expected. The teacher utterances had the lowest mean lexical density (11.88 ± 1.88) although they were expected to have the highest. It was initially expected that functional recasting would be used the least in this case, but the value (439 instances in total) lay between the values for cases 2 and 3. The teacher in case 1 had the lowest value for mean repeated content words relative to total words (13.20 ± 1.59), as expected. It was also expected that the teacher in this case would have the lowest value for mean repeated content words relative to total content words but contrary to this, the value was the highest (19.35 ± 6.99). Thus, the teacher used relatively few content words compared to teachers in the other cases and repeated them relatively frequently. Although comparable to the mean cohesive harmony index for the teacher in case 2, the teacher utterances in case 1 had the lowest cohesive harmony index (8.58 ± 2.21%) as expected. For case 1, the teacher's signature talk does is not fully aligned to the language context of the learners.

Case 2 involved an EFL teacher and 60% of the class being ESL learners. The teacher in this case has the highest mean proportion of nominalisation words relative to total words (3.82 ± 0.81 %). This is contrary to the prediction that the nominalisation value for case 2 would lay between the values for cases 1 and 3. For the teacher in case 2, the mean lexical density of lessons (23.68 ± 6.02) lay between the values for cases 1 and 3 as expected. The teacher in this case employed functional recasting the least (362 instances in total). This is contrary to the expectation that the nominalisation value for case 2 would lay between the values for cases 1 and 3. The teacher in case 2 had a value for mean repeated content words relative to total words (16.68 ± 4.14) which lay between the values for cases 1 and 3, as expected. However, it had the lowest value for mean repeated content words relative to total content words (12.25 ± 3.00) and this was not expected. The teacher in case 2 thus used relatively few content words compared to the teacher in case 3 but repeated them infrequently compared to the teachers in cases 1 and 3. The teacher utterances had a cohesive harmony index value (9.48 ± 3.40 %) which lay between the values for cases 1 and 3, as expected. For case 2, the teacher's signature talk is not fully aligned to the language context of the learners.

Case 3 involved an ESL teacher and 96% of the class being ESL learners. The teacher in this case used nominalisation relatively frequently (3.34 ± 0.49) compared to case 1. This is contrary to the expectation that the mean proportion of nominalisation words relative to total word would be the lowest for this case. For case 3, the teacher utterances had the highest mean lexical density (29.66 ± 6.15) although they were expected to have the lowest. Functional recasting was used the most in this case (514 instances in total), as was expected. The value for mean proportion of repeated content words relative to total words was the highest for this case (21.28 ± 5.03), as expected. However, instead of having a value for mean proportion of repeated content words relative to total content words, that was the highest, the value lay between the values for cases 1 and 2 and was comparable to the value for case 2. Thus, the teacher used many different content words and did not repeat them frequently. The teacher utterances had the highest cohesive harmony index (16.55 ± 2.62%), as expected. For case 3, the teacher's signature talk is not fully aligned to the language context of the learners.

Thus, while there are observable differences between particular cases in each of the analyses as described in the discussion and summarised in Table 13, the differences are not always aligned to the predictions and so the hypothesis is not supported. The differences between the teacher utterances of the three cases may be due to the differences in the qualifications and/or experience of the three teachers focused on in this study or the topic being taught (as has been discussed earlier). In addition, it could have arisen due to an inadequate understanding of the significance of language in teaching Physical Sciences or where such understanding exists, ineffective translation of it into modelling and scaffolding the movement towards the registers of everyday or scientific English.

It is encouraging that the Physical Sciences teachers in this study did employ functional language features for modelling and scaffolding scientific English. However, at the level of learning and teaching in the Physical Sciences classroom, modelling and scaffolding which is not aligned to the specific needs of learners in terms of their language context, may translate into ineffective apprenticeship into the register of scientific English. Thus, it may indeed be possible that Physical Sciences learners in South Africa face unequal opportunities due to unequal access to scientific literacy arising from levels of exposure to scientific English that are not aligned to their specific language contexts.

6.2. Recommendations

The conclusions from this study include that the use of particular systemic functional linguistic features by some Physical Sciences teachers in Pietermaritzburg is not aligned to the specific language contexts of the learners in terms of the proportion of ESL learners relative to total number of learners. This study has started filling in the puzzle regarding the modelling and scaffolding of Scientific English to which South African Physical Sciences learners are exposed. It is recommended that further studies be undertaken employing the analysis techniques used in the current study, and the results compared to those of this study.

These further studies could be carried out with Physical Sciences lessons at grade eleven or twelve level to identify any differences or similarities between grades, in terms of learners' exposure to the register of scientific English. The studies could also be carried out in different geographical contexts to determine if there are local or international trends. In addition, similar studies could be carried out with Life Sciences or Natural Sciences teachers and students to determine if there are trends within science subjects, or even with other subjects to test a similar hypothesis.

An interesting possibility which this study has raised is that individual Physical Sciences teachers have characteristic styles of talking in the science classroom. Greater evidence of this could provide insight into why some Physical Sciences teachers achieve consistently high pass rates with their Physical Sciences learners while others achieve consistently low pass rates, resulting in varying degrees of access to scientific literacy. This would be of considerable value for providing an empirical basis for Physical Sciences teacher training and professional development in the use of systemic functional linguistics for the purpose of improving access to scientific literacy for Physical Sciences learners.

The results and conclusions of this study have significant implications for the development of PCK both in the pre-service and in-service education and training of Physical Sciences teachers. Training programmes need to place a greater emphasis on the functional use of language in order to empower Physical Sciences teachers to adequately apprentice their learners into the use of the register of scientific English.

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Appendix 1: Informed Consent letter signed by principals of participating schools (see following pages).

21 May 2009

Dear Principal

My name is Kavish Jawahar and I am an M.Ed. student registered at the University of KwaZulu-Natal in Pietermaritzburg. My telephone number is 033 260 5365/ 082 769 4328.

As my research project, I have chosen to conduct research on the interactions between teachers and learners at various schools. The project title is: Exploring the use of functional language features to promote Scientific Literacy, by four Physical Sciences teachers in Pietermaritzburg. The focus of my study deals in particular, with the interactions between Grade 10 Physical Sciences teachers and their learners during Physical Sciences lessons. Your school's context suites the requirements (such as it having English as the Language of Learning and Teaching) for one of the cases I wish to study.

If you decide not to participate you will not be disadvantaged in any way. If you do decide to participate, I will conduct a pre-interview of about an hour in length with the Physical Sciences teacher identified. I will then need to record about 5 lessons in the Grade 10 classroom being taught by the particular Physical Sciences teacher, with the consent of both you and the Physical Sciences teacher. A post-interview of about an hour in length will also be conducted with the Physical Sciences teacher. The recording will be stored at the University of KwaZulu Natal for a period of 5 years after use, and then be destroyed. **Your name, the name of your school as well as the name of the Physical Sciences teacher will not appear in my thesis, or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibilities for the school, for you or for the Physical Sciences teacher involved, and you may withdraw from the study at any stage and for any reason.**

My research project is being supervised by Dr Edith Dempster from the School of Education and Development at the University of KwaZulu-Natal in Pietermaritzburg. Her contact telephone number is 033-2605723. If you need further information about the project, please contact Dr Dempster. If you agree for your school to participate in my research, please complete the attached consent form and if possible, call me on the number mentioned earlier, so I may collect the form. I thank you for taking the time to read this letter.

Yours sincerely

Kavish Jawahar

(Please complete the declaration below, and let me know when I may collect it).

I ………………………………………………………… (full name of principal), the principal of

………………………………………………………….. (full name of school) hereby confirm that I

understand the contents of this document and the nature of the research project, and I consent to my school participating in the research project.

I understand that my school is at liberty to withdraw from the project at any time.

Name of Principal	**Signature of Principal**	**Date**
……………………………………	…………………………………..	…………………..

Appendix 2: Informed Consent letter signed by teachers participating in this study (see following pages).

21 May 2009

Dear Teacher

My name is Kavish Jawahar and I am an M.Ed. student registered at the University of KwaZulu-Natal in Pietermaritzburg. My telephone number is 033 260 5365/082 769 4328.

As my research project, I have chosen to conduct research on the interactions between teachers and learners at various schools. The project title is: Exploring the use of functional language features to promote Scientific Literacy, by four Physical Sciences teachers in Pietermaritzburg. The focus of my study deals in particular, with the language interactions between Grade 10 Physical Sciences teachers and their learners during Physical Sciences lessons. Your school's context, (such as it having English as the Language of Learning and Teaching) suites the requirements for one of the cases I wish to study.

If you decide not to participate you will not be disadvantaged in any way. If you do decide to participate, I will conduct a pre-interview of about an hour in length with you. I will then need to record about 5 lessons in the Grade 10 classroom being taught by you, with the consent of both you and the school principal. A post-interview of about an hour in length will also be conducted with you. The recording will be stored at the University of KwaZulu-Natal for a period of 5 years after use, and then be destroyed. **Your name, the name of your school as well as the name of the principal will not appear in my thesis, or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibilities for the school, for you or for the principal of the school and you may withdraw from the study at any stage and for any reason.**

My research project is being supervised by Dr Edith Dempster from the School of Education and Development at the University of KwaZulu-Natal in Pietermaritzburg. Her contact telephone number is 033-2605723. If you need further information about the project, please contact Dr Dempster. If you agree to participate in my research, please complete the attached consent form and if possible, call me on the number mentioned earlier, so I may collect the declaration form. I thank you for taking the time to read this letter.

Yours sincerely

Kavish Jawahar

(Please complete the declaration below, and let me know when I may collect it).

I ………………………………………………………… (full name of teacher), an teacher at

………………………………………………………….. (full name of school) hereby confirm that I

understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time.

Name of Teacher	**Signature of Teacher**	**Date**
……………………………………	…………………………………..	…………………..

Appendix 3: UKZN Ethical Clearance Approval certificate for this study (see following page).

UNIVERSITY OF
KWAZULU-NATAL

RESEARCH OFFICE (GOVAN MBEKI CENTRE)
WESTVILLE CAMPUS
TELEPHONE NO.: 031 – 2603587
EMAIL : ximbap@ukzn.ac.za

9 SEPTEMBER 2008

MR. K JAWAHAR (200278003)
SCIENCE, MATHS AND TECHNOLOGY EDUCATION

Dear Mr. Jawahar

ETHICAL CLEARANCE APPROVAL NUMBER: HSS/0465/08M

I wish to confirm that ethical clearance has been approved for the following project:

"Exploring the use of functional language features to promote Scientific Literacy, Physical Science Educators in Pietermaritzburg"

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years

Yours faithfully

PXimba
....

MS. PHUMELELE XIMBA

cc. Supervisor (Dr. E Dempster)
cc. Dr. W Green
cc. Mr. D Buchler

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Appendix 4: Printout from Turnitin software indicating a similarity index of 16% for this thesis (see next page)

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Appendix 5: Jawahar, K., Dempster, E., & Green, W. (2008, 11-14 July). *Exploring the use of functional language features to promote scientific literacy, by four Physical Sciences educators in Pietermaritzburg.* Poster presented at the KwaZulu-Natal Research Students Forum, Pinetown (see following page).

Exploring the use of functional language features to promote Scientific Literacy, by four Physical Science educators in Pietermaritzburg

- a research proposal by Kavish Jawahar (UKZN)
- research supervisors : Dr. Edith Dempster (UKZN) and Dr. Whitfield Green (DOE)

1. Rationale

In SA, both Learner Teacher Support Materials and assessments such as the Grade 12 final examination are commonly available in English. This, together with the perception that it is the language of access and power, contributes to English being the Language of Learning and Teaching in most cases. Thus, in most cases, in addition to the challenges posed by the register of Science, English second language Physical Science learners face the challenge of learning in English. Unequal access to Scientific Literacy therefore arises through the avenue of language. Beyond being contrary to the Physical Science NCS, unequal access to Scientific Literacy results in unequal life chances for learners due to its widely recognised benefits, such as access to high paying jobs. This motivates for research to be conducted which explores how language is currently being used by Physical Science educators in South Africa.

2. Focus

This study focuses on the nature of language characterising the verbal exchange between Physical Science educators and their learners during Physical Science lessons

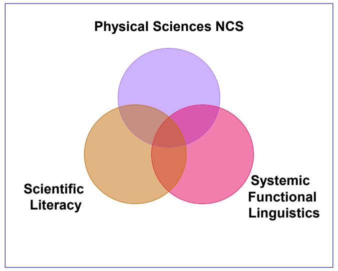

Figure 1: This study locates itself within the theoretical overlap between the Physical Sciences NCS, Scientific Literacy and Systemic Functional Linguistics

3. Theoretical Framework

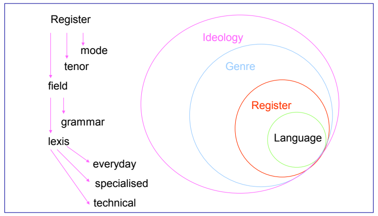

Figure 2: The Systemic Functional Linguistics model presented by Halliday and Martin (1993)

Systemic Functional Linguistics views language as an interlocking but open ended series of choices and as a resource for making meaning. It is thus a well suited theoretical framework for a study such as this. The 3 functional language features recruited for this study are nominalisation, functional recasting and lexical cohesion.

4. Related Studies

- **Rodrigues and Thompson, 2001** – analysed language used by two science educators to identify lexical cohesion.
- **Mohan and Beckett, 2003** – analysed the grammatical scaffolding provided by teachers to ESL learners.
- **Mohan and Slater, 2005 and Mohan and Slater, 2006** – analysed language used by science teachers to determine how language was used to build a theory-practice relationship.
- **Unsworth, 2006** – compared two texts in terms of the effectiveness with which they provided adequate scientific explanations.
- **Green, 2007** – analysed the use of implication sequences for the development of the register of science.

5. Research Questions

1. What is the nature of language characterising the substantive sequences used by Physical Science educators in four different language contexts in Pietermaritzburg, in terms of: (a) the patterns and frequency of occurrence of functional language features such as (i) nominalisation, (ii) functional recasting and (iii) lexical cohesion, (b) the lexical density and (c) the cohesive harmony index ?
2. To what extent is the use of functional language features by the Physical Science educator in each case aligned to (a) the requirements of the Physical Science NCS and (b) what literature in general, reveals to be effective language practice by Physical Science educators in diverse language contexts?

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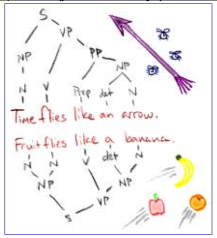


Figure 3: Linguistic humour depicting the challenges facing English Language Learners

6. Research Design and Methodology

Table 1: Details of the study

Method	Multiple-Case study (4 cases)
Learning Area	Physical Sciences
Grade	10
Lessons per case	5
Paradigm	Interpretive – Critical
Data Collection	Audio-visual Recording of lessons
Data Preparation	• Transcription of recording, identification of substantive sequences
Data analysis (for research question 1)	• Identifying and quantifying the use of functional language features in the substantive sequences • Calculating the lexical density and cohesive harmony index of the substantive sequences
Data analysis (for research question 2)	• A list of criteria constituting effective language practice will be drawn up from the NCS and from literature in general • The use of functional language features by the educators in each case, will be compared to this list

Table 2: Details of the cases

Case :	1	2	3	4
Teacher :	EFL	EFL	ESL	ESL
Learners Predominantly :	EFL	ESL	EFL	ESL

Ethical Considerations

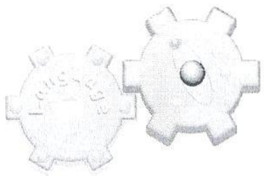
- informed consent from principals and the Physical Science Educators
- anonymity via the use of pseudonyms

http://www.matjin-nehen.com/category/art/humour/

Figure 4: More Linguistic humour depicting the challenges facing English Language Learners

Appendix 6: Jawahar, K. (2008, 23-26 October). *Systemic Functional Linguistics and Pedagogical Content Knowledge in Science.* Handout version of Microsoft PowerPoint presentation, Kenton Education Conference, Magaliesburg (see following pages).

Systemic Functional Linguistics
and
Pedagogical Content Knowledge
in Science



Kavish Jawahar
UKZN

1

This Presentation

1. Systemic Functional Linguistics is a critical component of Pedagogical Content Knowledge in Science

2. Analyzing science classroom discourse from the perspective of Systemic Functional Linguistics is one way of revealing the manifestation of Pedagogic al Content Knowledge

2

1.1. Everyday vs. Scientific Language

❖ Compared to everyday language, the language of science has:
- more technical lexis
- specialist grammar
- high information density
- a high level of abstraction
- authoritativeness ...(Fang, 2004)

❖ Technicality is 'the most noticeable feature of scientific English' ...(O'toole, 1996)

❖ Technicality:
- often contributes to it incomprehensible to science learners
- shapes the role of the science teacher

3

1.2. The role of Science Teachers

❖ 'learning technical terms is central to success in much of academic discourse and schooling' ...(Mohan and Slater, 2005, p. 156)

❖ 'the forms of scientific language scaffold, support and channel our thinking, reasoning, insight and even our creative imagination' ...(Lemke in Wellington and Osborne, 2001, pp. i-v)

❖ 'learning the specialised language of science is synonymous with learning science' ...(Fang, 2004, p. 337)

❖ giving greater attention to language is one of the most significant things that educators can do for the quality of science education to improve ...(Wellington and Osborne, 2001)

❖ **Science educators have the role of apprenticing learners into the use of science discourse ...(Lemke, 1990)**

4

1.3. Empirical Support for this claim

- 'Practice is best informed if it has both theoretical and empirical support' ...(Mercer et al, 2004, p. 374)

- 'thinking together' intervention programme ...Mercer et al (2004)
  - 'children's increased use of certain ways of using language leads to better learning and conceptual understanding in science'
  - this provides ' empirical support for the conception of science education as induction into a community of discourse or practice'

5

1.4. Domains of Teacher Knowledge

- Various domains of teacher knowledge have been advanced by Shulman ...(Shulman, 1987)

- ' SMK, PK and PCK remain at the forefront of what is essential to effective science teaching' ...(Zeidler, 2002)

- **Pedagogic Content Knowledge involves:**
  - a teacher's ability to make a subject accessible ...(Zeidler, 2002)
  - making a subject 'comprehensible' ...(Shulman, 1986, p. 9).

- PCK critical to science teachers, considering their role
- In science PCK includes modelling and scaffolding the language of science

6

1.5. PCK and SFL in Science

- language → Formal – focuses on form
- language → Functional – focuses on function

- Systemic Functional Linguistics (SFL)
  - language is more than a conduit through which meaning is poured
  - language is a tool for the construal of meaning ... (Halliday and Martin, 1993)

- It is thus a critical component of PCK in Science

7

2.1. SFL as Manifestation of PCK

In order to demonstrate SFL as a manifestation of PCK:

- SFL features relevant to the construction and deconstruction of technicality were identified
- One Gr 10 Physical Science lesson recorded and transcribed
- Substantive and non-substantive sequences separated
- Substantive sequences analysed for the SFL features
- Opportunities that were afforded by the use of these features was explored

8

Nominalisation

- Type of Grammatical Metaphor …(Halliday and Martin, 1993, p.79)
- Construction of technicality …(Unsworth, 1008, p. 201)
- most 'pervasive' problematic lexicogrammatical feature in science …(Halliday and Martin, 1993, p.79)
- Extensively used in Science …(Parkinson and Adendorff, 2005, p. 339)
- Involves actions, events and qualities being construed as nouns …(Parkinson and Adendorff, 2005, p. 339)
- E.g. Displacement and Acceleration

9

Functional Recasting

- Recasts → formal
  → functional …(Mohan and Beckett, 2003)
- 'incorporation and revision of everyday' …(Green, 2007)

T: We established that when the cyclist started at point A and he stopped at point A –he came back to point A, he covered a total distance of four hundred meters, which was the same thing as the perimeter of the circle. …

T: Now, what you needed to understand, well first and foremost you needed to understand the formula of the circumference of a circle, which is basically the perimeter of a circle. <u>Its like if I am putting a fence around the circle, that will be about four hundred meters</u>

10

Functional Recasting

- Inclusion Recast and Repair recast (Mohan and Beckett, 2003)

T: Definition of a vector somebody? (a learner raises their hand). Yes?
L: Sir, a quantity that has both magnitude and signs
T: Alright, a physical quantity that has both magnitude and direction.

- Suggestive Recast

T: Alright, if that is the size or the magnitude, what have you not told me as yet?

- Expansion recast

L: Is pi D wrong?
T: Pi d, there's nothing wrong. If you had to change, alright this is what I am being asked. Another way of writing the circumference, (writing on the board) is pi times diameter.

11

Lexical Cohesion

- continuity in text …(Halliday ,1985)
- lexical cohesion → repetition
  → synonymy → meronymy (part – whole) e.g. direction, vector
  → antonymy (opposite meaning)
  → hyponymy (specific – general) e.g. weight, force
  → collocation e.g. distance, displacement

…(Halliday and Martin, 2003)

alternative representation (using symbols) … (Green, 2007)
e.g. Displacment, $\vec{s}$

12

Discussion

- Nominalization
  - two instances identified (acceleration and displacement)
  - HOWEVER, they were not unpacked

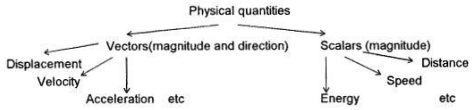
- Functional Recasting
  - repair recasts identified (to correct a definition)
  - suggestive recast (for suggesting a synonym)
  - incorporation of everyday (integration)
  - expansion recast (for simplification)
  - inclusion recast (for including unit of measurement)

13

Discussion (cont.)

- Lexical Cohesion
  - repetition (including technical terms)
  - synonymy – hyponymy and meronymy (construction of taxonomy)
  - collocation (related words not synonymous)
  - alternative representation (symbols)

- Taxonymy of technical words through lexical cohesion



14

Conclusion

- SFL is a critical component of PCK in Science
- Nominalization, functional recasting and lexical cohesion and important SFL features for modeling and constructing technicality
- Their occurrence highlight moments of PKC transformed into practice (or opportunities missed)
- Aspects of PCK manifesting:
  constructing technicality, correcting definitions of technical lexis, suggesting of technical synonyms, integration of technicality and the everyday, simplification of technicality, correcting technical representation, suggesting alternative representation, repetition of technicality

15

Thank You

16