Investigation of teachers' use of language during teaching of evolution in South African Life Sciences classrooms

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ABSTRACT

In South Africa there are eleven official languages and every citizen has a right to receive education in any of these languages. Nevertheless, the language of learning and teaching (LOLT) in most schools is either English or Afrikaans. Of the two languages English is more dominant because it is a global language and is preferred by parents. In a bid to embrace the call by UNSESCO (2007) which encourages science learning and teaching to be done in the mother tongue, South Africa implemented the teaching of science in indigenous languages in the lower grades in primary (1-3). Nonetheless, this endeavor has its merits and demerits. In South African schools most teachers and learners are English Second Language speakers. This study investigated the South African life sciences teachers' use of science classroom language (technical and non-technical components) when teaching evolution to grade 12 learners in public schools. The primary objective of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language towards suggesting strategies that they use to assist learners to better understand the science language. Three grade 12 life sciences teachers from two public schools in Johannesburg were observed and audio recorded three times while teaching evolution. A follow-up interview with each teacher was conducted to obtain clarity on language related issues that arose from the observations. As a result, the empirical data consisted of nine recorded lessons and accompanying field notes for each lesson as well as three recorded interviews. The interviews and the field notes were analysed using an interpretive approach whilst a strategy known as content analysis was used to analyse classroom observations so as to conclude on the teachers' preferred approach to language use during teaching. From the findings, it can be suggested that South African life sciences teachers who participated in this study employed a variety of strategies to present technical terms to their learners but lacked explicit awareness of the difficulty of the science classroom language.

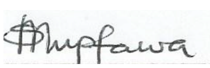
DECLARATION

I declare that this research report, titled;

Investigation of teachers' use of language during teaching of evolution in South African Life Sciences classrooms,

is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

It is being submitted for the degree of Master of Science at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination at any other university.



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CHAPTER 1: INTRODUCTION AND BACKGROUND OF STUDY

1.0 Introduction

The purpose of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language, beliefs regarding their roles to help learners with the science classroom language and the strategies they use to assist learners to better understand it. This study was conducted with three grade 12 life sciences teachers from two public high schools in Johannesburg. The study employed a qualitative case study approach in collecting and analysing data. This chapter presents the problem statement, the context in which the study was conducted, purpose, objectives and research questions that guided this study. It is in this chapter that the rationale for the focus on language and the topic of evolution as well as the justification for the study are discussed. In addition, a discussion on what the process of learning and teaching evolution may entail is presented. This chapter is concluded by a discussion on the role of language in learning and teaching of science.

1.1 Problem statement

South Africa is short of skilled personnel like doctors and science teachers yet the proportion of learners who achieve quality passes at 40% and above is low in life sciences. South African National Diagnostic reports for 2012-2015 attribute the low performance in life sciences to the following reasons. Firstly, learners are not familiar with the basic terminology applicable to the different topics and confuse similar terms. Secondly, learners experience difficulties in interpreting questions. They fail to provide reasons when asked or provide reasons that are not observable when asked for observable reasons or provide words for answers when asked for letters. Further, some topics like human evolution, genetics and meiosis are neglected as evidenced by little knowledge demonstrated by candidates in these concepts. Lastly, learners lack skills needed to draw graphs like pie charts (National Diagnostic Reports, 2012, 2013, 2014 & 2015). Of particular interest is the reason cited by Diagnostic Report (2015) which says that some candidates had problems distinguishing between verbs like *state, suggest, describe, explain* and *discuss*. In this study these verbs are called metarepresentational terms.

There are a lot of factors that influence the performance of learners in science. In their study on factors associated with high school learners' poor performance in mathematics and physical sciences Mji and Makgato (2006) identified teaching strategies, content knowledge, motivation and interest, laboratory usage, non-completion of the syllabus, parential role and language as factors affecting learner's performance in science.

In most African countries including South Africa poor performance in science is blamed on the language of teaching and learning (LOLT), which is English in most cases. Learners studying in their first language are proficient in the language of instruction and are considered to be advantaged with regards to learning science. In the same way, teachers assume that learners who are proficient in the language of instruction will perform well in science. However, research has shown that being proficient in the LOLT does not mean that learners will perform well in science. Indeed, all learners struggle with the science language regardless of cultural or linguistic background (Oyoo, 2014). This implies that the science teachers' classroom language including science text is different from everyday English; English used in science is a foreign language to all learners including first language speakers (Marshall, Gilmour & Lewis, 1991).

The reasons cited above do revolve around the science classroom language. The difficulties experienced by learners with terminology and graphs show how the science classroom language can be difficult to both learners and teachers. Therefore, this research sought to find out how life sciences teachers assist learners with the science classroom language to enhance understanding of science concepts when teaching. The focus topic in biology is biological evolution. The teaching of evolution is controversial all over the world despite its importance in the discipline of biology. This is due to the diversity in people's religious backgrounds. South Africa has not been spared from this war because of its 'rainbow' nature.

1.2 Context of the study

1.2.1 The importance of curriculum to the nation

A curriculum is a systematic and intended packaging of competencies that learners acquire through the process of learning in both formal and non-formal settings. The package consists of knowledge, skills, and attitudes which are underpinned by the values that the nation intends to instill in the society. A good curriculum plays a critical role in perpetuating lifelong competencies and social skills like tolerance, respect, constructive management of diversity, peaceful conflict management and respect for human rights, gender equality, justice and inclusiveness (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2016).

The school curriculum is meant to preserve the country's national identity and ensure that it grows through education. Thus, the school curriculum needs to be flexible in order to deal with new challenges and opportunities through integration of new and emerging issues in society. Consequently, a curriculum considers what the country wants to achieve in terms of development of learners and societal well-being (UNESCO, 2016). In a nutshell, a curriculum responds to national development policies and strategies.

In South Africa, the National Curriculum Statement Grades R-12 (NCS) provides an expression of the knowledge, skills and values that should be learned in South African schools (Department of Basic Education [DBE], 2012a). The SA curriculum plays various roles, some of which are as follows. Firstly, it aims at equipping learners with knowledge, skills and values needed for self-fulfillment and participation in their society as free citizens of a free South Africa, regardless of their socio-economic background, race, gender, physical ability or intellectual ability. Secondly, it provides learners with access to higher education and facilitates the transition from education institutions to the work place. Lastly, the curriculum provides employers with sufficient profiles of learner's competences (DBE, 2012a). An important feature about the curriculum is science because it has become part of the cultural heritage of all nations. As a result, all cultures have always wanted to understand how the world works and explore the frontiers of the unknown (DBE, 2012a).

1.2.2 Importance of science to the country

Science is considered to be central to the creation of wealth and improvement of quality of life of the contemporary society. In particular for SA, quality of life is enhanced through health care provision, meeting basic needs, reducing total cost of infrastructure provision, providing safety and security to all who live and work in it. Science is also known for promoting competitiveness and creation of employment as well as development of human resources. Lastly, science works towards promoting environmental sustainability and informational society (Department of Arts, Culture, Science and Technology, 1996). This implies that society expects science to provide solutions to its problems though it may not be the case all the time. Science education plays an important role in the development of any nation; it is the reason why every nation takes it seriously (Kola, 2013). The seriousness is also portrayed here in SA through the programmes that the government put in place to improve the quality of pass rate in science and provision of quality science teachers.

The life sciences sector impacts on all our lives since the nation benefits from the development of knowledge and the discovery of new medicines as well as treatments of diseases. Further, this sector employs lots of people. Life sciences is important to the nation as a whole because aspects of this sector are bound up in social issues like aging, control of infectious diseases, environmental challenges from global warming to waste management and the threat to biodiversity (Kola, 2013). In other words life sciences is important to the nation or society because it deals with issues that directly affect humankind.

In the South African curriculum life sciences is defined as the study of life at various levels of organization. It comprises of sub-disciplines like biochemistry, biotechnology, microbiology, genetics, zoology, botany, entomology, physiology (plant and animal), anatomy (plant and animal), morphology (plant and animal), taxonomy, environmental studies and sociobiology (animal behaviour) (DBE, 2012a).

1.2.3 The requirements for passing matric

At matric, learners are required to take a minimum of seven subjects. Three of these are selected from the following; a first language, a first additional language, mathematics or mathematical literacy. Learners are required to score 40% in these three subjects. One of these must be their home language. In addition to this, they are required to obtain 30% in three other subjects. These three subjects can be selected from the following list; life sciences, physical sciences, information technology, geography, history, religious studies, consumer studies, tourism, hospitality studies, accounting, business studies, economics, civil technology, electrical technology, mechanical technology, engineering graphics and design, agricultural management practices, agricultural science, agricultural technology, dance studies, design, dramatic arts, music and visual arts. So learners are considered to have passed if they meet this minimum requirement. Nevertheless, they can still pass even if they fail the seventh subject (Wedekind, 2013).

1.2.4 The importance of passing in South Africa

The school leaving matric exam is important in the South African education system. It is widely accepted that learners who do not reach, write or pass matric will never have proof for their educational status. When such learners look for jobs, employers will not accept school reports because they are not standardised, thus not reliable proof of achievement. On the contrary, learners who pass matric have economic gains in that it provides them access to further education and training resulting in the improvement of the learners' labour market prospects. Besides, passing matric determines who gets enrolled into which programs at the universities (Wedekind, 2013), though many universities are using National Benchmark Tests (NBT) as part of their admission criteria (Spaull, 2013). This implies that passing in the South African education system is vital because those who pass have access to jobs, universities, further education and training. However, universities and further education colleges have entry requirements which are different from those of passing the National Senior Certificate (NSC). On one hand, the bachelor minimum pass mark is 50% for LOLT (language of learning and teaching) of the Higher Education institute (HE) and four other subjects excluding life orientation. On the other hand, the diploma minimum pass mark is 50% for LOLT of the HE 40% for other subjects.

1.2.5 Life sciences pass rate

Table 1 shows that more than 50% of the learners who wrote life sciences in the years 2012-2015 passed (achieved at 30% and above). Nonetheless, the number of learners achieving quality passes (40% and above) is still low. This poses a challenge to the learners in that very few of them will be admitted into university for training in life sciences and science related careers.

Table 1: Life Sciences performance trends (2012-2015)

Year	No. wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved 40% and above	% achieved 40% and above
2012	278 412	193 593	69.5	120 734	43.4
2013	301 718	222 374	73.7	144 355	47.8
2014	284 298	209 783	73.8	139 109	48.9
2015	348 076	245 164	70.4	160 204	46.0

Adopted from National Diagnostic Report (2015, p.118)

The low pass rate in science is usually blamed on the difficulty of the subject. This general perception about the difficulty of the subject could result from failure to understand that the science classroom language is generally difficult. Besides, it is blamed on the language of learning and teaching (LOLT) since most of South African learners and their teachers are English Second Language speakers (ESL) (Ferreira, 2011; Mthiyane, 2016). As already mentioned before, the National Diagnostic Reports (2012, 2013, 2014 & 2015) on the contrary have identified terminology and action verbs like *describe* or *explain* to be some of the causes of poor performance in life sciences. This study therefore, sought to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language, beliefs regarding their roles to help learners with the science classroom language and the strategies they use to assist learners to better understand it.

1.3 Purpose and objectives of the study

The purpose of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language and the strategies they use to assist learners to better understand it. This study sought to address the following objectives:

- To establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language and beliefs regarding their role to help learners with the science classroom language.
- To investigate the strategies/approaches that South African life sciences teachers use to assist learners to understand the science classroom language.

1.4 Research questions

This research sought to address the following questions;

1. What knowledge do life sciences teachers have regarding technical and non-technical terms?
2. How if at all, do life sciences teachers assist learners to understand the science classroom language (technical and non-technical)?
3. How do the life sciences teachers perceive their role in assisting learners with the non-technical component of the science classroom language?

This was done in the topic area: Evolution

1.5 Rationale of the focus on language and the topic Evolution

1.5.1 Steps taken by the SA government to increase the pass rate in science

Poor mathematics and science results affect the availability of key skills required by the nation's economy like engineering. As a result, shortage of such skills negatively impacts on the nations' economic growth and job creation. In a bid to increase the pass rate in science the South African government established the Dinaledi schools Project, Funza Lushaka Bursary programme and the Secondary School Improvement Programme (SSIP). The Dinaledi Schools Project was established in 2001 by the Department of Education to increase the quality of mathematics and science through the support of the private sector. Specifically this programme was meant to increase the number of matriculants enrolled in university for training in mathematics and science careers (DBE, 2009).

The Funza Lushaka Bursary scheme is a national programme that was launched in 2007 under the leadership of the Department of Basic Education. This scheme is available to students who are willing to complete a teaching qualification in an area of national priority. Among the priority areas are subjects such as natural sciences, mathematics, life sciences and physical sciences (DBE, 2014). This is meant to promote the teaching profession in public schools especially in the science and mathematics fields.

Lastly, the Secondary School Improvement Programme (SSIP) was started in 2010 by the Gauteng Provincial government. SSIP is an extra mural supplementary programme for grade 10-12 learners in under-performing schools in the Gauteng province. This programme runs during weekends and vacations. The objective is to increase the provincial pass rate in mathematics and science (Gauteng Department of Education [GDE], n.d., p 9). Despite the government's initiatives to come up with such programmes, very little has happened at a systematic level to address the challenges faced by learners.

1.5.2 Focusing on Language

Despite the much excellent work on student difficulties with non-technical words used in the science context and the effect of second language on the teaching and learning science, scholars studying science language issues in education have not yet considered establishing South Africa's life sciences teachers' awareness of the difficulty of the science classroom language.

Further, strategies/approaches that life sciences teachers can use to assist learners to better understand the science classroom language when teaching evolution have not been explored. Yet without this information we have inadequate understanding of the life sciences teachers' knowledge of the role of language in the learning and teaching of science including its components (technical and non-technical). Consequently, we will not be aware of the strategies that they employ if ever they assist learners with the technical and non-technical terms of the science classroom language. This creates a condition of ill-informed policy decisions and a self-sustaining cycle of misunderstanding.

This study will fill this gap in the literature by establishing South African life sciences teachers' awareness of the place of technical and non-technical components of the science classroom language and the strategies employed to assist learners with the science classroom language. In education, the teacher's knowledge plays a critical role in determining how much learning takes place in the classroom. Therefore, results from this study will provide the science education fraternity with the general knowledge possessed by the SA life sciences teachers about science classroom language. Furthermore, results from this study will provide the Department of Education with information as to whether or not teachers are assisting learners with the science classroom language. Lastly, results from the study will furnish the science education fraternity with strategies that life sciences teachers can use to better assist learners with the science classroom language.

Biological evolution is a very important topic which is the central theme underpinning biology as a discipline (Clough, 1994; Dempster & Hugo, 2006; Rutledge & Warden, 2000). Thus, the teachers' understanding of the linguistic challenges of learning evolution in biology will equip teachers with knowledge needed to help learners to understand the concerned scientific concepts. Ultimately, it is in my hope that the quality of passes in life sciences examinations may improve thereby reducing the shortage of scientifically skilled manpower in South Africa.

As evidenced in the research questions, this study focused on how the teacher uses the science classroom language (technical and non-technical) in a life sciences classroom when teaching the life sciences/biology curriculum topic: Evolution.

1.6 Justification

The global rankings by bodies dealing with South African mathematics and science education have portrayed an undesirable picture in terms of the quality of school learners in these two subjects. In a survey conducted by the World Economic Forum (WEF) (2014) on the quality of mathematics and science, South Africa was ranked last out 148 countries. This poor performance in science means that South Africa will continue to face shortages of qualified skilled personnel in science related careers like science teachers, doctors and scientists (Oyoo & Semeon, 2015). As alluded to earlier on, science plays an important role in the development of a nation. Thus, poor performance in science has a negative impact on the growth of the country's economy.

In South Africa most of the learners are English Second Language (ESL) speakers. Thus gaining a level of proficiency in the language of learning and teaching (LOLT) is considered to be a necessary initial step. This is because learning is only possible when students are learning in the language that they are proficient in (Oyoo, 2007). As a result, it is assumed that when the English Second Language speakers have attained proficiency in the LOLT, learning can take place smoothly. It may be true that learners whose home language is not English may require more support to develop their English language skills but the science classroom language is foreign to all learners regardless of their linguistic background (Oyoo, 2007). This foreignness of the science classroom language is one of the factors contributing to the low performance in science.

The role of language in science learning and teaching has been a major focus in science education and research. Much attention has been paid to proficiency in the language of instruction which is usually English. Several scholars (e.g. Adams, Jessup, Creswell, Weaver-High & Rushton, 2015; Ferreira, 2011; Fung & Yip, 2014; Msimanga & Lelliott, 2014; Mthiyane, 2016; van Laere, Aesaert & van Braak, 2014) have focused on proficiency in the LOLT. In particular Ferreira (2011) focused on the effect of a second language like English on the performance of learners in life sciences. Adams *et al*. (2015) used inquiry to break the language barrier in chemistry by presenting a guided inquiry lesson which was meant to support the linguistic and conceptual development of English language learners. van Laere *et al*. (2014) investigated the role of student's home language in science achievement whilst Fung and Yip (2014) focused on the effects of the medium of instruction in certificate-level physics on achievement and motivation to learn. Msimanga and Lelliott (2014) investigated the nature of learner engagement with science content during small group discussion using their home languages. Finally, Mthiyane (2016) examined student teachers' beliefs surrounding the use of language in science classrooms. In spite of recognition of the central role of language in this matter, perhaps the focus has been on proficiency rather than the science classroom language. A couple of studies have been conducted on the difficulties experienced by students with non-technical terms that are used in the science context. However, most of these studies have been done in physics and chemistry not in biology/life Sciences.

The focus of my study was the teachers' use of science classroom language in a life sciences classroom when teaching evolution. In particular, I looked at how life sciences teachers use the technical and non-technical components of the science classroom language when teaching the topic evolution. Results from this study are important because they may help to improve the quality of teaching and passes in life sciences. Ultimately, it is in my hope that South Africa as a nation will benefit from the study as the shortage of skilled personnel such as doctors engineers and science teachers may be reduced.

1.7 What the process of learning and teaching of evolution may entail

1.7.1 Learning evolution as a new language

Science language refers to the terminology or concepts used in science. These words have a clear meaning in science but may have other meanings in everyday language. According to Oyoo (2014) science classroom language consists of technical and non-technical terms which pose a challenge to learners during the teaching and learning process. Hence, learning evolution can be like learning a new language to the learners because in evolution biology familiar objects acquire new technical terms. For instance, the fossil *Lucy* whose scientific name is *Australopithecus afarensis*, *Little foot* known as an *Australopithecine* without a species name at the moment and *Mrs Ples* whose scientific name is *Australopithecus africanus* (Gebhardt, Farham, Preeth & Pillay, 2013).

In addition, concepts with both everyday and science meanings pose problems on the teaching of evolution. Such words are *select*, *pressure,* and *adapt.* In everyday language *selection* implies choosing or the presence of a selector whilst in evolution the word refers to a random process which is not guided. Also, the word *pressure* is used as a causal agent or pushing evolution towards a goal rather than an environmental factor contributing towards differential survival in a population. Lastly, everyday *adapt* means acclimatising to the new environment (Allen, 2012) yet in evolution biology *adapt* refers to differential survival and reproduction in a population with variation and individuals with heritable traits (characteristics) survive in a given environment (Gebhardt *et al*., 2013). Further, the presence of new objects with new meanings in science also cause challenges in the learning of evolution. Examples of such words are *genes*, *mtDNA*, *phenotype*, *genotype*, *gametes*, *genome*, *trait*, *chromatid*, *fossil and allele* (Gebhardt *et al*., 2013).

1.8 The role of Language in Learning and Teaching science

School science is considered to be a practical subject that is taught using experiments. Nevertheless, experiments without language cannot be effective for teaching and learning science (Oyoo, 2012). Though practical activities in a science classroom can be interesting, motivating and useful in getting ideas across, they cannot speak for themselves. It is only through the teacher's and learners' talk around these activities (Leach & Scott, 2003) that science teaching and learning can take place. It is against this background that Mortimer and Scott (2003) identify talk as being central to the meaning making process, thus central to the learning process.

My view of learning and teaching is influenced by Vygotsky (1978) who views learning as a dialogic process. According to this view, new ideas appear firstly on the interpsychological plane where individuals talk as they interact with each other. As they discuss and work through ideas, every individual has to make sense of the new ideas for himself/herself through the intrapyschological plane. Therefore, this perspective views learning science as a process of social enculturation where the learner internalises the cultural tool (science classroom language) as a cognitive tool which he\she then uses to actively construct personal meaning (Leach & Scott, 2003). Central to Vygotsky's view is the importance of language in mediating thought. For Vygotsky, language is basic for thought, meaning that words are the means through which thought is formed (Howe, 1996). Therefore, all learning originates in social situations where ideas are rehearsed between individuals mainly through talk. As interactions continue through talk each individual makes sense of what is being communicated through words as tools for thinking.

In a science classroom, the scientific view is introduced to the learners through teacher talk. Teacher talk enables the teacher to support learners in making sense of the scientific view. In addition, language enables the learners to engage consciously in the dialogic process of meaning making (Mortimer & Scott 2003). Thus, language provides tools for learners to think through the scientific view for themselves. So language plays a critical role in all activities that are associated with effective teaching and learning science (Oyoo, 2012). This means that language is required in all strategies that a teacher can employ to enhance understanding of concepts even when involved in a practical. Consequently, the learning and teaching process of science relies on language for the construction of knowledge.

In a science classroom, language is used as a tool that facilitates communication between teacher and learners (Muralidhar, 1991). The teacher uses language to introduce new ideas, give instructions, and assess learners' understanding of concepts during interactions and practical activities. In addition, Yore *et al*. (2004) argue that language is used as means of doing science and constructing science understanding. This shows that language plays a very important role in the learning and teaching of science. Furthermore, Msimang (1992) contends that language is a carrier of culture. The language of science carries the culture of those who participate in it (scientists). Thus to learn science is learning to talk science (Lemke, 1990) which implies communicating the language of science as a member of the science community.

Language is a major barrier to most students learning science, hence the need to consider every science lesson as a language lesson (Wellington & Osborne, 2001). It is against this background that the intervention of the science teacher becomes crucial. Teachers play an important role in assisting learners to master the science classroom language which is unique because of its terms and style of talking (Mortimer & Scott, 2003). Science teachers play a key role in the learning process since their talk is the major source of information for their learners.

1.9 Chapter summary and research report outline

In this chapter an introduction and a general overview of the study has been provided. This chapter firstly presented the problem statement followed by a discussion on the context of the study. The purpose, objectives and research questions guiding the study were then presented. Furthermore, the rationale for the focus on language and the topic of evolution as well as justification for the study was presented. Also, a discussion on what the process learning and teaching evolution may entail was provided. Finally, the role of language in teaching and learning science was presented. The structure of the rest of this research report is provided in the next section.

Chapter 2 generally presents the theoretical framework guiding analysis and arguments presented in this study as well as a review of the literature related to this study. This study reviews literature on the science classroom language and biological evolution. So the literature on technical and non-technical components of the science classroom language as well as difficulty of the science classroom language is presented first. This is followed by a review of literature on biological evolution. Evolution controversy, teachers' knowledge of and views about evolution, importance of evolution and problems associated with the teaching of evolution are also discussed in this chapter.

Chapter 3 presents a detailed account of the research design and methodology adopted in this study. The data collection methods used in this study are discussed and the observation, and interview schedules are provided. The context of the study is provided, in terms of the background of teachers and schools in SA. Also the population and sample details are provided in terms of the participating teachers and participating schools. It is in this chapter that the data collection process is presented, from gaining access to conducting classroom observations and interviews. This chapter is concluded by a discussion on the issues of validity/trustworthiness and reliability/credibility.

Chapter 4 deals with data presentation and analysis. In this chapter, the analysis process is discussed in terms of verbatim transcription and content analyses. The findings are presented case by case in terms of interviews and observations. Chapter 4 is concluded by the participants' general performance on the science classroom language.

Finally, in Chapter 5 the key aspects of this research are discussed and critiqued and a summary of results is presented. It also in this chapter that limitations of the study and recommendations are presented.

CHAPTER 2: REVIEW OF LITERATURE FRAMEWORKS

2.1 Introduction

The purpose of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language and the strategies they use to assist learners to better understand it. This chapter therefore, places the study into perspective by presenting the conceptual framework underpinning the study. In addition, review of related literature is presented in this chapter. Literature review assists the researcher in framing the research topic, identifying the gaps in literature, avoiding repetition of studies that have been done before and identifying areas that are need of further research (McMillan & Schumacher, 2006). Thus, the concepts discussed in this chapter assisted me in developing the questions that guided this study.

This chapter presents a review of literature on the science classroom language and biological evolution. The science classroom language is presented as consisting of technical and non-technical components. This is followed by literature on the difficulty of the science classroom language. It is in this chapter that a review of literature on biological evolution is presented. In particular, literature on the following aspects about evolution is reviewed; the evolutionary theory, evolution controversy, teachers' knowledge of and views about evolution, the importance of biological evolution and problems associated with learning and teaching of evolution.

2.2 Conceptual framework

Edwards and Mercer (1987) coined the 'two thirds rule of classroom communication' from work conducted by Ned Flanders (1970) cited in Oyoo (2012) on classroom observations. They argue that Flanders demonstrated that for about two thirds of the time, there is somebody talking in the classroom. About two thirds of this talk in the classroom is teacher talk which could be lecturing or asking questions. This implies that in a classroom during the lesson the teacher does most of the talking.

The two thirds rule of the classroom interaction highlights the importance of language to learners during the learning process and the need for researchers to focus on teachers' classroom language. The teachers' classroom language can be equated to practical work in terms of enhancing learning of science concepts (Oyoo, 2012). As much as the teaching and learning process demands that the practical work done in a science classroom meets the learning demands, the science teachers' classroom language should also meet the learning demands like context and linguistic levels (Oyoo, 2009).

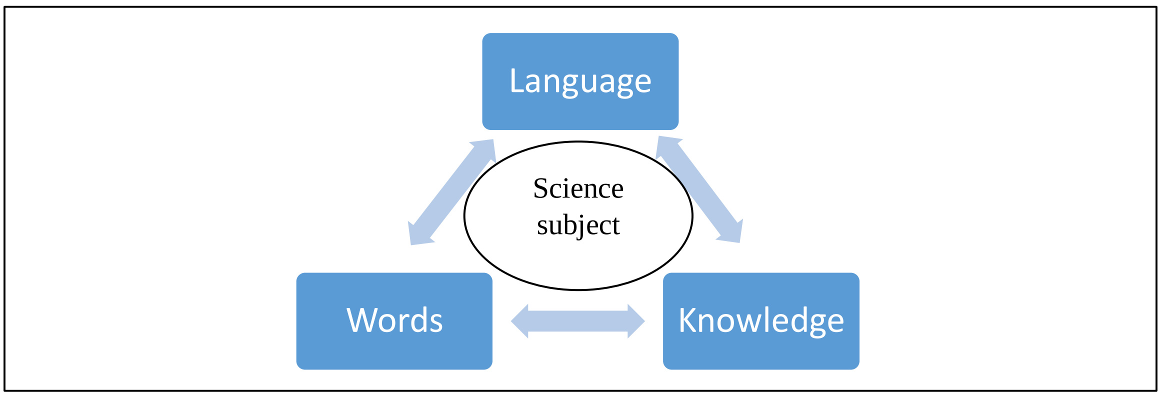
Since the teacher is talking most of the time in the science classroom, the issue of quality of this talk becomes crucial. This warrants the need to investigate the quality of teacher's talk in the science classroom. Vygotsky (1978) coined the law of cultural development which views learning as a process taking place on two planes. He argues that learning is initiated on the social plane as learners interact with each other using language. Once the knowledge has been constructed socially, each individual takes ownership of the knowledge through the internalisation process. The intermental plane ensures that the information is conveyed to the receiver (learner) who is then challenged to think or debate in his/her mind. This debate in the learner's mind (intramental plane) results in the process of internalisation as the learner constructs his/her own knowledge (Vygotsky, 1978). As a result, for learning to take place, there has to be talk which is initiated or guided by the knowledgeable other (teacher). This talk is facilitated by a set of tools, symbols and sounds which are referred to as language.

The actual talking on the social plane enables the individual learners to construct their own scientific knowledge as suggested by constructivist perspectives on learning. Thus learning science like evolution biology, entails learning a language. Learning a science language is the same as learning words. My focus on the use of words in a science classroom is based on the perception that words cannot be separated from language and that words constitute the language. Hence, focusing on words is the same as focusing on the language itself as done in Oyoo (2012). My conceptualisation of the link between language, words and knowledge is shown in figure 1. The link between words, language and knowledge forms the conceptual framework that guided this study and has been argued in the following words:

> *All of what we customarily call "knowledge" is language. Which means that the key to understanding a "subject" is to understand its language…What we call a subject is its Language. A "discipline" a way of knowing, and whatever is known is inseparable from symbols (mostly words) in which knowing is codified.*
>
> Postman & Weingartner (1971, p.102)

It is important to note that my conceptual framework was based on outdated literature because it is what researchers in this field of language have neglected for a long time. This focus on language is informed by the pragmatic perspective on language which argues that the meaning of each word is its ‘use’ and ‘function’ in the context of use (Gyllenpalm, Wickman, & Holmgren, 2010). Thus, meanings of words depend on the way they are used in particular contexts like science. So it is important to ensure that there are shared meanings of all words of the science classroom between the teacher and learners during instruction (Oyoo, 2012). It is the duty of the teacher to make sure that learners understand the science classroom language. Further, since the everyday language ceases to be when used in science, the contextual meanings of words need to be recognised as used in the science context.

Figure 1: Conceptual framework showing the link between language, words and knowledge



2.3 Review of Literature of the science classroom language

The science classroom language consists of words which can be classified into two groups which are technical and non-technical components.

2.3.1 The technical component

The technical component refers to the terminologies that are unique to the science subject in question. For instance, words like *zygote*, *mitosis* are words that are characteristic to biology. Likewise, Gardner (1972) maintains that technical words also include physical concepts like names for chemical elements, plants, organs, processes and apparatus used in the laboratory. These technical terms give science its identity.

2.3.2 The non-technical component

The non-technical component of the science classroom language refers to the non-technical words used in science texts or by teachers for instruction. Oyoo (2014) further classifies non-technical terms into three categories which are; everyday words used in the science context, metarepresentational terms and logical connectives. Firstly, everyday words used in the science context are words that are associated with the teachers' language as well as the science text but are not distinct science concepts. An example of this is the word *diversity*, which may be used in everyday language but becomes a 'specialist' word when used in biology. It is these words like *adapt* or *select* that pose challenges to students when learning science since they attain new meanings when used in evolution biology (Rector, Nehm & Pearl, 2013).

Secondly, metarepresentational terms are those terms that are not science words but signify thinking processes which can be metalinguistic verbs or metacognitive verbs. On one hand, metalinguistic words usually take the place of a verb which has something about saying for instance, *define*, *explain*, *argue*, *suggest* or *criticise*. On the other hand, metacognitive words take the place of a verb which has something to do with thinking for example *calculate*, *analyse*, *observe*, *predict*, *hypothesise* or *infer* (Oyoo, 2014; Wilson, 1999).

Lastly, logical connectives serve as links between sentences in the science text or science teachers' language. Such words include the following; *therefore*, *conversely*, *if*, *moreover* or *since* (Oyoo, 2014).

2.4 Difficulty of the science classroom language

It seems like the difficulty of science as a subject is due to the science technical terms which are foreign to learners. The situation is made worse by everyday words which assume new meanings when they are used in science context. Owing to this, learners still struggle with such words even if they are learning science in their mother tongue (Oyoo, 2012). As a result, the strategies employed by teachers to assist learners through the science classroom language become critical in the formation and development of science concepts.

2.4.1 The difficulty of the technical component

All over the world school science is considered to be difficult. In this study this issue is argued on the unfamiliar nature of the science words or technical terms used in the science classroom. In a science classroom the technical terms are referred to as science words, scientific terms, science content or science terminology. Though the difficulty of science has always been attributed to the difficulty of the science subject matter, it can be blamed on science words whose meanings are different from those of everyday language. Owing to this, science words are considered to represent a new language which is foreign to the learners. Thus, the general difficulty of science technical words is caused by their foreignness to the learners (Oyoo, 2014). This implies that the technical component of the science classroom language is new to the learners.

2.4.2 Difficulty of the non-technical component

As discussed earlier in section 2.3.2, the non-technical component of the science classroom language consists of everyday words used in the science context, metarepresentational terms (metalinguistic and metacognitive verbs) and logical connectives. All these three categories of the non-technical component of the science classroom language are generally difficult to impose challenges on the teaching and learning of science.

2.4.2.1 Difficulty with non-technical terms used in the science context

Some studies have been conducted on the difficulties experienced by students with non-technical terms that are used in the science context. Most of these studies were based on Gardner's study which was conducted in 1971, for instance Cassels and Johnstone (1980), Marshall and Gilmour (1991) and Pickersgill and Lock (1991. In his pioneer study conducted in Papua New Guinea, Gardner tested the understanding of 599 words on a sample of students from form 1-4 who were not English first language speakers. This study was meant to detect the difficulty of non-technical words used in science of which three words *disintegrate, random* and *spontaneous* stood out to be the most difficult to the students. In other studies conducted by Gardner with Australian English first language students in 1972 and Philippines English second-language speaking students in 1976, similar results were obtained which revealed that learners encountered difficulties with meanings of everyday words when used in the science context. Nonetheless, English speakers from Australia encountered fewer difficulties with meanings than their fellow counterparts from Philippines who were English second language speakers. This could mean that the language of instruction influences learners' understanding of the non-technical words used in the science context (Gardner, 1972, 1976). Perhaps more research would be required to prove this notion right. Findings from Gardner's study motivated other scholars from different parts of the world to undertake similar studies.

A study later conducted by Cassels and Johnstone (1980) with British students revealed a similar trend to what Gardner had obtained. In fact, students were seen to be struggling with the meanings of everyday words used in the science context and the general vocabulary. Another study followed in 1990 in Papua New Guinea in which Marshall and Gilmour (1991) tested the understanding of 45 non-technical words selected from the words that are commonly used by teachers in their teaching. Non-technical words like *exert* and *random* were tested on a sample consisting of learners ranging from grade seven to university students. Results from this study showed that learners have problems with meanings of everyday words though university students had a better understanding of these words than lower level students.

Another study conducted in Britain by Pickersgill and Lock (1991) showed that there is no difference between boys and girls in terms of understanding of non-technical words. In other words, both girls and boys misunderstood everyday words when used in the science context. However, the same study revealed that there is positive correlation between the learners' score on the test of understanding of non-technical words used in the science context and on a verbal reasoning test (Oyoo, 2011). This correlation may imply that proficiency in the language of instruction means better understanding of the meanings of non-technical terms used in science. This may call for further research.

Scholars in this field have addressed the important issue of the difficulties experienced by English second language learners at different levels of education subject areas (Farell & Ventura, 1998; Gardner, 1971, 1972; Oyoo, 2000; Oyoo & Semeon 2015; Prophet & Towse, 1999). In particular, Farell and Ventura (1998) focused on non-technical terms that are used in Physics whilst Prophet and Towse (1999) compared learners from Botswana (second language) and United Kingdom (first language) in terms of their performance on the non-technical terms. Oyoo (2000) conducted a similar study where he compared first and second language learners from United Kingdom and Kenya in terms of their performance on non-technical terms used in the science context. Locally, here in South Africa Oyoo and Semeon (2015) investigated the difficulties that grade 12 learners encounter with everyday words used in a science context. In another study, Oyoo (2007) concluded that even first language speakers struggle with the non-technical component of the science language. Overall, Oyoo (2011) concludes that the trends running through all these studies concerning learners' difficulties with meanings of everyday words were the same regardless of gender, linguistic or cultural background or research design. A study conducted recently by Oyoo (2016) also reveals that South African learners with everyday words used in the science context. This shows that all learners, first and second language speakers experience difficulties with everyday words used in the science context.

2.4.2.2 Difficulty of the metarepresentational (metalinguistic and metacognitive) terms

Oyoo (2012) argues that this component of non-technical terms has not been studied much. To be specific no research has been conducted to explore the difficulties that learners experience with metarepresentational terms. Clark (1997) cited in Oyoo (2012) investigated the confusion caused by two everyday words which are *describe* and *observe*. These words may not have been acknowledged as metarepresentational terms but the discussion of this study identifies them as such. Also the difficulties encountered by learners with these terms are evidenced by the poor performance in science which is attributed to poor understanding of these terms. For instance, the National Diagnostic Report (2015) argues that some learners had problems distinguishing between action verbs like *state, suggest*, *describe, explain* and *discuss*. These action verbs are what are called metarepresentational terms in this study. Even the Kenyan reports on the learners' performance on a physics examination cited that learners also experienced difficulties with words like *define* and *distinguish* (Oyoo, 2014). More evidence is provided in Oyoo (2014) where one student acknowledged that one may fail the examination because he/she does not understand the meaning of such words. Metarepresentational terms are usually associated with assessment, hence challenges with such words result in failure despite having the required content.

2.4.2.3 Difficulty of the logical connectives

Logical connectives form the third category of non-technical words used in science classrooms. They serve as links between sentences in the science text or science teachers' language. Such words are; *therefore*, *conversely, if, moreover, since, consequently* or *in order to*. There is not much evidence on the difficulties encountered by learners with logical connectives except for the study conducted by Gardner (1977). In this study, Gardner intended to identify commonly used logical connectives and measure junior secondary students' difficulties in comprehending the connectives. In his results, he found that the most difficult connectives were the ones commonly used in science text and teacher talk. Such words are consequently, hence, frequently, occasionally, often, alternatively, as, in contrast, similarly, unlike, namely, for instance, that is, again, also, further, in addition and moreover (Gardner, 1977). The value of logical connectives in science is that they link observation to inference, theory to explanation, experiment to findings as well as hypothesis to findings. Hence, students need to understand the meanings of these logical connectives for them to participate effectively in the science classroom.

Ultimately, research has shown that all learners including those learning science in their home language or proficient in the language of learning and teaching experience difficulties with the non-technical component of the science classroom language. This therefore, implies that even students learning in their mother tongue like isiZulu in the case of South Africa will still face challenges with the science classroom language. In this study these ideas were applied in the area of language and the topic evolution in SA high school curriculum.

In this study, as a means to source answers to the research questions already listed, the specific concerns during the classroom observations and follow-up interviews included:

- Is there evidence confirming the teacher's knowledge of the science classroom language?
- How does the teacher use the technical terms - how are these concepts explained?
- How does the teacher use non-technical terms (everyday words used in the science context, metarepresentational and logical connectives)?
- Does the teacher consider contextual factors like, whether learners are second language speakers of the language of instruction or not and available resources?
- What are the teachers' perceptions regarding their role to help learners with language in the science classroom?

2.5 Review of Literature on biological evolution

2.5.1 The theory of evolution

The theory of evolution by natural selection was formulated by Darwin in his book "On the origin of species" which was published in 1859 (Gebhardt *et al*., 2013). The theory of evolution by natural selection is a process by which organisms change over time due to changes in inheritable physical traits (characteristics). There are two ideas that are central to Darwin's theory of evolution. The first one states that species were not 'created' in their present forms but evolved from an ancestral species. The second one states that diversity of life results from modifications of populations by natural selection where some traits are favoured by the environment over others (Gebhardt *et al*., 2013, p. 246).

Gebhardt *et al*. (2013) argue that natural selection is a preservation process which causes the traits of organisms that have the ability to leave more offspring to be more common in succeeding generations. This process operates on traits that are inheritable. So natural selection is an equivalent of domestic breeding. Over centuries human breeders have produced dramatic changes in domestic animal populations by selecting individuals to breed. Thus breeders eliminate undesirable traits gradually over time. Likewise, natural selection gets rid of inferior species gradually.

Evolution is the change in heritable traits (characteristics) of biological populations over successive generations (Raven & Johnson, 1996). Thus human evolution is an evolutionary process that led to the emergence of anatomically modern humans. Darwin's ideas caused a lot of controversy which continues even today because it is considered to be conflicting with religious views about creation. This controversy is experienced more with the sub-topic human evolution. This topic focuses on the evolutionary history of primates, particularly the genus Homo and the emergence of *Homo sapiens* as distinct species of the hominins.

2.5.2 Evolution controversy

Many scientists appreciate that evolution is the central theme underpinning biology as a discipline. It has the ability to organise principles and empower scientists to find answers to the frequently asked questions about form and function, from molecular to the highest forms of life on earth (Rutledge & Warden, 2000). So evolution makes it easy for biology teachers to organise the concepts as they teach and expose learners to the ways of understanding the world around them. In spite of its value, evolution has suffered a lot of criticism from the public both abroad and locally. In particular, there are debates in education as to whether evolution, creationism or intelligent design should be taught in biology classes in America (Rutledge & Warden, 2000). This controversy results in teachers being at the frontlines of the evolution wars (Branch & Scott, 2008) which are common everyday in biology classrooms.

2.5.3 Teachers' knowledge of and views about evolution

Although teachers are expected to ensure that their learners have a deeper understanding of the evolutionary theory, Rutledge and Mitchell (2002) and Trani (2004) sadly found that American teachers have low levels of understanding and acceptance of evolutionary theory. This was consistent with the reports about the general public. Therefore, some of the teachers do not present evolution in their biology lessons. These studies portray the importance of the subject matter to the biology teacher, if ever evolution is to be emphasised in the high school biology classes. Trani (2004) further suggests that it is imperative to employ only biology teachers with a higher level of understanding of science and evolution.

One of many sentiments made by teachers across the world as the call to teach evolution in high school biology classes intensifies is reported in Trani (2004. p. 419) “I won’t teach evolution, I don’t believe in it; besides it’s only a theory and it is against my religion”. Thus, it is clear that evolution as a topic is controversial in nature, hence neglected by teachers.

A study conducted locally by Sanders and Nqxola (2009) shows South African teachers’ lack of knowledge about evolution. In this study they investigated concerns and needs of secondary school teachers. They found that most South African biology teachers did not have sufficient knowledge to teach evolution when it was introduced to the FET life sciences curriculum in 2008. In addition, teachers were concerned about the controversial nature of evolution. Moreover, some teachers who marked the matriculation examination written in 2008 reported that learners from some schools skipped questions on evolution (Sanders & Nqxola, 2009). This research indirectly shows that some teachers did not present evolution in their biology teaching. The reasons for skipping evolution are not known, hence can be researched further. Consequently, evolution becomes an important topic for this study.

2.5.4 Importance of Biological Evolution

This study focused on how the teacher uses the science classroom language (technical and non-technical) in a life sciences classroom when teaching grade 12 learners the topic evolution. Evolution refers to the genetic changes that take place over time leading to the formation of new species of organisms (Gebhardt *et al*., 2013). It has enormous relevance in our society since it is the central theme underpinning biology. It is the only biological explanation for the diversity of life. In particular evolution offers explanations for the similarities that we find in different life forms, changes occurring within populations and the development of new forms of life. Hence, excluding evolution or compromising its treatment in the curricula deprives learners of this important and unifying scientific concept.

Evolution plays a key role in many aspects of our activities and lives ranging from improvements in crops, livestock and farming methods, to the rise in pesticide resistance in agricultural pests. Natural selection informs the design of new technologies to protect crops from insects and diseases. Scientists apply evolution in environmental conservation by using plants and bacteria adapted to pollution to replenish lost vegetation and to clean up toxic environments. Further, studying mechanisms of evolution help conservation experts to come up with measures to protect endangered species facing extinction. Moreover, evolution is central to the advancement of medicine because principles of evolution are used to study and treat illnesses such as coronary heart disease and cancer (Raven & Johnson, 1996). Consequently, studying evolution is a remarkable way for students to learn the process of scientific inquiry, gathering, analysing information, test competency hypothesis and eventually come to a consensus about phenomena. Overall, evolution biology assists learners to make informed decisions throughout their lives.

2.5.5 Problems associated with the teaching of evolution

Evolution has been identified as one of the most difficult topics in biology (Smith, 2010). Teaching and learning evolution can be hampered by learners' prior conceptions, their views about the biological world, and religious orientation. Prior conceptions are a major factor that influences the learning and teaching of evolution (Alters & Nelson, 2002). Some of these prior conceptions may be misconceptions or misunderstandings about the nature of science. These misunderstandings or misconceptions are caused by viewing science as only experimental, lack of the role of the value of observation and indirect evidence, confusion of meanings of basic terms like *theory* and *law* (Smith, 2010). Dealing with misconceptions about evolution can be a problem because some of them are caused by religious beliefs.

Moreover, teachers have their own issues regarding the teaching evolution. National Diagnostic Reports (2012, 2013) argue that poor performance in evolution is also caused by teachers who skip the topic when teaching. Some do so because they are scared of the potential controversy associated with the teaching of evolution. To avoid such controversy, some teachers present evolution as though it takes place within species only (microevolution) ignoring macroevolution (species evolving into new species) (Berkman & Plutzer, 2012). Such teachers deny learners exposure to evidence on how natural selection results in the formation of new species and the concept of common ancestry. Owing to this, learners need to be exposed to both microevolution and macroevolution for them to understand evolution and its role in diversity.

National Diagnostic Report (2015) considers the learners' performance in evolution to be poor and attributes it to poor understanding of the basic terminology associated with the topic. Such words are *biogeography*, *phylogenetic tree*, *continuous*, *discontinuous variation*. To improve performance in evolution, the National Diagnostic Report (2015) suggests that South African teachers should employ strategies like identifying new terms in every lesson and breaking down terms into prefixes and suffixes and giving meanings. For instance, splitting the word *biodiversity* into *bio* and *diversity*. This shows that even South African education officials know that language is a factor that influences performance in science.

2.6 Chapter summary

This chapter highlighted the conceptual framework that guided this study and a review of literature relevant to this study. The technical and non-technical components of the science classroom language and its difficulty were examined. Furthermore, the theory of evolution, evolution controversy, teachers' knowledge of and views about evolution, importance of evolution and problems associated with learning and teaching evolution were discussed. The next chapter discusses the research design and methodology adopted in this study.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents the research design drawn to address the main objective of this study. The main aim of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language and the strategies they can use to assist learners to better understand it. A detailed account of how the research was conducted is also provided. This includes the research approach, procedures of getting into the research site, sampling method, data collection techniques and analysis methods. It is in this chapter that the rationale for the choice of approach and research instruments is provided. This chapter is concluded by discussing issues of validity/trustworthiness, reliability/credibility and ethical considerations.

3.2 Research Design

According to Opie (2004) researchers can either be positivists or interpretivists. Positivists believe that knowledge is hard, real and can be transmitted in a tangible form whilst interpretivists believe that knowledge is softer, subjective and based on experience. For positivists knowledge cannot exist beyond what is objectively and observable whilst for interpretivists knowledge is perceived as created in the individual's mind. Therefore, positivists are likely to employ quantitative procedures such as surveys. They tend to undertake large studies in search for generalised results. On the contrary, interpretivists are likely to use qualitative procedures which focus on individuals or small groups. As a researcher, I believe that knowledge is subjective and based on experience thus created in individuals' minds.

McMillan and Schumacher (2010) and Creswell (2012) concur that a researcher can adopt quantitative, qualitative or mixed approaches when conducting a study. Quantitative research designs emphasise objectivity when measuring and describing phenomena. Thus, objectivity is maximised through the use of numbers, statistics, structure and control. In contrast, qualitative designs emphasise on collection of data on naturally occurring phenomena. Hence, most of the data collected in qualitative designs are in form of words instead of numbers. With mixed methods design researchers use both quantitative and qualitative approaches to take advantage of the strengths and weaknesses of both approaches.

As an interpretivist, I adopted qualitative case study procedures in this study for collecting and analysing data. According to Fraenkel, Wallen, Hyun (2012) qualitative research investigates the quality of relationships, activities, situations or materials. In qualitative research the natural setting is the direct source of data and the researchers are more important than the research instruments. Researchers using this approach believe that activities can best be understood in the settings in which they occur. So researchers go directly to the particular setting of interest like a school to collect data through observation and interviews. In this case, the researcher can use a pen and paper or audio or video taping equipment to record the data. In addition, qualitative data are collected in form of words or pictures rather than numbers as in quantitative research. The kinds of data collected in qualitative research include; interview transcripts, field notes photographs, audio recordings, videotapes, dairies, personal comments, memos, official records or anything else that may communicate the actual words or actions of people. Hence, participants' assumptions, motive, reasons, goals and values are likely to be the focus of the researchers' questions (Fraenkel *et al*., 2012).

A case study is one of the five major types of qualitative research. It is a form of research that is concerned with provision of a detailed report of one or more cases (Creswell, 2013). In other words, a case study focuses on describing a particular case in detail and learns from it. The other four forms of qualitative research are phenomenology, ethnography, grounded theory and historical research.

Phenomenology is a form of qualitative research that tries to understand how an individual or a group of individuals experience a phenomenon whilst ethnography is a form of research concerned with the description of the culture of a group of people. In this case culture refers to shared attitudes, values, practices, norms, material things and language (Creswell, 2013). Historical research focuses on events that happened in the past (Cresswell, 2013) whilst Grounded theory is a qualitative approach aimed at generating and developing a theory from the data collected by a researcher (Strauss & Corbin, 1998).

A case study was adopted for this study because it enabled me to closely observe life sciences teachers as they tought evolution in their specific contexts. This approach was more approapriate for my study since it enabled me to obtain detailed accounts of how life sciences teachers use the science classroom language when teaching evolution to grade 12 learners. The case study approach is more varied than phenomenology which focuses on individuals' experience of some phenomenon, ethnography which is concerned with some aspect of culture, grounded theory which focuses on developing a theory. Thus a case study is holistic because it is conducted in a real life context instead of reliying on the participants (Creswell, 2013). In this study, a case study allowed me to use various methods like direct classroom observations and interviews to collect data about life sciences teachers' use of science language when teaching evolution. I did not rely on what the teachers said during the interviews only but also sat down in their classrooms and observed them as they taught the topic of evolution. Therefore, my case in this study was the topic of evolution. I observed life sciences teachers teaching the topic evolution so as to contribute towards effective teaching of evolution in South African classrooms.

On the whole, a qualitative case study research design was adopted for this study because the researcher sought to gather information about certain characteristics of life sciences teachers regarding the science classroom language. In particular, the study probed life sciences teachers in terms of their awareness of the technical and non-technical component of the science classroom language with regard to the strategies that they employ to assist learners with the science classroom language. Their perceptions regarding assisting learners through the non-technical terms were also probed. So I visited the life sciences classrooms and observed participant teachers as they taught evolution in order to establish the strategies they used to assist learners with the science classroom language. A follow up interview was then conducted with each participant to check and verify language issues that arose from the classroom observations. These interviews were meant to assist me in collecting data for addressing research questions 1 and 3 of this study.

3.3 Data collection methods

3.3.1 Classroom observations and interviews

Fraenkel *et al*. (2012) identify three main techniques that can be used by qualitative researchers for collecting data. The first is observing people as they conduct their daily activities as well as recording what they do. The second one is conducting in-depth interviews with people so as to get their ideas, opinions and experiences. The last one is analysing documents or other forms of communication. Observation refers to watching people as they go about their daily business and recording what they actually do (Fraenkel *et al*., 2012). Opie (2004) suggests that when using observation for data collection one needs to devise some form of recording so as to identify aspects of behavior relevant to the study, hence the need for an observation sheet/schedule accompanied by the field notes.

According to Fraenkel *et al*. (2012) the term interview refers to the process of carefully asking questions that are relevant to the study. It is an important method which is used by researchers for checking or verifying impressions obtained through observation. Besides, interviews can provide information about peoples' attitudes and their values. Interviews are conducted with the aid of an interview schedule to make sure the interview goes well. When using interviews, the researcher needs to conduct a pilot study using the designed interview schedule. This assists the researcher in eliminating any ambiguous, confusing or insensitive questions.

Of the three instruments used in qualitative research, the most appropriate for my study were classroom observations and interviews. Observations were appropriate because my study sought to find out the strategies/approaches that life sciences teachers use to assist learners with the science classroom language (technical and non-technical components) when teaching evolution. Classroom observations allowed me to watch the life sciences teachers as they taught so as to obtain the information needed to address my second research question. This is supported by Fraenkel *et al.* (2012) who argue that if one wants to know what they actually do in their natural settings, there is no substitute for watching them in action. Interviews were more appropriate for addressing my first and third research questions pertaining to the teachers' knowledge and their perceptions about non-technical terms. More so, the interviews were meant to follow-up on issues that arose from the classroom observations. In this study data were collected using audio-recorded classroom observations, interviews and field notes. Therefore to test the feasibility of my interview and observation schedules, I conducted a pilot study. The following section presents the context of the study in terms of the teachers' and schools' backgrounds as well as sampling.

3.4 Context of the study and sampling

3.4.1 Background of teachers and schools in South Africa

The South African Schools act No. 84 of 1996 provides for two types of schools which are public and independent (UNESCO, 2010). The public schools are governed and supported by the state. The majority of the teachers are employed by the state in the public schools (UNESCO, 2010).

Initial teacher education (ITE) programmes result in the production of teachers with either a four-year Bachelor of Education (BEd) degree or a one year Post Graduate Certificate in Education (PGCE) after completing a three year undergraduate degree. In both cases the teacher holds a four-year qualification in teaching, thus the current official qualification requirement for a teacher in SA is M+4 meaning a (school-leaving) matric certificate plus four years of ITE. Nonetheless, the previous official requirement was M+3 which is matric plus three years of ITE. Therefore, most teachers in SA are qualified with M+3. During training the teachers are given an opportunity to choose the phase they would like to teach. That is; Foundation, intermediate, senior and further education training phases. Some institutions allow combination of two phases. However, for the intermediate, senior and Further Education and Training (FET) phases, the teachers are given an opportunity to choose subjects for specialisation in the following fields; languages, mathematics, the sciences, technology, the humanities and business management (DBE, 2012b).

All teachers teaching in public schools in South Africa teach the same content from a common curriculum to the matriculants who will write the same university entrance examination. Thus in this study, the life sciences teacher's qualification (M+4 or M+3) was not considered for the selection process. Furthermore, the teachers' experiences in teaching were not considered for the selection of the participants for this study. Nevertheless, participants for this study were selected because they were teaching life sciences to grade 12 at a public high school during the time of this research.

3.4.2 Population and Sampling

Sampling is a process of identifying individuals who will participate in research and this sample represents the population to which the researcher intends to apply the results (Fraenkel *et al.*, 2012). The sample for this study consisted of three life sciences teachers who were teaching grade 12 at two public schools in Johannesburg. The sampling method used for selecting these teachers was purposive with regard to class level they are teaching this year. McMillan and Schumacher (2010) define purposive/purposeful sampling as a process used by researchers to select particular individuals from a population that will be informative or representative with regard to the topic of interest. So using the knowledge about the population, the researchers use their own judgment to select participants who will provide the best information to address the aim of the research.

Learners taught by the selected teachers automatically participated in the classroom observations. The advantage of using purposive sampling method is that it is less costly and time consuming. It is also easy to administer, usually assures high participation rate, receipt of needed information and generalisation is possible to similar participants. However, purposive sampling method is less representative of the identified population and difficult to generalise to other participants. More so, results are dependent on the unique characteristics of the sample and there is a higher chance of error due to the researcher or subject bias.

Since this study was focusing on the life sciences teachers' use of language in SA life sciences classrooms when teaching evolution, I had an option of choosing one level from grades 10, 11 or 12. On the one hand, the life sciences curriculum for grade 10 requires learners study the background of evolution by focusing on the history of life on earth without getting into details of the concept of evolution by natural selection. So there is no focus on human evolution which usually sparks controversy as mentioned earlier. On the other hand, the grade 11 curriculum does not cover much on evolution. In fact, it requires learners to study phylogenetic trees only when focusing on plant and animal diversity. The grade 12 curriculum requires learners to study the concept of evolution by natural selection and human evolution which is controversial. It is against this backdrop that I selected grade 12 teachers to participate in my study. Besides, in South Africa grade 12 determines the number of students enrolling for tertiary education to train in life sciences and science related careers.

3.5 Sample details

3.5.1 The two participating schools

The two participating schools are located in neighboring Johannesburg suburbs in Gauteng province. They are both public coeducational secondary schools. School 2 does not have boarding facilities whilst School 1 has boarding facilities which can accommodate 400 learners though it boarded only 75 at the time of this research. Both were school fee paying schools, although School 1 was more expensive than School 2. Further, both schools expected school fees to be paid over twelve months. School 2's enrollment was 1200 whilst that of School 1 was 1296.

Both schools used the CAPS curriculum document and offered grades 8 to 12. School 1 had two grade 12 life sciences teachers (one was the HOD) who were teaching two classes each whilst school 2 had two grade 12 life sciences teachers and six classes. At this school the HOD taught four life sciences classes while the other teacher taught two. Both schools were non-denominational in terms to religious affiliation. School 1 has well maintained buildings, garden and sporting fields. The sporting fields were perfect for sporting programmes like rugby, cricket, athletics, hockey and netball. Overall, the school offered 22 different sports and extra murals. School 2 has good infrastructure which was going down slowly due to poor maintenance. The next section presents details about the participant teachers. In this study Mr A is a male teacher from school 1, Mrs B is a female teacher from School 1and Mrs C is a female teacher from school 2.

3.5.2 The three participating teachers

3.5.2.1 Mr A from School 1

Mr A, a grade 12 life sciences teacher was also the HOD for the computer applications technology (CAT) department at school 1 during the time of research. He held a Bachelor of Science Degree in Biodiversity and Conservation Biology, Honours Degree in biodiversity and Conservation Biology as well as a PGCE in teaching life sciences and natural sciences. He obtained all his qualifications from the University of Western Cape in South Africa. Mr A had been teaching life sciences for six years at the time of study.

3.5.2.2 Mrs B of School 1

Mrs B, a life sciences teacher who was also the head of department (HOD) for life sciences at School 1 had been teaching for over twenty years at the time this research was conducted. In terms of qualifications she held a Bachelor of Science Degree in zoology, Post Graduate Diploma in education both obtained from the University of Witwatersrand. In addition to that, she held a Diploma in Laboratory Animal Technology obtained from Technikon SA.

3.5.2.3 Mrs C of school 2

Mrs C, a life sciences teacher who was also the head of department (HOD) for life sciences at School 2 had been teaching life sciences for 18 years at the time this research was conducted. In terms of qualifications she held a Higher Diploma in Education for teaching life sciences obtained from Thabamoopo College of Education. She also attended Vista University and Matthew Goniwe School of Leadership and Governance for Leadership and management. The next section deals with the actual data collection process.

3.6 Data collection process

3.6.1 Gaining Access

Ethics deal with beliefs about what is considered to be wrong or right, proper or improper and good or bad (McMillan & Schumacher, 2010) when conducting research. Since the focus of this study was on humans, ethics were considered. So I applied for ethics clearance from the Ethics Committee at the University of the Witwatersrand and my protocol number was 2016ECE019M (see appendix 4A). I also applied for permission from the Gauteng Department of Education (GDE) to conduct the study in two public secondary schools in Johannesburg. This was done by completing a GDE request form and attaching the following documents; a copy of my research proposal, observation and interview schedules, information sheets for principals, SGB chairs, teachers and learners as well as consent forms for both teachers and learners. Permission was granted by the GDE (see appendix 4B for the GDE approval letter).

To gain access to the two participating schools, permission was sought from each of the principals and School Governing Body (SGB) chairs by giving them the information letters (see appendix 3A and 3B respectively) and explaining the objectives of the study. Both principals granted me permission verbally to conduct the study at their schools. I then invited the teachers and learners to participate in the study and issued them out with teachers’ and learners’ information sheets as well as consent forms (see appendix 1 and 2 respectively). The information letters informed the potential respondents of the goals of the study and what the researcher hoped to achieve. In addition, the information letters assured the respondents that participation was free and they had a right to withdraw their participation from the study at any time.

Participants were only engaged in the study when permission was obtained from them through consent forms. Further, I was always open and honest with the participants and never misled them during the study. Data collection was anonymous and confidential as there was no link of names or identities to the research findings. When writing the report I retained anonymity of the schools and participants by using pseudonyms. Overall, this research adhered to the ethical considerations of the Faculty of Education, University of Witwatersrand.

3.6.2 Preparation for classroom observations

After gaining access to the schools and consent from the participating teachers, I then asked the teachers for copies of their timetables. I also asked the teachers to choose the classes that they wanted to teach as they participated in the study so that I would know the time to visit each participant. The topic evolution is usually taught during third term. So whilst I was waiting for the right time to collect the data (when the participants are teaching evolution) I had to decide on the role that I would take as researcher during the observation process. Cohen, Manion and Lewis (2011) identify four roles that a researcher can assume during observations which are; complete participant, participant-as-observer, observer-as-participant and complete observer.

According to Fraenkel *et al*. (2012) when researchers assume the role of complete participant, they interact with the participants and their identities may not be known by the participants. On the contrary, researchers who take on the role of participant-as-observer participate fully in the group's activities but make it clear to the group that they are conducting research. Researchers who choose the role of observer-as-participant make their role very clear by not pretending to be members of the group though they may participate a little in the group's activities. Lastly, researchers who assume the role of complete observer are detached from the group as they only observe the activities of the group without participating. The four roles have their own strengths and weaknesses. A complete participant is likely to get a true picture about the group's activities whilst a complete observer is likely to have the least effect on the action of the group under study. Participant-as-observer and the observer-as-participant are both likely to focus their attention on the researcher's activities instead of the normal group's routine.

For my study I chose to assume the role of a complete observer during the classroom observations. This role was adopted because the objectives of my study did not require me to be a participant. Instead, I was supposed to observe teachers as they taught evolution so as to establish their awareness of the difficulty of the science classroom language and the strategies they use to help learners to understand it. This was to be done with minimal effect on the activities of the teacher and the class.

I also had to make a final decision regarding the observation schedule, in terms of the specific concerns to be included. For the classroom observation schedule (see appendix 6). Since the classroom observations were supposed to be recorded I had to look for audio recording instruments. I then conducted a pilot study with another life sciences teacher who was not going to be part of the study. Finally, I asked my principal for permission to visit the participating schools for data collection. My principal gave me permission on condition that my classes were attended to by a colleague.

3.6.3 The pilot study

The pilot study was conducted well before the actual data collection when the researcher was waiting for the participating teachers to start teaching the topic *evolution* (usually taught towards the end of term 3). The pilot study was conducted to check the feasibility the observation and interview schedules as well as testing the three recording instruments that I was going to use for collecting data. I used three recording instruments so as to capture all the conversations clearly and to make sure that I back up information in case something went wrong with any one of them. Also, the pilot study was meant to assist in gauging roughly the amount of time required for each interview session so as to plan accordingly.

So the pilot study was conducted with a grade 10 life sciences teacher who was teaching the topic circulatory system to grade 10 learners. Consent was sought from the concerned teacher and her learners through their parents. This pilot study was conducted in two parts. Firstly, a classroom observation was conducted whilst recording the lesson with the three audio recording instruments (mp3 player, audio recorder and Samsang cellphone), using the observation schedule and taking some field notes. The researcher wanted to see roughly the strategies to expect during the actual observations. Apparently this teacher was from School 1. So during the observation she used images on PowerPoint to present words that were listed on a slide which she referred to as terminology/important terms. Besides PowerPoint, she used the chalk board for drawings. Further, she used the strategy recommended by the National Diagnostic report (2015, p. 121) of splitting words into prefixes and suffixes. She split the term *Bicuspid* into bi and cuspid and referred to the everyday meanings of these words. Also when explaining the words *inferior* and *superior vena cavae*, she provided learners with explicit everyday meanings of inferior and superior. However, the science context meaning of the word *circuit* was provided omitting the alternative meaning when she was explaining *systemic* and *pulmonary circuits.*

Secondly, an interview with the teacher was conducted after the researcher had listened to the audio recording of the observed lesson. This was meant to test the feasibility of the interview schedule and to find out how much time would be required for the actual interviews with the participants. In addition, this part was meant to test the audio recording instruments.

Two challenges were encountered during the pilot study. The first one was that, the audio recording was not very audible. The researcher considered locating the recorders in the front, close to the participant teachers so as to capture all the teachers' utterances.

The second one was that, while listening to the recording one of the instrument went off because the cell was flat. This taught the researcher to use a new cell whenever starting a new recording. Finally, the pilot study assisted the researcher in perfecting her observation schedule. When using it during the pilot study, the researcher realised that there were two specific concerns that were addressing the same issue. As a result, the two concerns were merged to form one specific concern.

3.6.4 Conducting classroom observations

3.6.4.1 Mr A of School 1

Three classroom observations were conducted with Mr A. These were used to collect information about the strategies employed by Mr A to assist his learners to better understand the science classroom language.

An observation schedule was used to record the information (see appendix 6). Mr A was observed three times teaching the same class. This class consisted of learners of mixed race and abilities. He was observed teaching the topic *evolution*. The first lesson was on evidence for *evolution* as he was starting to teach the topic. The next lesson observed was on *natural selection* and the last one was on *speciation*.

3.6.4.2 Mrs B of School 1

Mrs B was observed three times teaching the topic evolution to the same class. This class consisted of learners of mixed race and abilities. An observation schedule similar to the one used for Mr A was used to collect data (see appendix 6). The schedule was used to collect information about the strategies employed by Mrs B to assist her learners to better understand the science classroom language. The first lesson was on introduction to evolution as she was starting to teach the topic. The next lesson observed was on evidence for *evolution* and the last one was on *natural selection.*

3.6.4.3 Mrs C of School 2

Mrs C was observed three times teaching the same lesson to three classes of different abilities. The three classes consisted of learners of mixed races. An observation schedule similar to the one used for Mr A and Mrs B was used for Mrs C (see appendix 6). The schedule was used to collect information about the strategies employed by Mrs C to assist her learners to better understand the science classroom language. The lesson observed was on evidence for evolution.

3.6.5 Preparation for teacher interviews

After conducting three observations with each participant teacher, the researcher listened to the three recordings. Questions were then compiled based on how the individual participants used and explained technical and non-technical terms during observations. This meant that the interview schedules for the three teachers were slightly different although some of the questions were the same.

3.7 Data analysis procedure adopted for this study

The first step of analysis was transcribing the data (audio tapes) verbatim. An interpretive approach was used to analyse the interview responses and the field notes. Further, content analysis was used to analyse the classroom observations so as to make conclusions about teacher's preferred approach to language use when teaching evolution. Cohen *et al*. (2011) define content analysis as a process of summarising and reporting written data which involves coding, categorising, comparing and concluding. Coding and categorisation starts with definition of units of analysis (words/sentences) and categories. Content analysis was used for interpreting meanings of technical and non-technical words mentioned implicitly and picking words used explicitly. The overall analysis process was based on the specific concerns in the classroom observations and the main areas that were investigated in the interviews with the teachers.

3.8 Rigour: Reliability and validity

"Validity and reliability are two important concepts to keep in mind when doing research, because in them objectivity and credibility of research are at stake" (Silverman, 2004, p. 283). The researcher dealt with issues of reliability and validity throughout the research process.

3.8.1 Reliability/Credibility

Creswell (2012) defines reliability as the stability and consistence of the scores obtained from a specific instrument whilst Fraenkel *et al*. (2012) define reliability as the consistency of the inferences made by researchers over time, location and circumstances. Hence, in qualitative research reliability can be treated as credibility (Janesick, 2000). Since my research adopted a qualitative case study approach, issues of reliability or credibility were addressed though member checking, where the participating teachers were given an opportunity to read and correct the transcriptions. Also, to ensure credibility the researcher audio recorded the classroom observations and interview conversations.

3.8.2 Validity/Trustworthiness

Creswell (2012) defines validity as the development of sound evidence to prove that the interpretation of the test scores matches with its intended use. On the contrary, McMillan and Schumacher (2010) define validity as the appropriateness, usefulness and meaningfulness of the inferences made by the researcher from the collected data. Since this study adopted a qualitative case study approach, McMillan and Schumacher's definition was adopted for this study.

Shenton (2004) suggests that to ensure validity of results, all people approached should be given opportunities to refuse to participate in the project. This ensures that all the data collection sessions involve only those who are genuinely willing to take part and are prepared to offer data freely. In this study the researcher gave all the people approached an opportunity to accept or refuse to participate through the information letters and consent letters that participants signed. The participants were encouraged to be frank and assured that there were no right or wrong answers. Moreover, they were told that they had a right to withdraw their participation from the study at any time.

In addition, Shenton (2004) argues that frequent debriefing sessions between researcher and supervisor, redefinition of research questions, probing during interviews and peer scrutiny of the research project assist the researcher in assuring validity. In this study, the researcher and supervisor conducted a lot of debriefing sessions which widened the views of the researcher and assisted in redefining the research questions until they were addressing all cases within data. The University of Witwatersrand school of Education conducted a peer scrutiny session in form of PowerPoint presentations which gave the researcher an opportunity to share information and get constructive feedback. Questions, ideas, and observations brought in by colleagues, peers and academics helped the researcher to refine her methods, research design and strengthen her arguments. Further, the researcher examined previous research findings to access the degree to which her project's results were agreeing with those of the past studies.

3.9 Chapter Summary

This chapter dealt with the research design and methodology of the study. The sampling methods, data collection methods as well as the analysis methods were discussed. The rationale for choosing all these methods was provided. Further, issues of validity, reliability and ethical considerations have been discussed. In the next chapter the research findings are presented, analysed and discussed.

CHAPTER 4: DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter presents the analysis of data and findings obtained from this study. To answer the research questions below, data were obtained through the use of classroom observations and face to face interviews with the participating teachers. The classroom observations were meant to gather information about the teachers' strategies or approaches so as to answer the second research question whilst the interviews were meant to gather information that would be used to answer the first and third research questions which are concerned with the teachers' knowledge and perceptions about the science classroom language respectively.

This research sought to address the following research questions as highlighted in section 1.4:

1. What knowledge do life sciences teachers have regarding technical and non-technical terms?
2. How if at all, do life sciences teachers assist learners to understand the science classroom language (technical and non-technical)?
3. How do the life sciences teachers perceive their role in assisting learners with the non-technical component of the science classroom language?

This was done in the topic area: Evolution

The following section deals with the analysis strategy used in this study. The data analysis strategy is presented first followed by the findings from the observations and the interviews.

4.2 Data Analysis strategy

Data analysis was guided by the conceptual framework below adopted for this study which focuses on the link between words, language and knowledge which was highlighted in section 2.2.

> *All of what we customarily call "knowledge" is language. Which means that the key to understanding a "subject" is to understand its language…What we call a subject is its Language. A "discipline" a way of knowing, and whatever is known is inseparable from symbols (mostly words) in which knowing is codified.*

Postman & Weingartner (1971, p.102)

As highlited in section 2.2, the focus on language in this study was informed by the pragmatic perspective on language which argues that the meaning of each word is its 'use' and 'function' in the context of use (Gyllenpalm *et al*., 2010). Thus, the meanings of words depend on the way they are used in particular contexts like science. So to analyse meanings of technical and non-technical words, the researcher analysed the way words were used and explained in the science context.

4.2.1 Data analysis

This study used classroom observations and face to face interviews for data collection. These classroom observations and interviews were audio-recorded. Therefore, the initial stage of analysis was data transcription of the nine classroom observations (three lessons for each of the three participating teachers) and three interviews (one for each participating teacher). Eight of lessons were between thirty five to forty five minutes whilst one of them was nearly one and quarter hour long. Data transcription was done to prepare the data for visual review (McMillan and Schumacher, 2010). Transcription is the process by which a researcher converts field notes and audio-recorded information into a format that makes it easy for analysis (McMillan and Schumacher, 2010). Verbatim transcription was followed by content analysis which is presented in the next section.

4.2.2 Content Analysis

Content analysis is a strategy that allows researchers to study human behavior in an indirect way by analysing their communications (Fraenkel, Wallen & Hyun, 2012). Once transcription was done, the researcher determined the unit of analysis and categories used for classification before the beginning of analysis. The unit of analysis was how language was used in the life sciences classroom and categories used for classification were based on the research questions that guided this study, stated in section 4.1.

The first category was knowledge which was meant to classify information so as to provide evidence confirming the teachers' knowledge of the science classroom language. This category was further broken down into smaller coding units. The researcher decided that the unit of analysis for this category was going to be words like *technical/scientific terms, non-technical* *terms (everyday words used in the science context, metarepresentational terms and logical connectives).*

The second category was strategies/approaches. This category was meant to classify the information describing the strategies that teachers used to assist learners to understand the science classroom language (technical and non-technical terms). This category was further divided into two sub-categories which are teacher's instructional strategies, use and explanations of technical terms and teacher's instructional strategies, use and explanations of non-technical terms.

To deal with the first sub-category the researcher decided that the unit of analysis was going to be technical words so as to deduce the strategies/approaches used by the participating teachers. Here the researcher analysed the way technical words were explained so as to make conclusions about the teachers' strategies. Such strategies included the following; practical/experiments, field trips/educational tours, whole class discussion, debate, cues and questions or question and answer, analysis of students' work, using prior knowledge, probing, identifying similarities and differences/comparison, integration of content areas, lecture, read aloud, accountable talk, effective questioning, direct instruction, scientific storytelling, formative assessment process, homework and practice, stories, recapping/repeating, real life scenarios, cooperative learning, music and songs, non-linguistic representations, project based learning, peer-teaching/collaboration, word wall, realia, reinforcement effort/providing recognition and summarising/note taking (Washoe Country School District, 2015).

Furthermore, in the first sub-category the researcher analysed the use and explanations of following words so as to make conclusions regarding the teachers' strategies; *species, fossil, fossil record, scientific hypothesis, scientific theory, speciation, palaeontology, anatomy, morphology, physiology, comparative anatomy, homologous structures, humerus, radius, ulna, carpals, metacarpals, phalanges, biogeography, genetics, trait, genes, meiosis, fertilisation, mule, gene pool, allele, genome, interbreed, crossbreed, inbreeding, chromosome, chromatid, homologous pairs, analogous structures, heterozygous pairs, gametes, sexual reproduction, phenotype, genotype, DNA, mtDNA, hybrid* and *hybrid vigour* (Gebhardt *et al*., 2013). In this case I analysed how participants used and explained these words.

The second sub-category in the strategies category was teachers' instructional strategies, use and explanation of non-technical terms. Here the researcher divided the category into smaller classification units of everyday words used in the science context, metarepresentational terms and logical connectives. In terms of everyday words used in the science context the following words were identified for classification; *evolution, microevolution, macroevolution, diversity, variation, continuous variation, discontinuous variation, crossing over, adaptive radiation, fertile, sterile, convergent evolution, population, geographic barriers, pressure, adapt, 'Mrs Ples', geographic isolation, continental drift* and *yield* (Gebhardt *et al*., 2013). In terms of metarepresentational terms, the researcher identified the following words as the classification units; *define, discuss, suggest, describe, explain, distinguish, hypothesise, conclude, state, differentiate, infer* and *deduce* (Gardner, 1977).

In terms of logical connectives, the following words were identified as the classification units; *however, similarly, if, hence, since, in addition, therefore, further, in order to, also, further, as a result, namely, that is, for instance, unlike* and *alternatively* (Gardner, 1977). In this sub-category the researcher analysed how participants used and explained everyday words used in the science context, metarepresentational terms and logical connectives in order to find out how the participants used and explained these words.

The third sub-category in the strategies category is the consideration of contextual factors which was further broken down into the following categories*;* age, culture, religion/beliefs, preconceived ideas/experiences, learners' language, abilities and available resources such as textbooks, data projectors, computers and chalk/white boards. Here the researcher analysed knowledge of these words in terms of how the participants used those factors in their teaching.

The last category was perceptions which dealt with the teachers' beliefs and attitudes regarding their role in assisting learners with the non-technical component of the science classroom language. Thus this category was divided into the following classes (phrases)*;* not my duty, it's my duty, its English language teachers' duty, I can't teach English and we need to help learners with English. These classes assisted the researcher to interpret the participant's attitudes and beliefs regarding their role in assisting learners with the non-technical component of the science classroom language. Observations and findings are presented and discussed in relation to literature in the following section.

4.3 Classroom observations and interviews

The purpose of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language and the strategies they can use to assist learners to better understand the science language. So this study focused on the teachers' use of technical and non-technical terms in the life sciences classrooms. To achieve this objective direct classroom observations and face to face interviews were conducted with three grade 12 life sciences teachers who were selected to participate in this study. In fact, each of these participant teachers were observed three times whilst teaching the topic *evolution*. The observations were followed by one interview session per participant teacher. In both cases all utterances during the classroom observations and all responses during interviews with the participants were audio-recorded. Classroom observations were conducted to gather information about the instructional strategies employed by the teachers as they assist learners with the science classroom language as alluded to in section 4.1.

In this study, face to face interviews were meant to gather information regarding the teachers' knowledge about the science classroom language and their perceptions about their role in assisting learners with the non-technical component of the science classroom language as discussed in section 4.1. The interviews were a follow-up of the classroom observations. So the interview schedules for the participants were different because of the issues that arose from the participants' lessons regarding the science classroom language (see appendix 5). Nonetheless, some of the questions in the interview schedules were the same.

Overall, presentation of findings from observations and interviews is done on a case by case basis in the next section. In this section, as alluded to in section 3.5.1, Mr A is a male participant from school 1, Mrs B is a female participant from school 1 and Mrs C is a female participant from school 2. In addition, letters T, R and symbols L1/L2 and Ls represent teacher, researcher who is the author, individual/specific learner and two or more learners respectively. Mr A's interview and observations findings are first presented.

4.3.1 Interview: Mr A of School 1

Mr A was interviewed once after being observed three times whilst teaching the topic *evolution*. As mentioned earlier the interview was meant to gather information regarding Mr A's personal details and the strategies he employed when assisting learners with the science classroom language. An interview schedule specifically designed for Mr A was used to collect the data (see appendix 5A).

4.3.1.1 Mr A of school 1

Mr A, a life sciences teacher was also the HOD for the computer applications technology (CAT) department at school 1 during the time of research. He held a Bachelor of Science Degree in Biodiversity and Conservation Biology, Honours Degree in biodiversity and Conservation Biology as well as a PGCE in teaching life sciences and natural sciences. He obtained all his qualifications from the University of Western Cape in South Africa. Mr A had been teaching life sciences for six years at the time of study.

4.3.1.2 Evidence of knowledge of the science classroom language: Mr A

Technical terms

Though Mr A was aware of the technical component of the science classroom language, he was not aware of the non-technical component. As such he regarded non-technical words as English words. This is shown in the excerpt below;

R: Okay. Aah… are you aware of the value of aah…the non-technical component of the science classroom language?

Mr A: The non-technical component?

R: Yes…

Mr A: So…that's like the non …the non-scientific words?

R: Yah…like the non… yah the words that eee…like we…we borrow form everyday language then we use it in the science con… aah…context and you find they normally change their meanings.

Mr A: Yah!

R: So that's on type, the other type is the logical connectives I think that one you know the one thee…the ones that we use to connect… or to link up sentences like the…

Mr A: Yah!

R: The if's…, the however's…

Mr A: Okay! I think sometimes as teachers we use those non-technical… terms to help our learners understand, so you normally… or I find you would… would give them the technical term but that means absolutely nothing to them, you need it to relate it to a term they understand. So you relate it and explain it in… a term that they understand and say that the term is similar to… the scientific term. But I am also aware that sometimes the terms that we use its… doesn't have the same meaning that but I would rather have word that they understand that's close to the scientific term than them not knowing or understanding the term at all.

Clearly unaware of the non-technical component of the science classroom language, Mr A was aware of the language difficulties that learners face when learning evolution and extended that to other life sciences topics from grade 10 to 12. Mr A admitted that everything taught is new to most learners such that it is difficult for most of them to understand and be confident to use the science classroom language correctly. On being asked whether he was aware of language difficulties that learners encounter when learning evolution Mr A had this to say;

Mr A: *Aam… I think when you teach a subject like life sciences it doesn't matter if you grade 10 all the way up to grade 12 it doesn't matter what topic you teaching. Every time you teach them something, it's something new to them, for most of them it's something new, so I think regardless what topic you teaching, you are teaching them a new word aam…with a new meaning aam… adding another word to their vocabulary, so most of them aam…will have difficulty under …understanding the term and using it in the correct context aam… until such a point where they feel confident with the topic, feel confident with the subject itself as life sciences, so… learners do have… great difficulty with using the correct language for a specific topic until they get to a point when they are quite comfortable [Not audible] many learners never get that… that point where they are totally comfortable and I think when you mark their tests and essays aah… that's when it becomes very clear their understanding of the terminology and the language they are using is not correct.*

The excerpt above shows that Mr A was aware of the difficulties experienced by learners with regards to the technical terms. All the participants in this study were aware of the difficulties that learners encountered with technical terms. These findings support literature since such difficulties have been identified in the following studies; Cassels and Johnstone (1980); Farell and Ventura (1998); Ferreira (2011); Gardner (1971), (1972); Marshall and Gilmour (1991); Mthiyane (2016); Oyoo and Semeon (2015); Pickersgill and Lock (1991); Prophet and Towse (1999). Mr A identified the areas of difficulties to be the science terms, using the terms in the correct context and being confident with the subject. He also revealed the importance of assessment in determining the learners' understanding of the terminology (technical terms). He attributed this difficulty to the strange nature of technical words which supports Ferreira (2011); Oyoo (2014) and Mthiyane (2016) who argue that the general difficulty of the technical terms is caused by their foreignness to the learners.

Non-technical terms: Everyday used in the science context

By virtue of lacking awareness of the non-technical terms, Mr A also lacked awareness of everyday words used in the science context. As such Mr A treated everyday words used in the science context as technical terms during his teaching. He explained the science context meanings of words like *humerus* and *radius* but never referred to their alternative/everyday meanings as evidenced by the excerpt below;

> T: *Okay there is no biceps [Inaudible]… [Referring to images on PowerPoint] what we can see here if it's the arm it must be the… humerus which is the big bone okay, then we down to the elbow where the joint is and then we have the ulna and the radius from the grade 11 when you did the skeleton you know the ulna is the one that lines up with the thumb and the radius is another side.*

Here radius and humerus were only explained in terms of the science context meanings omitting alternative or everyday meanings. This shows that Mr A lacked awareness of the non-technical component of the science classroom language. Failure to explain the everyday or alternative meanings constitutes lack of awareness of the difficulties that learners encounter with such words. Such difficulties have been recorded in Ferreira (2011) and Oyoo (2012).

Non-technical words: Metarepresentational terms

During the classroom observations, Mr A used the words *discuss* and *explain* several times when referring to assessment. On being asked if his learners understood words like *explain* or *discuss* (metarepresentational terms), Mr A had this to say;

> *Mr A: Amm…because I have taught grade 10, 11 and 12, previously I know in some grade 10 textbooks there is a section on scientific method and if I recall correctly there is a list of these words and what the mean and what its expected of them so like the previous question I think because they grade 12 learners I do amm…make an assumption that they understand what I mean by those words that if you say explain you need to elaborate, if you just say list its point form amm… and just based on the group I am working with now amm… I can see that some of those words they don't understand based on their assessments aam…but previous groups that I have had amm… I haven't had a problem with them understanding those… terms.*

The excerpt above shows that Mr A admitted that he assumed that life sciences learners were taught words like *define*, *explain* or *discuss* (metarepresentational terms) in grades 10 and 11. As a result, he assumed that learners already understood those words when they get to grade 12 though assessments showed him that they did not understand these words. So in his practice, Mr A never made specific time to explain the meanings of such words. Nevertheless during the interview session, Mr A and Mrs C concurred that they explained words like *explain* or *define* (metarepresentational terms) during revision of cycle tests and June examinations. On being asked if he makes time to help learners with such words Mr A had this to say;

> *Mr A: Well I don't make specific time to teach them these words but when we go through the cycle tests and when we go through the June exams and the question then says explain the question to them I do also speak to them about what's expected and what the structure is and under those circumstances I may explain, what explain means that you give more detailed information but I haven't had a lesson where I have just taught it to them.*

Mr A admitted that his learners face difficulties regarding words like *explain* or *define (*which are called metarepresentational terms in this study) but does not find time to teach learners meanings of such words except during feedback time after assessment.

Non-technical terms: Logical connectives

Despite lacking awareness of the value of logical connectives in science classroom language, Mr A used two logical connectives in the three lessons observed. On being asked whether his learners understood logical connectives (*if* and *however*), Mr A admitted that he assumed that learners in grade 12 understood these words. Owing to this, he said that he was not sure of whether his learners understood these words or not. On being asked whether he took time to teach his learners these words, Mr A had this to say;

> *Mr A: l think when learners get to grade 12 we just make the assumption that they understand what those words mean, so I don't ever make a conscious des…decision to teach them that this is, when I say if this is the circumstances under which I am saying it or the word however, so l am not sure whether that they understand aah…connecting words like that but I make the assumption…*

This means that Mr A lacked awareness of the value of logical connectives in the science classroom language. As a result he lacked awareness of the difficulties that learners encounter with the logical connectives and never bothered to explain meanings of such words. Though there is not much evidence on the difficulties encountered by learners with logical connectives, they have been recorded in the study conducted by Gardner (1977). Teachers' knowledge of the science classroom language affects the teachers' perceptions about the science language. Thus the next section presents Mr A's perceptions about the science classroom language.

4.3.1.3 Mr A's perceptions about the science classroom language

On being asked about whether he believed that it is his duty to as a life sciences teacher to teach learners the non-technical component of the science classroom language, Mr A had this to say;

> *Mr A: Emm…I think that… I think we don't consciously take on that responsibility, like we are not like oh my kids are coming in today I need to teach them these non-technical words but as you explaining various concepts you using the non-technical words and if you see that they are confused you explaining non-technical words because there is no way they are going to understand the technical scientific words unless they know the non-technical words because we use them together we link them together so is it my responsibility to teach it them I don't think so but if I want my learners to be successful, I am obligated to ensure that when non-technical terms are used with these technical terms that I explain how they work together in asking a question or in explaining a concept, so I don't feel like I should but I am obligated because I want my learners to succeed.*

The excerpt above reveals Mr A's lack of awareness of the non-technical terms even after explaining all the categories of non-technical terms. He regarded non-technical terms as words that are used to explain technical terms. In other words, he considered non-technical terms to be English words which are part of the medium of instruction. Regarding his role in assisting learners with the non-technical component, Mr A believed that it not his responsibility, but does so because he wants his learners to succeed. This implies that Mr A was unaware of the difficulties that learners experience with regards to non-technical terms.

4.3.2 Classroom observations: Mr A of school 1

As highlighted in section 3.3.1, three classroom observations were conducted with Mr A. These were used to collect information about the strategies he employed to assist his learners to better understand the science classroom language.

An observation schedule was used to record the information (see appendix 6). Mr A was observed three times teaching the same class. This class consisted of learners of mixed race and abilities. He was observed teaching the topic *evolution*. The first lesson was on evidence of *evolution* as he was starting to teach the topic. The next lesson observed was on *natural selection* and the last one was on *speciation*.

4.3.2.1 Mr A's instructional strategies, use and explanation of technical words

In dealing with a technical term like *fossil record*, Mr A used integration of other content areas as a strategy. So the term *fossil record* was explained using learners' prior knowledge from geography about sedimentary rocks through probing. After eliciting information from the learners, Mr A then introduced concept of fossil record as shown in the following excerpt;

> T: *… The first piece of evidence that scientist use as evidence for evolution is the fossil record those who do geography what type of rock do we find there?*
>
> *Ls: [Chorusing] Sedimentary*
>
> *T: Sedimentary rock, what we know about sedimentary rock is that it is laid down in layers eeh…laid down in layers and pressuring causes them to harden in and form structure. What we also know about sedimentary rock is that if we look at the layers the bottom layer is the oldest in terms of time and the layers on top of newer, younger layers. Okay, so what they do is that they look at a piece of rock like that… and they find fossils in this rock, so if they find fossil in this low down section it means that the animals are very… old, okay in terms of time, and lot of those species they may be find fossils in the rock they may be extinct now, so they no longer around. But aa …analysing these fossils they see that…individual of species that are extinct are similar to this that are extanct.*
>
> *L2: What's extanct?*
>
> *T: Good question, thank you for asking. Extanct is the opposite of extinct so extinct means not one individual of the species left, extanct means the species is still alive*
>
> *L2: Like a lot of them*
>
> *T: Like a lot of them. Okay …so if…if according to scientists if older animals that are extinct now has similar animals that are alive now it must mean that these two species may be have a common ancestor.*

Mr A used the words *extinct* and *extanct* in his discussion of the word *fossil* where *extinct* was simply defined as the species that are no longer around and *extanct* was defined through direct instruction as species that are still around after one learner had requested for the meanings as indicated in the excerpt above.

The word *mutation* was used as one of the factors that result in *variation*. This word was explained through the use of examples such as *gene* and *chromosomal mutations* as shown in the following excerpt;

T: *Then we have got mutations remember we talked about different types of mutations. Mutations are changes in either gene mutations as in changes in gene sequences or we have chromosomal mutations where the chromosome is affected as a whole. So those can bring about changes big enough to bring about new species or to bring about changes within that population.*

The excerpt above shows that the teacher explained technical terms explicitly and knew his content very well.

Mr A attempted to explain the term *outbreeding* by using the learners' prior knowledge. Unfortunately, none of the learners had ideas about the term so he explained it through direct instruction, which is a strategy where content is presented through teacher lecture or demonstration (Washoe Country School District, 2015) as shown in the except below;

T: *Then we also have outbreeding… Have you ever heard of outbreeding?*

Ls: No

T: Have you heard of in breeding?

L2: No

T: Never heard of inbreeding?

L2: No…

T: Okay, so outbreeding occurs in most population where unrelated individuals of a population will mate and produce offspring with a greater genetic variation random mating incre…increases the chances of survival because it unlikely that both parents will carry a lethal allele, inbreeding is when individual from the same family group breed together, okay we discussed this before. If I have a weakness and I have a child with my sister and she has the same weakness because we related to one another there is good chance that she has the same weakness I have in terms of genetics. There is a good chance that the child if its fertile will… also have the same weaknesses but if I reproduce…I reproduce with someone that's not in my family and I have weaknesses and she doesn't have the same weakness and she has weaknesses genetically and I don't have those weaknesses, we put ourselves in a good position for our child not have those weaknesses. Okay, that is what is referred to as outbreeding, its random mating to increase genetic variation.

The excerpt above provides evidence of how explicit Mr A was when explaining technical terms.

The term *genetic drifting* was explained using the pepper moth story (dark and light forms) through direct instruction as shown in the excerpt below;

T: And then we have genetic drifting aah… this is when some genes become more or less prominent in a population…aah…in the frequency of a gene in a gene pool where a population occurs this change in a genotype of a population will result in the phenotype of an individual or the su…successive generations, genetic drift tend to affect small populations, it another process due to change [Inaudible]…process over a more desired genotype. There was…I don't have details and the names and stuff, there was a farm and in this farm there were moths…pepper moths… okay the barks of the trees that these pepper moths lived were light in colour…so what colour do you think the pepper moths were? Light in colour but because of genetic variation in the population we have had those that are dark in colour, like brown and black same species [Inaudible]…just that they were that colour, which ones will reach sexual maturity?

L2: The light

T: The light colour, because they could use the bark as camouflage and hide away from predators. Could the moths with a dark colour do that?

L2: No

T: Is there good chance they will reach sexual maturity? No! Will they pass their genes for black and brown colour? No because they die before they had a chance to. Years passed and the area had a factory built close by the factory produced a lot ash, the ash started to accumulate on the bark of the tree, change the bark of the tree from a light to a dark colour what happened to the population over time?

L2: [Inaudible]

T: The population died out the black, so we the option that here that the population died out here we have the population evolved…evolved to black any other options? Any other options? [Silence] first of all the population won't die, because remember whe…within that population are dark coloured moths which ones were now reaching sexual maturity?

Ls: The dark coloured.

T: The dark coloured ones…Which ones are passing on their gene to the next generations?

Ls: The dark coloured ones.

The excerpt above provides further evidence of how explicit Mr A was when explaining technical terms. In addition, the word *speciation* was discussed using learners' preconceived ideas where Mr A started by probing learners for the meaning of the word *speciation*. Mr A then referred back to the word *species* which he considered to have been covered in grade 11 during the topic population ecology. To discuss the word *species,* Mr A referred to characteristics of *species* like morphology, behavior, reproduction and production of a *viable offspring* through question and answer. He then used the example of a donkey and a horse mating to produce a mule and finally defined the terms *species* and *speciation* through direct instruction as shown in the excerpt below;

> *T:* *If you take mule and reproduce it with another mule. It's not going to make another mule they are sterile, they are not viable. Which is an indication that the donkey and a horse are not the same species. The donkey is a species on its own and the horse is a species on its own. The close…the closely enough related to be able to reproduce, but the offspring that they are reproducing are not viable offspring which makes a donkey one species and the horse its own species. Is that clear okay. So umber one there has to same characteristics and produce viable offspring is that all. Okay that is basically it. Now we gonna discuss speciation, which is the formation of new species but what we going to discuss is how…this happens. How new species are brought about. Okay, okay the reason I'm talking about species because you can't if a new species is being produced unless you know what a species is okay. So a species is a group of organism similar in appearance and behavior that can interbreed to produce fertile offspring. Organisms or closely related species that look similar may under certain circumstances interprod… interbreed and produce an offspring however the offspring are infertile because of mismatch of the different chromosomes. So a donkey has a certain chromosome number and a horse has a certain number of chromo…chromosome which is not the same. So how does that work? That's why the offspring are fertile, infertile. For example horses belong to the species and the donkey they look similar and do interbreed however, their offspring called a mule are sterile. These two species are therefore reproductively isolated because the offspring produced are sterile because of hybrid sterility. Eeh…reproductively isolated means that I'm a species, the donkey is a species and the horse is a species and we will ever never be the same species because the offspring we are producing are sterile. So, we isolating each other sexu…eeh…reproductively. So let's have a look at speciation. Speciation is the evolution of new species from a parent species in such a way that…*

The other strategy employed by Mr A in his teaching is the lecture method which is similar to the direct instruction strategy. Mr A used this strategy to present reasonable amounts of information, using examples and visuals on PowerPoint. For instance, Mr A used the lecture method to discuss the following terms in the second lesson observed, *breeding* and *cross breeding* using horse breeding in horse riding and maize breeding as examples. The following excerpt shows how Mr A explained the term *breeding*;

T: *Okay, so what are breeders doing? Breeders are saying that that horse has good characteristics…that horse has good characteristics I want that so I'm going to deliberately breed them together. Have guys watched 'Jack ass', I don't know if it's one or two. How they actually harvest male horse's semen*

Ls: *Yes*

T: *Yaah…I'm not gonna elaborate but if you have seen it that's actually what they do. And they…they won't let these individuals ne…necessarily breed with one another. Okay they will harvest the semen from the male and artificially insert it into the female okay. Eem…I have a friend who breeds Rottweilers. Now he has a plot with cages with these Rottweilers and obviously can't let his dogs breed with one another because there not gonna be genetic variation within his breed of Rottweilers. Okay but what are we doing? We are selecting characteristics and making decisions based on that. When it comes to…so artificial selection or selective breeding means purposely breeding organisms with certain traits. Humans have been artificially selecting characteristics in animals and plants for centuries. For example animal breeders often change the characteristics of domestic animals by breeding individuals that have the desired qualities. Such as speed in race, horses milk production in cows and egg-laying in chickens and chicken that does not lay eggs is that a benefit to an egg-laying egg…chicken farm sorry? No! A cow that's not producing milk. No! You should not breed with them. For example a horse race…a horse breeder has four horses. Horse A is a fast male runner and horse C is the fastest runner she would therefore breed horse A and horse C. They even do this even if the fastest runners were brothers and sisters. Then she would cross breed the fast running offspring from A or C to produce more fast runners. So eventually all offspring will be fast running.*

The excerpt above shows that Mr A explained explicitly the two technical terms *breed* and *crossbreed*. Nonetheless, the teacher assumed that all the learners had watched the movie 'Jack ass' hence did not explain how semen was harvested. Use of such biased examples can disadvantage some of the learners.

On one hand, *Sympatric speciation* was defined through direct instruction using an example of brown and rainbow trout in fish. On the other hand, *allopatric speciation* was explained explicitly using the Galapagos finches. Galapagos Islands are located on Eastern Pacific Ocean in a country called Ecuador (United Nations Educational, Scientific and Cultural Organisation/International Union for Conservation of Nature [UNESCO/IUCN], 2007). Also to define the terms *sympatric speciation* and *allopatric speciation* Mr A split each of the terms into two. For instance, *sympatric speciation* was split into *sympatric* and *speciation* and explained as meaning to other homeland whilst *allopatric speciation* was split into *allopatric* and *speciation* and defined it as same homeland. This supports literature (National Diagnostic Report, 2015). The excerpt below shows how Mr A explained the term *sympatric speciation.*

T: Sympatric speciation means…sympatric means same homeland, so other homeland means that they are separated somehow by something physical they are not living in the same area. Sympatric separation means they are in the same area, they are in the same area but something else is separating them. So sympatric separation is brought about by reproductive isolation.

Here Mr A split the technical word into two words and explained explicitly the meaning of sympatric but omitted the meaning of *speciation*. Maybe he assumed that his learners already knew it from the preceding discussions. To explain the term *viable offspring* Mr A used the direct instruction strategy to define the term and further used an example of the mating of a horse and donkey to produce a mule as shown in the excerpt below;

T: You are able to reproduce viable offspring. What does viable offspring mean? Viable offspring? Yes…your mouth was moving…yes

L: [Inaudible]

T: Capable of reproduction themselves. For example a horse and a donkey can reproduce and whoever the female is there the donkey or horse will give birth but the problem is that the offspring that they produce is not viable. What…what do we call aah…what do we call an offspring of a horse and a donkey. What is it name?

Ls [chorusing]

T: It's a mule

Ls: [Laughing]

T: If you take mule and reproduce it with another mule. It's not going to make another mule they are sterile, they are not viable. Which is an indication that the donkey and a horse are not the same species? The donkey is a species on its own and the horse is a species on its own. The close…the closely enough related to be able to reproduce, but the offspring that they are reproducing are not viable offspring which makes a donkey one species and the horse its own species.

The word *physiology* through direct instruction was explained as follows.

T: And physiologically, physiological is not physical. Physiologically is the way the body works, okay morphology and anatomy is the physical body. Physiology…physiology is how the body works, how the body produces insulin. How is blood transported around the body, how is waste products remove from *the body. Those are all physiology, how the body works so they can change like that.*

Mr A explained the word physiology using production of insulin, transport of blood and removal of waste as examples. This shows how flexible Mr A was regarding his content knowledge.

4.3.2.2 Mr A's instructional strategies, use and explanations of non-technical words

In this study the term non-technical term refers to everyday words used in the science context, metarepresentational terms and logical connectives. Therefore, the teachers' use and explanation of technical words in terms of everyday words used in the science context, metarepresentational terms and logical connectives is presented here. The next section presents findings in terms of everyday words used in the science context.

Everyday words used in the science context

Mr A's lack of awareness of the non-technical component of the science classroom language implied lack of awareness of everyday words used in the science context. As a result Mr A used everyday words used in the science context the way he used technical terms. Mr A used learners' prior knowledge through probing to introduce and build new words/concepts. This was evident in the first lesson observed where Mr A was starting to teach the topic of *evolution*. This is evident in the following except;

T: *Okay…now first of all, what do you understand, what is you understanding of evolution? So when you see or hear evolution, what is the first thought and ideas that come to mind?*

L1: *Chang…*

T: *Se… [Inaudible]. That's the right word*

L1: *Changing in order to fit into our habitat.*

T: *So his understanding is that organisms change in order to adapt to certain situations, certain environments, certain changes within the environment, is that correct. Okay…evolution say it, anybody else, when you hear evolution…Yes… Tshepo [Not real name]*

L2: *Sir eem… what I know evolution is… is eeh… the growth of like entire species to be able adapt to like…eeh…like…*

L3: *Adapt*

L2: *Yaah… adapt and grow and sort of like eeh… in the environment that they are in to be able to you know be able to work and grow.*

T: *Okay… So what I'm hearing you say is that species want to be successful…*

L2: *Yes.*

T: *In order for them to be successful they need to change.*

L2: *Yes*

T: *[Inaudible] …What is the purpose of getting species?*

L2: *To be successful.*

T: *To be successful, to be reproductively successful. We already know that in order to be reproductively successful your offspring needs to survive to sexual maturity…*

He started by asking learners what they understood by the term *evolution* and for ideas that came to their minds when they heard the word *evolution*. So as the learners provided their responses he used those ideas to introduce and teach the new words or concepts that he wanted to teach them.

The term *evolution* is an everyday word that has a different meaning when used in the science context. As are a result, learners face difficulties in understanding its science context meaning. A teacher who is aware of the difficulties encountered by learners with such words would refer to the everyday meaning of such a word, provide the everyday meaning and finally provide the science context meaning.

The term *inheritance of acquired characteristics* was explained using Jean Baptista Lamarck's giraffe story about how the ancient giraffe with a short neck acquired a long neck as shown in the excerpt below.

T: *Maybe I should use this example, imagine this tree, very big tree 5metres to 10 metres in size and hundreds of thousands of years ago giraffes had a very thin… not a thin neck*

L2: *Short neck.*

T: *So what happened was that all these giraffes were competing with one another… for food because they were all eating on the leaves at the bottom of the tree…above where they can reach I mean, there is resources that is not being used and now I'm competing with a whole lot of individuals for only leaves on the bottom but there is* *leaves at the top that no one is using. So you know what happens two giraffes with short necks reproduce, do we look like our siblings and exactly like our siblings*

Ls: No…

T: No, there are changes, there is differences these differences we refer to as variations. Okay, if you look at your siblings really looked at them you would see your ears may be different shape, the distance your ear is away from the head may be a little different from, your low attachment could be different, your nose shape and size could be different, your eye position and distance like all those little things there could be differences in them. So it's no surprise that two giraffes can have an offspring that has a long neck. It's just a variation and now have this population of giraffes with a short necks and this one young giraffe with a long neck. What is that giraffe going to be able do that others cannot?

Ls: [chorusing] Reach to the braches that are…

T: Reach to the branches that are higher, does that individual need to compete with anybody…

Ls: No…

T: Is that individual borne predation; is that individual going to reach sexual maturity?

L2: Yes

T: Yes…Is that individual going to produce another generation?

Ls: Yes

The excerpt shows how explicit Mr A was in explaining the science context meanings of everyday words used in the science context. Omissions on explanation of everyday or alternative meanings reveal that Mr A lacked awareness of the difficulties that learners experience regarding these words.

Mr A further used a real life scenario about a learner born of accounting parents to discuss how *acquired characteristics* cannot be passed to the offspring. This was shown in the following excerpt;

T … What does your parents do for a living? [Pointing at one of the learners]

L6: Accounting

T: Accounting okay, so her parents I'm assuming went to university they did a course or a degree in accounting and are now working in an accounting firm.

Okay, we happy with that? When she was born, could she do tax returns, could she balance books?

L2: *No*

T: *Could she do that?*

LS: *No*

T: *Can she still do that?*

LS: *No*

Here Mr A used the scenario to show that acquired characteristics like accounting skills cannot be passed onto the offspring. This was meant to provide a real life example so that they could relate to the giraffe story and understand better. The use of a real life scenario may help learners to take ownership of the concepts taught and maybe understand them better. However, the use of such scenarios can be sensitive to learners in that some of them may be orphans and some parents may not be educated or working.

The Mr A arrived at the term *natural selection* though the use of stories by firstly, referring to Darwin's voyage and then discussing the term *natural selection* by referring conditions leading to natural selection. In explaining the conditions other terms cropped up like *overproduction of offspring, survival of the fittest* and *struggle for existence* whose meanings in the science context were explained explicitly though the everyday meanings were omitted totally as shown in the following excerpt.

T: *…Okay, so let's chat about what natural selection is. Natural selection will come about only under certain conditions, natural selection will only come about under certain conditions. Let's look at those conditions: overproduction of offspring, which means that there is more offspring produced than is going to survive to sexual maturity. We explained this point. There need to be a struggle for existence. Natural selection and evolution will not take place unless there is no struggle for existence. If the giraffes with short necks were not having to compete with each other and other herbivores at the time because would all be able to reach the bottom leaves, then half of the population would have had long necks and half would have [Inaudible] and because there is a struggle to exist, because there is only survival of the fittest, one needs to win and one needs to lose, in this case whoever is going to reach sexual maturity, whoever is going to reduce completion with other organisms is going to win. So there is need for struggle for existence otherwise evolution, natural selection would not occur.*

Mr A provided the science context meanings of the everyday words like *overproduction of offspring*, *struggle for existence* and *survival of the fittest*. However, the everyday meanings of those words were not provided. This shows that Mr A lacked awareness of the non-technical component of the science classroom language.

The term *natural selection* was then explained by splitting it into nature and selection. The science context meanings were provided explicitly although the everyday meanings were omitted. The word *pressure* was explained explicitly in terms of the science context meaning. However, reference to use of *pressure* when used in physics was not provided. Also the everyday meaning of *pressure* was not considered. Maybe the physics meaning was not provided because Mr A is a life sciences teacher who may not have known it. Horse riding, domestic animals like dog species, chicken and cows were used as examples to explain *artificial selection*. Mr A also referred to the movie 'Jack Ass' in trying to explain how semen is harvested during *artificial selection*. The term *adaptive radiation* was explained using direct instruction and examples of different types of finches that Darwin found on the Galapagos Island were used. Galapagos Islands are a group of islands located on the Eastern Pacific Ocean in a country known as Ecuador (UNESCO/UICN, 2007). There were omissions in terms of the everyday meanings for instance, the everyday meaning of *radiation* from the sun. There were also omissions in Mr A's explanations of the everyday words, *infertile* and *sterile* as shown in the excerpt below;

> T: *… Organisms or closely related species that look similar may under certain circumstances interprod… interbreed and produce an offspring however the offspring are infertile because of mismatch of the different chromosomes. So a donkey has a certain chromosome number and a horse has a certain number of chromo…chromosome which is not the same. So how does that work? That's why the offspring are infertile. For example horses belong to the species and the donkey they look similar and do interbreed however, their offspring called a mule are sterile. These two species are therefore reproductively isolated because the offspring produced are sterile because of hybrid sterility. Eeh…reproductively isolated means that I'm a species, the donkey is a species and the horse is a species and we will ever never be the same species because the offspring we are producing are sterile.*

The excerpt above shows how explicit Mr A was when explaining contextual meanings of the two words *infertile* and *sterile*. It reveals Mr A's lack of awareness of the non-technical component of the science classroom language because the science context meaning of the words were provided omitting their everyday meanings.

All the three lessons were characterised by the use of non-linguistic representations in form of images on PowerPoint, an example is provided in the following the following excerpt;

> T: *… Okay the second piece of evidence there is…is descent by modification. And what this is… is that there are…okay, [Referring to images on PowerPoint] let's look at these five animals, one two, three, four, five. We have a bird, whale, horse, cow and human being and we are looking at the arm of these five species or okay group of animals. You will notice that all of them have a … biceps can you see a biceps there?*

Here Mr A used images to present the concept of *descent by modification*, below is another example where he used images on PowerPoint.

> T: *Desert biome, grass biome, all these. And you will find that similar animals in different continents were also living in similar biomes. Okay, so this is an indication of biogeography. [Referring to the images on PowerPoint] This diagram that you see at the bottom here is one of the favourite diagrams for explaining evolution emm… from Darwin's point of view okay what he found was that there is a cluster of islands okay a lot of islands and on these islands there were different food sources for these birds, okay so think about it this way we have islands okay and then we have mainland, say it [Inaudible]…okay I don't need details we will discuss this later okay you've got mainland and island what they find is that the same species found in the mainland is found on these islands but they are different because the food found on these islands are different. [Referring to the images on PowerPoint]For example if you look at this individual over here what do you think that individual feeds on?*

The excerpt reveals that Mr A used images of different types of finches that were found on the Galapagos Islands to present the concept of *biogeography*. Almost every term/concept taught in Mr A's lessons was accompanied by images/pictures. During the interview session on being asked why he used a lot of pictures/images Mr A had this to say;

> T: *…Learners are not interested in words if you put a whole lot of words on a slide they don't see it, they don't read it but when you show them a picture they gonna remember that picture for a very long time and hopefully when they see that picture they will associate it with the information that has been given.*

Mr A used a lot of pictures or images in his teaching because he believed that learners understand and remember pictures more than words they hear or see on the slides.

There are only two incidences where Mr A referred to everyday meanings of words used in the science context in the three lessons observed by the researcher. The first incidence was when Mr A referred to the everyday meanings of *acquired* and *inheritance* after splitting the term *acquired* *inheritance*, though the terms were not explained explicitly. The second instance was when Mr A referred to the alternative example of the meaning of *yield* as evidenced in the following excerpt;

> T: *... Many plant species have been artificially selected for characteristics or trash…traits such as fragrance, drought resistance, and yield. What does yield mean? Yield…plants don't drive up to a sign… a yield sign and slow down and wait for other car to cross. Yield means how mu…how much fruit it produces. So one tree may produce 6 apples and the other one may produce 15 apples. The tree that produces 15 apples has a greater yield than the one with produces 6 apples.*

Mr A only referred to the alternative example of the use of the term *yield* though alternative meanings of the word were not provided explicitly. Here the teacher assumed that all learners knew the meaning of yield as used in driving. Use of such a biased example may put other learners at a disadvantage if they do not know what the teacher is talking about. Overall, Mr A lacked awareness of the everyday words used in the science context as such he treated everyday words used in the science context as technical terms. He explained them using the strategies that he used to explain technical (scientific terms).The next section deals with Mr A's use and explanations of metarepresentational terms.

Metarepresentational terms

Mr A used metarepresentational terms by associating them with assessment. For instance, during the three lessons observed by the researcher, Mr A warned his learners that they can be asked to *explain* evidence for *evolution, speciation* or *allopatric speciation*. Nonetheless, Mr A just warned the leaners but did not discuss the meanings of such words as *explain*. Mr A referred to two metarepresentational terms (*explain* and *discuss*) in the three lessons observed. The next section deals with Mr A's use and explanations of the logical connectives.

Logical connectives

In the three lessons observed, Mr A used two logical connectives which are *if* and *however* and the most frequently used was *if*. Mr A used these words when explaining the *law of acquired inheritance* to link up sentences. These words were used without explaining their meanings because he assumed that his learners understood them. This implies that Mr A lacked awareness of and the value of logical connectives in the science classroom language. As a result he lacked awareness of the difficulties that learners' encounter with regards to these words. The next section presents Mr A's consideration of contextual factors.

4.3.2.3 Mr A' consideration of contextual factors

Mr A considered contextual factors when teaching the topic *evolution.* He considered the learners' concerns about *evolution* before proceeding with the topic. In the first lesson observed, Mr A asked learners what made them uncomfortable with *evolution* and allowed them to provide their opinions. This is shown in the following excerpt;

> *T:* *What…what makes you uncomfortable about the word evolution? When I said it I was just looking around the room and I can see the people that are uncomfortable by it okay what about this word, this term makes people uncomfortable? Friendships have been destroyed…*
>
> *Ls:* *[Laughter]*
>
> *T:* *…by this word. What else do you feel like…yes!*
>
> *L4:* *[Inaudible]*
>
> *T:* *So your concern is that people were monkeys before and now are humans…*
>
> *Ls:* *Yes…*
>
> *T:* *…and it makes you uncomfortable to feel that I am here as a result of a monkey.*
>
> *Ls:* *[Laughter]*
>
> *T:* *Okay, that makes some people uncomfortable we'll leave it at that for now. What makes you uncomfortable?*
>
> *L5:* *Religion… [Inaudible]*
>
> *T:* *So the religious side of evolution, okay so what about the…what about evolution… makes you uncomfortable in terms of the religious aspect of it? What about… yeh…*
>
> *L6:* *Like many people say God didn't exist and like [Not clear]…*

The excerpt above shows that Mr A considered religion and culture before proceeding with the new topic *evolution.* Hence, he assured his learners that they are not expected to change their beliefs as evidenced in the following excerpt;

> *T:* *What we are about to discuss is not to change your religious beliefs but it's for you to learn an explanation for something you may observe…*

Besides religion and culture Mr A also considered contextual factors like the age of his learners. In particular, he used a story which was appropriate for the age of his learners to introduce the concepts of *theory* and *hypothesis* where he talked about the importance of evidence. The story was about a boy cheating on a girl, who had to gather enough evidence before confronting the boyfriend. This story related to the learners because of their age.

Further, Mr A considered contextual factors like learners' preconceived ideas about words and probing them further to build new concepts. In one of the three lessons observed Mr A referred to the word *species* which he considered to have been covered in grade 11 to find out if learners remembered the term as evidenced in the excerpt below.

> *T: Before we can discuss the formation of new species, you need to know what a species is. In grade 11 you learned about species, populations, eeh…population ecology and the term species was taught to you. Okay what is a species what makes individuals part of a species. For example we all species in here okay. What is the definition of the word species? Have you guys reached your word limit for the week? Its Friday now have so much left in you saving some for the weekend, species…question number one, where you taught this in grade 11? Yes… is there a consensus. So I don't have to get your grade 11 teachers in here, to find out if they taught this to you. What does species mean? What does species have in common? What makes individuals a part of a species?*

Mr A asked the learners for the meaning of species and wrote the learners' responses on the board for them to see what they were saying and even probed them further to elicit more information. He then used learners' preconceived ideas to build the concept of *speciation.* Generally, Mr A considered contextual factors in his teaching.

4.3.2.4 Mr A's general performance on the science classroom language

Mr A was aware of the technical component of the science classroom language. Furthermore, he was aware of the difficulties that learners encounter regarding technical terms. As such he used a lot of strategies in the three lessons observed to assist his learners to understand them better. In explaining technical terms he used various scenarios some of which related to real life. Almost every concept or term presented during his practice was accompanied by an image or picture because he believed that learners understand things better if they see pictures. Besides using pictures, Mr A used Lamarck and Darwin's theories which constitute a strategy called scientific storytelling to explain terms. His overall strategy in dealing with the technical terms was the lecture method coupled with non- linguistic representations in form of pictures or images on PowerPoint.

On the contrary, Mr A lacked awareness of the non-technical component of the science classroom language and regarded it as English words. This implied that he lacked awareness of the everyday words used in the science context, metarepresentational terms and logical connectives. Despite using metarepresentational terms (define, explain or discuss) and logical connectives (*if* or *however*) in his practice, Mr A did not explain the meanings of such words. Hence, Mr A lacked awareness of the difficulties that learners encounter with regards to non-technical terms.

All in all, Mr A employed the following eleven strategies in his practice during three observations; use of prior knowledge, probing, cues and questions/question and answer, direct instruction, lecture method, integration of content areas, stories, real life scenarios, scientific storytelling, repetition, non-linguistic representation in form of pictures and images. Of the eleven, the overall strategy used by Mr A in assisting learners to understand the technical terms was the lecture method coupled with non-linguistic representations in form of pictures and images on PowerPoint.

4.3.3 Interview: Mrs B of School 1

One interview session was conducted with Mrs B after having been observed three times teaching *evolution* to the same class. The interview was meant to collect data about Mrs B's personal details and information regarding her awareness of the technical and the non-technical component of the science classroom language as well as her perceptions regarding her role in assisting learners with the non-technical terms. An interview schedule specifically designed for her was used to gather the information (see appendix 5B).

4.3.3.1 Mrs B of School 1

Mrs B, a life sciences teacher who was also the head of department (HOD) for the life sciences department at School 1 had been teaching for over twenty years at the time this research was conducted. In terms of qualifications she held a Bachelor of Science Degree in zoology, Post Graduate Diploma in education both obtained from the University of Witwatersrand. In addition to that, she held a Diploma in Laboratory Animal Technology obtained from Technikon SA.

4.3.3.2 Evidence of knowledge of the science classroom language: Mrs B

Technical words

Just like Mr A, Mrs B was aware of the technical component of the science classroom language. As such she was aware of the difficulties that learners encounter when learning *evolution*. On being asked about specific constraints encountered when teaching *evolution* with regards to language, Mrs B had this to say;

> *Mrs B: Not really it's a [Inaudible]…language it's more content wise where they actually would have a block, but not really language… and have you… actually… take a term and describe a term they know what you are talking about that's what it comes down to. However you use proper English… now that's one thing I stress in class that you do have to use proper English… because these kids also have a problem expressing themselves in English if you use proper English in class, reinforcement, learning takes place… as the command of English language not necessarily the scientific language.*

The excerpt above shows that Mrs B was aware of the difficulties that learners face with regards to life sciences content (technical terms). However, she considered proficiency in the language of instruction to be important in learning life sciences. This supports findings in Mthiyane (2016).

Non-technical words: Everyday words used in the science context

Mrs B's lack of awareness of the non-technical component of the science classroom language implied lack of awareness of the everyday words used in the science context. As a result Mrs B used everyday words used in the science context the way she used technical terms. In her practice, Mrs B provided learners with the science context meanings omitting everyday or alternative meanings of such words as evidenced in the excerpt below.

> *T: Okay, you basically see in number 1, first embryonic stage, you cannot distinguish it all and that suggestion that all organisms are very highly related to fish, what is the reason that makes them say that? Could you people shut up here! That they have a common ancestor. They believe that [Inaudible]…and I'm not saying you must believe that. Right but basically my point I'm making is that in your first part of embr…embry…embryology all your organisms look exactly the same if you look at them and as development goes you can actually see there is changes so your, this the first month hee…the first month of embryonic stage, the first trimester, it doesn't matter [Inaudible]… what organism it is. It is the first part of development, the [Inaudible] the first trimester, okay, you all see that, aah…your textbook does this diagram in it, I'm not going to make copies of this diagram. Now we now looked at fossils, now we have looked at comparative*

embryology. But there are other ways as well… [Bell rings] there is common ancestor, comparative anatomy but tomorrow we gonna continue on that point [Noise].

Mrs B explained explicitly the meaning of common ancestor in the science context but never explained its everyday meaning. This shows that Mrs B lacked awareness of the everyday words used in the science context and the difficulties associated with them. This lack of awareness meant that Mrs B did not help learners explicitly for them to understand the science classroom language

Non-technical terms: Metarepresentational terms

On being asked whether her learners understood metareperesentational terms like *explain* or *discuss*, Mrs B had this to say;

> *Mrs B: Yes they do because they have been practicing them a lot [Inaudible] a lot of the activities we did we actually [inaudible] and as you have seen some of the presentations I have …I mean this is an exam question that they answered where they are asked to explain how Lamarck would describe whatever the case maybe… and I show them how the explanation should be done.*

Though Mrs B's practice provided evidence of her showing her learners how to answer examination questions, the meanings of the words *explain* and *discuss* were not provided. Such omissions mean that Mrs B did not assist learners explicitly to understand the science classroom language better.

Logical connectives

In her practice, Mrs B used words like *however* and *if* which are logical connectives. So on being asked whether her learners understand such words or not Mrs B had this to say;

> *Mrs B: Yah your top learners would… and then your top learners…the bottom class maybe not but your top do that because they are your 80 to 90 percent… they would actually understand the however if this happens whatever the case may be they would understand they may be able to follow.*

Though she admitted that learners do not understand those words, she still contended that the top learners do. On being further asked whether she took time to explain such words (*if* or *however*) to learners or not Mrs B had this to say;

Mrs B: Yaah… you have to look at the [Inaudible]… you have reached [inaudible]…and then if they do ask I would explain that I think in my common English words this is the question. But matric level you need to know that…I cannot teach you English in matric [Pause] however you need to take into consideration that for a lot of these learners is not a first language… however you know English medium school with home language English therefore you need to understand it.

The excerpt reveals that Mrs B considered logical connectives to be English words which must be taught by teachers of English not life sciences teachers. However, after considering that her learners were English second language speakers, she admitted that life sciences teachers are also teachers of English. The next section deals with Mrs B's perceptions about the science classroom language.

4.3.3.3 Mrs B's perceptions about the science classroom language

On being asked whether it is her duty to help learners with the non-technical component of the science classroom language, Mrs B had this to say;

Mrs B: Yes! [With soft voice] We have to… we have to help these learners… we cannot to leave them… [Inaudible]… if they do not understand what you are talking about… if its non-technical… if you take…make it…take any term and make it non-technical for them to understand, and then I do it basically on a daily basis…using a simple way to explain the concept that they can understand the concept but then bring in the technical term while the concept is the wording… that they can actually follow through and learn the concept the way you want them to learn… it's no use learning a word that they don't know what it means, [With a soft voice] you've got to simplify for them.

Besides showing that Mrs B believes that it is her duty to help learners with non-technical terms, the excerpt above reveals that Mrs B lacked awareness of the non-technical component of the science classroom language. Hence, she regarded the non-technical component of the science classroom language to be English words. This means that Mrs B did not assist learners explicitly to understand the science classroom language.

4.3.4 Classroom observations: Mrs B of School 1

As highlighted in section 3.3.2, Mrs B was observed three times teaching the topic evolution to the same class. This class consisted of learners of mixed race and abilities. An observation schedule similar to the one used for Mr A was used to collect data (see appendix 6). The schedule was used to collect information about the strategies employed by Mrs B to assist her learners to better understand the science classroom language. The first lesson was on introduction to *evolution* as she was starting to teach the topic. The next lesson observed was on evidence for *evolution* and the last one was on *natural selection*.

4.3.4.1 Mrs B's instructional strategies, use and explanations of technical terms

The word *fossil* was first mentioned but not defined. *Palaeontology* was then explained before *fossil* through direct instruction. Maybe this was a tactic because in the interview Mrs B said that learners need to know what *palaeontology* is before *fossil.* In explaining the word *fossil* Mrs B used non-linguistic representations like images on PowerPoint of different types of fossils (footprints, tar pits, amber and plant and animal imprints made on rocks). The word *Palaeontology* was repeated two times in the same lesson for reinforcement as cited by the participant during the interview. To present *phylogenetic trees/cladograms* the participant used a video clip on PowerPoint with examples of *phylogenetic trees/cladograms.*

The term *comparative embryology* was split into *comparative* which is an everyday word used in the science context and embryology which is a technical term. This supports literature in National Diagnostic Report (2015). Mrs B provided the everyday meaning of the word comparative and then defined the word *embryology* through the direct instruction strategy using embryonic photographs of fish, amphibians, birds and mammals on PowerPoint as shown in the excerpt below;

T: *What does the word comparative mean?*

Ls: *Comparing*

T: *Compare, to compare, now there is…explain embryonic development [Unclear]...the problem is you are talking.*

L: *Shhhh*

T: *I said embryology*

L1: *What is embryology?*

T: *You did human reproduction didn't you?*

L1: *Oh! Embryo*

T: *Embryology, study of embryo, okay, as far as embryonic development this is called [Inaudible]… [Referring to images on PowerPoint] with all embryos exactly the same you cannot distinguish between cat, duck or human.*

Mrs B's practice just like Mr A's was chararcterised by use of non-linguistic representations in form of images/pictures on PowerPoint. She explained technical terms explicitly.

Images on PowerPoint of the forearms of a frog and a bird were used to present the term *homologous structures.* Also the term *analogous structures* was presented using the images on PowerPoint of the bird and insect.

T: *now we had homologous now we have analogous. What does analogous now mean?*

L1 *Different*

T: *In this case we will look basically at the wings of insects and birds, alright and even though things look…have the same function, they look different. Take the wing of a bird and the wing of an insect, do they look the same? Definitely not. So we talk about convergent evolution. So divergent is similar and convergent is different.*

The above excerpt provides evidence about Mrs B's use of pictures during her practice. On being asked why she used a lot of pictures and images during her teaching Mrs B had this to say;

Mrs B: *It's easy for them to relate when you start telling them a story and pictures …come on the kids are visual…more visual than auditory, they see and it's easy for them to see what you are talking about than just sitting and [inaudible] at the back and they have no clue of what you are talking about. You show them a picture they will know what you are talking about.*

Mrs B believed that learners understand things better if they see pictures or images.

An example of the appendix in humans was used to explain the term *vestigial structures* after defining it through direct instruction. The word *biochemistry* was explained in terms of the concepts involved such as DNA, proteins and sequences of genes as shown in the excerpt below.

T: *Okay, then we look a biochemistry what do we look at? DNA, [Inaudible] proteins, sequences of genes. Most organisms a large number of primates are a similar [Inaudible]. For example humans and primates, humans and the chimpanzee for example [Inaudible] they are closely related to the primates again there is common ancestor. Our DNA structures are basically similar and* *sequencing of the genes are also similar but there is a slight variation. Okay that's what I'm gonna do about biochemistry…*

Mrs B used the direct instruction strategy to discuss term *biochemistry*. She did not explain term but used examples to discuss it.

In the second lesson observed, Mrs B repeated the terms that she had covered in the first lesson (*palaeontology, comparative embryology and comparative anatomy*). During the interview session, the Mrs B said that she repeats terms that she would have covered for reinforcement purposes.

To discuss the term *biogeography* Mrs B used learners' prior knowledge, where she referred to the work done in grade 10 on *biodiversity*. She actually asked her learners where animals like lion, leopard, rhino, elephant and buffalo (the big five) are found and the type of animals found in Asia and America and then referred to all that as *biogeography* as shown in the excerpt below;

T: *You did do animal biodiversity haven't you?*

L2: Grade 10

T: Okay, okay so for example we won't find Marsupials here unless they have been brought in, where would we find those animals?

Ls: Australia

T: And New Zealand. Okay, what are you gonna find in Africa?

L2: Lions mam

T: The big five

L1: Zebra

T: Okay, what are gonna find in America?

Ls: [Chorus, inaudible]

T: Haa-haa

Ls: [Laughter]

T: Haa-haa…you gonna interestingly you gonna find the wolf [Inaudible]…

L3: You can find a white tiger

L2: *Asia*

T: *Okay, [Inaudible] ... yet Asia the place if tigers, China the Panther*

Ls: *[Laughter]*

T: *Geez… okay, I'm not gonna carry on with this. Okay that is something called biogeography guys…*

The term *biogeography* was then discussed by referring to animals found on different continents. However, in the excerpt zebra was provided as one of the big five but the teacher never responded to that. Maybe she did not hear that response. Just like Mr A, Mrs B used Darwin's discoveries to explain the term *biogeography*, like the tortoise with long and short necks found on the Galapagos Islands. These Islands are located in eastern Pacific Ocean and belong to the Country Ecuador (UNESCO/UICN, 2007). Lastly, the word *outbreeding* was explained using a real life scenario as shown in the excerpt below.

Mrs B: *Now think about if we actually have related individuals breeding would we have variation. That's what human population actually do. You don't marry your brother or uncle or your cousin. You actually use an unrelated person. Outbreeding, bigger genetic variation.*

The use of real life scenario relates to the learners lives such that it becomes easy for them to comprehend the technical terms in question. The next section presents Mrs B's instructional strategies, use and explanations of non-technical terms

4.3.4.2 Mrs B's instructional strategies, use and explanations of non-technical terms

Everyday words used in the science context

The following words; *adapt* and *evolution* were used in the teacher's discussions but the meanings of the words both in the science context and everyday English language were not provided as shown in the following excerpt.

T: *Come on guys we starting evolution, and the first thing that we need to know is what is evolution? What is evolution what is it? What is evolution?*

Ls: *[Chorusing, inaudible]*

T: *Evolve from what?*

L1: *Change*

[Noise]

T: *Decisively populations would adapt to the changes in the environment, okay one thing you need to realise I have used the word populations… I didn't say individuals why?*

Ls: *[Chorus & unclear]*

T: *Can't just be one… one thing changing and one it's on organism, its specific changes within a population, okay it's for survival and those organism if the population can't adapt it dies out. Okay now another one I want to ask, what is a theory? What is a theory?*

Here, Mrs B asked learners what *evolution* is but eventually did not provide learners with the science context meaning or the alternative meanings. Also the word *adapt* was just used in the discussion the teacher never bothered to refer to its meaning in the science context or everyday use.

Mrs B used the non-linguistic strategy by showing images on PowerPoint of fish, salamander, tortoise, chicken hawk, cow and rabbit to present the term *common ancestor* as evidenced in the excerpt below.

T: *Right, common ancestor, and likewise you gonna see we gonna refer common ancestor quite a lot okay, when especially we talk about human evolution. Okay, they believe that all organisms are related [Referring to the image on PowerPoint] so I want you to have a look here, okay have a look at especially to top one, number one. You have a fish… you have a salamander, a tortoise, a chick, a hawk, a cow, a rabbit and a human, okay you have to see they all look basically the same. If you were given that…*

[Interruption from the bell]

T: *Okay, you basically see in number 1, first embryonic stage, you cannot distinguish it all and that suggestion that all organisms are very highly related to fish…*

The excerpt reveals that Mrs B lacked awareness of the non-technical component as such she treated everyday words used in the science context the way she treated technical terms. Therefore, Mrs B never explained the alternative/everyday meaning of the term *common ancestor*. This means that Mrs B did not assist learners fully to understand the science classroom language.

With the concept/term of *use and disuse*, Mrs B presented the science context meaning using Lamarck's giraffe story explaining how the ancient giraffe with a short neck acquired a long neck was used. She also used the snake story about the disappearance of its legs as evidenced in the following excerpt;

> *T:* *And acquired characteristic, he basically states that if you leave some characteristic or acquired skill it will be immediately be given to your offspring. And we know that is impossible. It's not, can't do it… then we looked at his giraffes. He basically said that giraffes with short necks as we mentioned, the necks became longer…acquired [Coughing] excuse me this characteristic and now will pass it to the offspring. Sounds too good to be true isn't it? Okay said I stretch my therefore it longer... Okay same applies to the snakes because snakes don't need legs [Inaudible]…use and disuse.*

Use of Lamarck's stories constituted the scientific storytelling strategy. Mrs B lessons were characterised by stories. Moreover, she used a real life scenarios to emphasise that one cannot pass on a wound growing on her/his forehead to the offspring. The science context meaning of *natural selection* was presented by referring to the various types of finches discovered by Darwin on his voyage on the Galapagos Islands as shown in the except below.

> *T:* *…Right [Clearing throat] now we gonna look at several examples of natural selection. One of them is Darwin finches of the Galapagos Islands. First all he thought it was a common ancestor, but in this case it was the middle one seed-eating, but somehow [Inaudible]…but the finches start changing their beak shapes. Some of them would eat butter and fruit you can see they have a large… much bigger beak. Then the [Inaudible]…insects and leaves you can see there is a big differentiation in the beaks if one cross to the other side. You can see they are all related. However, natural selection took place. Those ones on the specific Islands ahaa…having traits to survive. Actually, [Inaudible] Why? The beak is too big to fit into the wood on the tree trunk…*

Mrs B's explanations, had omissions when it comes to everyday meanings of these words. Thus, Mrs B did not explicitly assist learners to understand the science classroom language.

Mrs B employed the comparison strategy in form of a table to explain the two terms *hypothesis* and *theory* using the learners' preconceived knowledge. Mrs B acknowledged that learners were taught the word hypothesis in grade 11 because she taught grade 11 learners as well at that time. The following excerpt shows how the two words *theory* and *hypothesis* were dealt with.

T: *Right here we got what is the difference between a hypothesis and a theory because we not going to use Charles Darwin's theories?*

L2: *We gonna use what?*

T: *Okay, but what is a hypothesis? You actually have been taught a hypothesis since primary school*

Ls: *[Chorus]*

T: *But some of you still don't know, you still write it down, when you are asked to give a hypothesis you give us a question. A hypothesis is not a question okay, it's a testable statement. It's never a question. And basing on the statement you would either say it is accepted or rejected. It's never false and I have repeated that since grade 11. Hypothesis is never false, it's either accepted or rejected or true or not true for whatever you are resting. A theory on the other hand okay, is a substantiated explanation of some aspect and it basically incorporate some evidence as well okay. If you look at the example I give you about the egocentric theory. The sun is at the center of the universe and the planets revolve around it. Do we know that we turn around the sun?*

She repeated the terms *theory* and *hypothesis* over and over again for emphasis as indicated in the interview session. All the explanations referred to above omitted reference and explanations of the everyday meanings of the words. This implies that Mrs B did not assist learner explicitly for them to better understand the science classroom language. The next section presents Mrs B's use, and explanations of metarepresentational terms.

Metarepresentational terms

Mrs B used two metarepresentational terms in the three lessons observed. Just like Mr A, Mrs B used metarepresentational terms in assessment. Mrs B warned her learners that they can get a question that would ask them to *explain* the differences between Lamarck and Darwin's theories or *explain natural selection*. In addition, Mrs B referred to a past examination question dealing with cacti with short and long roots. The question asked the learners to *discuss* the scenario using *natural selection*. Thus, Mrs B guided the learners on how to answer such a question though she did not provide learners with the meaning of *discuss* as evidenced in the excerpt below.

T: *…It's also natural selection [Referring to image on PowerPoint]. We actually have a cacti lot, we have some with deep roots and some with shallow roots. As time went on okay, we are now using Darwin's theory, those ones with shallow roots could not obtain water in the dry seasons they died. Remember goes down deep in the ground. Those with the longer roots managed to get water they give* *off offspring with longer roots. It's not this characteristic of long roots but its natural selection.*

Due to lack of awareness of the non-technical component of the science classroom language Mrs B did not bother to explain the meaning of the word *discuss* which is an example of metarepresentational terms in this study. This deficiency in explanations meant that Mrs B did not explicitly assist learners to understand the science classroom language.

Logical connectives

Despite using logical connectives in her practice, Mrs B lacked awareness of the value of these words in the science classroom language and the difficulty that learners experience with such words. As a result, Mrs B regarded logical connectives to be English words and never bothered to explain them during her practice. In brief, Mrs B did not help learners fully to understand the science classroom language. The following section presents Mrs B's consideration of contextual factors.

4.3.4.3 Mrs B's consideration of contextual factors

Mrs B considered the different learners' backgrounds and encouraged them to keep religion out of the discussions about *evolution* as shown below in the excerpt below;

T: *No they don't! Guys let's keep religion out of this? Alright, right at the end we will deal with the other facts about how things happened on earth. Right now let's keep religion out. How would you say a snake came about [Inaudible]…if you use Lamarck's first law?*

This shows that Mrs B considered learners' beliefs; hence she encouraged them to keep religion out of the discussion on *evolution*. She also considered that learners stay in urban areas where they have access to televisions and watch movies as she referred to the movie titled 'Jurassic park' as she explained the formation of *amber fossils*. Mrs B considered contextual factors like learners' preconceived ideas and used them to introduce the new terms and concepts. For instance, she considered the work done in grade 10 to discuss *living fossils* like the *Coelacanth*. She showed an understanding that learners covered *evolutionary relationships* in grade 11 though they tend to forget all that when they get to matric. This is shown in the excerpt below;

T: *Okay, have… we going to look at these things again as we go with the work aa… cause it gonna come up in quite a few questions. We gonna look at* *relationships…evolutionary relationships. You gonna see them between the human and the primates, you ganna see them between eem… basically between other different organisms as well. So please know them be able to read them. There is one other problem we notice is that you people can't read things. If now you have done this before when you come to this level suddenly that prior knowledge is gone. Okay we need to work on this guys. And as I said already we are three weeks away from prelims. And there is a huge amount of work that needs to be done. Are there any questions?*

The shows that Mrs B was aware of the concepts taught in the preceding grades and referred to them to remind learners. Mrs B showed that she understood that learners are not familiar with the new terms about evolution thus she encouraged them to consider the terms. The next section provides Mrs B's overall performance on the science classroom language.

4.3.4.4 Mrs B's overall performance on science classroom language

Mrs B like Mr A, was aware of the technical component of the science classroom language and the difficulties that learners encounter regarding technical terms. As such she used a lot of strategies in the three lessons observed. In explaining technical terms she used the lecture method coupled with non-linguistic representations in form of pictures/images on PowerPoint like Mr A. This similarity could be due to the availability of data projectors at School 1. Almost every concept or term presented during her practice was accompanied by an image or picture because she believed that learners are more visual than auditory. Thus, they understand things better if they see pictures. Besides using pictures, Mrs B used Lamarck's and Darwin's theories (scientific storytelling) which constituted the strategy called history and philosophy of science (HPS) to explain terms. Just like Mr A, Mrs B's overall strategy in dealing with the technical terms was the lecture method coupled with non- linguistic representations in form of pictures or images on PowerPoint.

Mrs B just like the other two participants, lacked awareness of the non-technical component of the science classroom language and regarded it as English words. This implied that she lacked awareness of the everyday words used in the science context, metarepresentational terms and logical connectives. Despite using metarepresentational terms (*define, explain* or *discuss*) and logical connectives (*if* or *however*) in her practice, Mrs B did not explain the meanings of such words. She perceived the teaching of non-technical terms to be duty of teachers of English, though she said that life sciences teachers should assist learners with English skills. Thus, Mrs B lacked awareness of the difficulties that learners encounter with regards to non-technical terms. Lack of awareness of the non-technical component implies that Mrs B did not explicitly assist learners to better understand the science classroom language.

Mrs B employed the following ten strategies in her practice during three observations; use of prior knowledge, probing, cues and questions, direct instruction, lecture method, stories, real life scenarios, scientific storytelling, non-linguistic representation in form of pictures or images on PowerPoint and comparison. Of the ten, the overall method used by Mrs B to assist learners to understand the technical terms was the lecture method coupled with non-linguistic representations in form of pictures and images on PowerPoint. The next section presents Mrs C's case in terms of interview and observations findings.

4.3.5 Interview: Mrs C of School 2

Just like the other two participants, Mrs C had one interview session. The interview was meant to collect her details and information regarding her knowledge about the technical and non-technical components of the science classroom language and her perceptions regarding assisting learners with the science classroom language. An interview schedule specifically designed for Mrs C was used to collect the data (see appendix 5C).

4.3.5.1 Mrs C of School 2

Mrs C, a life sciences teacher who was also the head of department (HOD) for life sciences at School 2 had been teaching life sciences for 18 years at the time this research was conducted. In terms of qualifications, she held a Higher Diploma in Education obtained from Thabamoopo College of Education. She also attended Vista University and Matthew Goniwe School of Leadership and Governance for Leadership and management.

4.4.5.2 Evidence of knowledge of the science classroom language: Mrs C

Technical terms

Just like the other two participants, Mrs C was aware of the technical component of the science classroom language. Nonetheless, she lacked awareness of the non-technical component of the science classroom language. On being asked if she was aware of the difficulties that learners encounter when learning evolution with regards to language, Mrs C had this to say;

Mrs C: Yes…you know emm…you know evolution has so many difficult emm… concepts some of them they… they are not able even to pronounce eeh… to pronounce them… so that might also be a challenge eeh… for them so most of the time when we just do evolution and then they come across those eee…difficult words to pronounce…

R: Eehm…

Mrs C: …and then we also check on their performance when… they are writing especially their final papers when we do analysis of question papers…

R: Eehm…

Mrs C: … we still find that it's still find it's a problem with the learners they can write those word, they can't pro…pronounce them so you keep on repeating saying one thing all the time and then I end up saying to them that… it's better they pronounce something or a word the way they will understand.

Mrs C admitted that *evolution* as a topic has so many difficult concepts/terms which are also difficult to pronounce. She added that learners do not do well with terminology (technical terms) which is evidenced by the learners' performance in the final examination papers. As a way of assisting her learners, she said that she encourages them to keep on repeating the terms and pronounce the words the way they understand them. This was actually evident in her lessons observed.

On being asked about the constraints encountered with regard to language when teaching *evolution*, Mrs C cited learners' beliefs and the language of instruction just like Mrs B. Mrs C maintained that as a teacher she cannot teach *evolution* in her mother tongue because of the diversity of learners who have different backgrounds in terms of language and beliefs. She therefore, concluded by saying that there is no alternative for English even if learners do not understand the evolution concepts. This supports findings in Mthiyane (2016). Mrs C was aware of the difficulties that learners experience with the science classroom language.

Non-technical terms

Everyday words used in the science context

Just like the other two participants, Mrs C lacked awareness of the non-technical component of the science classroom language. As such she lacked awareness of the everyday words used in the science context, metarepresentational terms and logical connectives. As a result Mrs C, just Mr

A and Mrs B used everyday words used in the science context the way she used technical terms as shown in the excerpt below.

> *T:* *Thank you. That is eeh… his first law. [Writing on the board] The law of inheritance of acquired characteristics. The law of inheritance of [Noise] acquired eeh…chara…cteristics. So we have the two laws. He gave us an example of what…the giraffe and he is saying that these characteristics will be passed to the… offspring, the characteristics people will be passed to the offspring. So if this ee…giraffe is ee…going to breed we are going to see ee… the young ones with what…ee…long necks. That is the law of inheritance of acquired characteristics.*

This implied that Mrs C provided learners with the science context meanings of such words omitting the everyday or alternative meanings.

Non-technical terms: Metarepresentational terms

Mrs C confused metarepresentational terms like *define* or *explain* with Blooms taxonomy. When asked if she was aware of the functional value of such words Mrs C had this to say;

> *Mrs C:* *Yes because isn't that they are going to be looking at the levels of the questioning so it's very much proper for the learners to know that whenever the…those focus areas neh… that's the Blooms taxonomy's when they have to approach… the approach of the question… coz always they have to that if… I have been asked about to analyse… to analyse, to describe and then the synthesis of… they have to have that knowledge of what they have to do in that case.*

The excerpt above shows that Mrs C lacked awareness of the non-technical component of the science Classroom language. However, she was aware of the difficulties that learners encounter with words like *define* or *explain* (metarepresentational terms). So Just like Mr A, Mrs C said that she dealt with such words (*define* or *explain*) during feedback time after writing cycle tests or the June examinations but does not really find time to teach learners the meanings of these words.

Non- technical terms: Logical connectives

On being asked about the functional value of logical connectives in science, Mrs C had this to say;

> *Mrs C:* *Emm…do I nor… I don't normally use those words [laughing] because immediately you keep on using that if …these…however…you know… for me… I*

don't see any [Inaudible]…maybe you can… because isn't that all of us we are learning all the time [laughing].

R: Okay… [Laughing] …

Mrs C: …but I normally don't use these words…

The excerpt above shows that Mrs C lacked awareness of the functional value of logical connectives in the science classroom language. As such, during the interview she claimed that she did not use such words, yet she actually used them in her practice during observations. This lack of awareness of the non-technical component means that Mrs C did not explicitly assist learners to better understand the science classroom language. The next section presents Mrs C's perceptions about the science classroom language.

4.3.5.3 Mrs C's perceptions about the science classroom language

Mrs C perceived the teaching of the non-technical terms as the duty of the teachers of English language as shown in the following excerpt;

R: …do you think emm…it's our…it's our duty as life sciences teachers to teach learners or help learner to understand those words?

Mrs C: No! [With emphasis] I don't think so neh…

R: Ehem

Mrs C: …because my understanding is that eem…we have an English teacher there who is supposed to during their grammar period,

R: Ehem

Mrs C: …they actually learn those words, so mine what I have to do in life sciences is if they are using those words answering question based on life sciences.

R: Ehem

Mrs C: Not that eem… I'm like okay spend my time saying that alright now I'm going to explain eee… what the meaning of describe what …what…no!

The excerpt above shows that Mrs C lacked awareness of the non-technical component of the science classroom language. As a result, she regarded the teaching of such words to be the duty of teachers of English. All participants in this study regarded non-technical terms as English words as such this lack of awareness resulted in difficulties with such words as argued by Marshall and Gilmour (1991). The next section presents Mrs C's classroom observations.

4.3.6 Classroom observations: Mrs C School 2

As highlighted in section 3.3.3, Mrs C was observed three times teaching the same lesson to three classes of different abilities. The three classes consisted of learners of mixed race. An observation schedule similar to the one used for Mr A and Mrs B was used for Mrs C (see appendix 6). The observation schedule was used to collect information about the strategies employed by Mrs C to assist her learners to better understand the science classroom language. The three lessons observed were on evidence for *evolution*.

4.3.6.2 Mrs C's instructional strategies, use and explanations of technical words

Mrs C employed the recap strategy to explain again the words *palaeontology* and *fossil*. Mrs C used the lecture method with the first class to discuss *biogeography, interbreed, molecular biology*, *genetics* and *fossil record* as shown in the excerpt below.

> *T:* *And then these fossils were found where ee… in those sedimentary rocks and the biogeography, e…also that eem…population in mainland 1 and mainland 2 where you find that ee… they are not going to do what…to interbreed because ee…Charles Darwin is saying that ee…more offspring they are going to be produced but those ones with ee…favourable characteristics will survive and then embryology, that is another way that is evidence on eem…evolution that they were looking at the embryos of ee…different organisms. And evidence from molecular biology and genetics.*

Molecular biology and genetics were not explained. Mrs C's approach was totally different when she was teaching the second class (considered to be the best class). She started by reminding the learners that she was not going to use the same approach for all the classes she was teaching. She then asked her learners to *define* in their workbooks the words that she had listed on the chalkboard (the technical words on this list were *species* and *homologous structures).* She then revised the learners' definitions through question and answer. When defining the word *embryology*, Mrs C referred to the *embryos* of chicken, fish and human as shown in the excerpt below.

> *T:* *The fossils the embryology, looking at the embryos of different animals neh… the embryo of the fish neh… the embryo eeh…of the eeh…chicken, eeh…the fish, the chick and also eeh…the embryo of the human.*

The explanation in the excerpt above was done without pictures, maybe pictures were used in the previous lesson.The next section deals with Mrs C's instructional strategies, use and explanations of non-technical words.

4.3.6.2 Mrs C's instructional strategies, use and explanations of non-technical words

This section presents the use and explanations of the non-technical terms with regard to everyday words used in the science context, metarepresentational terms as well as logical connectives. The following section deals with the use and explanations of everyday words used in the science context, metarepresentational terms and logical connectives.

Everyday words used in the science context

The term *use* and *disuse* was used twice in the first lesson observed by the researcher. The science context meaning of the term was provided explicitly using the read aloud method, where one learner was asked to read a passage from the textbook about *inheritance of acquired characteristics*. The passage talked about the giraffe story of how the ancient giraffe with short neck acquired the long neck and the snake story which talks about how snakes legs disappeared due to lack of use (scientific storytelling). Thus the words *use* and *disuse* as well as *inheritance of acquired characteristics* were used and explained the way they are used and explained in the textbook as evidenced in the following excerpt;

T: *Law of inheritance of acquired characteristics. Anyone to read that paragraph for me? Read… [Referring to a learner]*

L6: [Reading] The modifications brought about by the frequency of use or disuse were able to be transmitted to their offspring .in other words felt that animals deliberately made changes to become adapted to their environment. These structural changes were then handed down to the next generation. Lamarck gave the following as an example how his theory worked. The long legs of the heron were a result of its effort to stretch and lengthen them in order to survive in a [Not clear]…habitat. The long neck of giraffe came about because it wanted to feed on tree tops where it would have less competition from other herbivores. The legs of the snake disappeared because it did not use them in its gliding movement. Also its body became thin and long to allow it to crawl through narrow spaces. A seed of a meadow plant blown by wind to dry and stormy ground gives rise to a poorly developed plant which is very small and well adapted to drought. Its descendants will all give rise to similarly dwarfed plants and adapted plants.

The word *radius* was used in one of the discussion but its science context meaning was not considered as well as their alternative or everyday meanings as shown in the following excerpt;

T: *We look at their ulnas and radius we found that all of them they are from eee…common ancestors. And then eee…homologous structure are similar to divergent eee…evolution where we are saying that they have what eee…similar characteristics but performing different the functions. So we are continuing [unclear]…ee…origin about ideas about origin, your textbook in front of you, your study guide in front of you… origins about origins. Origins of ideas about eee…origins.*

The science context and alternative meanings of the word radius was not provided. Maybe the meanings had been provided in the preceding lesson since Mrs C was recapping. Failure to provide alternative meanings constitutes lack of awareness of the non-technical component of the science classroom language. This implies that Mrs C did not assist leaners fully to understand the science classroom language.

Accountable talk a strategy where learners talk to each other about ideas(Washoe Country School District, 2015), was employed by Mrs C to deal with the words like *use and disuse* where the learners were allowed to discuss the term *use* and *disuse* as a class as evidenced in the excerpt below;

Ls: *[Start debating, all speaking at once]*

T: *Aah…okay…*

L2: *The use part of eeh of Lamarck's aah…*

T: *Can you listen…so he is sharing this with everyone*

L2: *I think aah…the use part makes sense where the fact that in my situation I use my left hand and since I use it way more it's actually bigger than my right hand or if you look at someone's chest like righ…the hand that you use is actually bigger than the other but then in the part of disuse where it actually disappears becomes aah…fishy if I should say.*

Ls: *[Noise]*

L2: *Not disappear as such because remember, didn't we get the example….*

T: *Aah…anyone…anyone this is becoming so interesting*

Ls: *[Noise, debating and talking at once]*

L4: What happens to you if you have one foot that is bigger than the other one?

Mrs C's practice was characterised by repetition of words like *common ancestor, divergent evolution and convergent evolution* which were covered in the previous lesson. The terms *common ancestor* and *divergent evolution* were discussed by referring to the fore limbs of a bat, horse, seal and monkey. The term homologous structures was explained by splitting the term into homo and logous and then providing learners with the meaning of homo as same and then saying that homologous structures entails same structures performing different functions as suggested by The National Diagnostic Report (2015).This shown in the excerpt below;

T: … homologous structures which are eeh…similar and performing different eeh…characteristics. Same, homo means same, homo means what? Same neh…homo and then homologous structures. So these structure are the same but they are performing what? Eeh… different eeh…functions

Science context meanings of these words were provided explicitly though there were omissions in terms of providing everyday meanings of such words. The word *adaptation* was used in the discussions but contextual and everyday meanings were not provided. Just like Mr A and Mrs B, Mrs C lacked awareness of the everyday words used in the science context and the difficulties that learners encounter with such words. These results support the findings in Oyoo (2012). Lack of awareness of this component of the non-technical component implies that Mrs C did not help learners explicitly to understand the science Classroom language. The next paragraph presents Mrs C's use and explanations of metarepresentational terms.

Metarepresentational terms

Mrs C used three metarepresentational terms in the three lessons observed which are *define*, *explain* and *describe*. Mrs C used metarepresentational terms to assess her learners or check remembrance after covering certain terms/concepts in previous lessons. The word *define* was used three times in the three lessons observed. Learners were actually asked to *define* terms listed on the chalkboard. Though Mrs C used these words frequently, there was an omission in that she did not explain the meaning of *define* to the learners. She also sang the metarepresentational terms into a song as she reminded the learners that they will be asked to *define* terms like *evolution*. Besides asking learners to *define* terms the participant warned learners about assessment where she told her learners that they will be asked to *explain* the two laws *of use* and *disuse* and *acquired characteristics* and incorporated the metarepresentational terms in song so as to remind them the they will be asked to define terms like *evolution.* Although she lacked awareness of the metarepresentational terms, Mrs C used the word *define* in a more practical way than the other participants. The next paragraph presents Mrs C's use and explanations of logical connectives.

Logical connectives

Mrs C used the word *if* twice when discussing hypothesis testing, reliability and validity though in the interview she claimed that she did not use such words. This shows that Mrs C lacked awareness of the functional value of logical connectives in science classroom language. The next section presents Mrs C's consideration of contextual factors.

4.3.6.3 Mrs C's consideration of contextual factors

Mrs C considered contextual factors in her practice. She understood that her learners did not read when they are on their own. As a result she engaged the read aloud strategy in her teaching to encourage them to read on their own. Her different approaches for the three classes of different abilities show that she considered her learners' abilities in planning for her lessons. Mrs C showed that she was aware of the controversial nature of the topic *evolution*. This is evidenced in the following excerpt;

> T: *Remember I have said that when we are doing evolution I know that you are belonging to various eeh… religion. And then we know that in most cases ehh…religious people they are against evolution. What is important for us is that eh…we are doing it as a… part of our eeh…syllabus neh... Not that eeh… after we have done evolution you go back home you are going to say that madam C [Not her real name] said that eeh… there eeh… Jesus Christ is not in existence.*

Thus, Mrs C assured her learners that they were learning *evolution* for the sake of the syllabus not for them to change their beliefs. Mrs C also considered the diversity of her learners.

> *Mrs C: is all about approach right how do I approach them, eee…these learners because at the same time we must think that we are teaching different learners with different beliefs*
>
> *R: Ehem*
>
> *Mrs C: …so the approach is very important and also English as a language and there is no way that I can be able to explain evolution like in my own mother tongue and looking at the eem… the diversity*

R: *Emm*

Mrs C: ...so you just have to stick to…to English

The excerpt above shows that Mrs C understood that some of her learners were English second language speakers. The next section presents Mrs C's overall performance on the science classroom language.

4.3.6.4 Mrs C's general performance on the science classroom language

The strategies employed by Mrs C for the three classes were different. In the first lesson (average class), Mrs C only employed three strategies which are repetition, lecture and the read aloud methods. However, she used a variety of strategies when teaching the class she considered to be the best class of the three. The strategies employed with this class were; question and answer, recap of terms covered in previous lesson, use of learners' preconceived ideas, reading aloud, and accountable talk. Overall, Mrs C used ten strategies to assist learners with the technical terms. Before starting the lesson with the best class, Mrs C reminded them that she was going to employ different approaches to teach the three classes. She actually said that with the other classes she had to repeat things over and over again. The lesson with the third class was characterised by four strategies which are repetition of words, reading aloud, accountable talk and use of images in the course textbook. Mrs C believed that the best approach to assist learners to understand the science classroom language would be practical, experiments and educational tours because learners get to see things that the teacher would have taught them.

Just like the other participants, Mrs C was aware of the technical component of the science classroom language. She was also aware of the difficulties that learners encounter regarding technical terms. As such she used a variety of strategies (ten) in the three lessons observed. In explaining technical terms she used various scenarios some of which related to real life. Mrs C was unique in the strategies she employed in her teaching. Her lessons were characterised by one learner reading passages from the textbook aloud followed by her explanations through the lecture method. She also incorporated terms into song. Another strategy unique to her was accountable talk, where her learners talked to each other about the concept of use and disuse. Besides using pictures in the textbook, Mrs C used Lamarck's and Darwin's theories which constituted a strategy called scientific storytelling to explain terms. Mrs C's overall strategy in dealing with the technical terms was the lecture method coupled with the read aloud method.

Just like Mr A and Mrs B, Mrs C lacked awareness of the non-technical component of the science classroom language and regarded it as English words. These findings are similar to those obtained by Oyoo (2012). This implied that Mrs C lacked awareness of the everyday words used in the science context, metarepresentational terms and logical connectives. Despite using metarepresentational terms (*define, explain* or *discuss*) and logical connectives (*if* or *however*) in her practice, Mr C did not explain the meanings of such words. Nonetheless, Mrs C used words like define, explain (metarepresentational terms) in a more practical way than the other participants because she actually used them in her practice to check her learners' understanding. In brief, Mrs C like the other two participants lacked awareness of the non-technical component and the difficulties that learners encounter with regards to non-technical terms. These results are similar to findings in Oyoo (2012) and Oyoo and Semeon (2015). The next section presents the chapter summary.

4.4 Chapter summary

In this chapter the data analysis strategy was presented in terms of data transcription and content analysis. Then results from both classroom observations and teachers' interviews were analysed and presented case by case.

The following are themes that were common to the three participants. Scientific storytelling was common to all the three participants especially the story about the ancient giraffe which had a short neck and acquired a long one because it wanted to eat high in the trees. The use the fore limbs to discuss the concept of a *common ancestor* and *divergent evolution.*

The following words were also common to the three participants; *evolution, divergent evolution, convergent evolution, homologous structures, analogous structures, ulna, radius, law of use and disuse, law of inheritance of acquired characteristics, theory, interbreed, crossing over, embryology* and *variation* (Gebhardt *et al*., 2013).

Use of learners' prior knowledge coupled with probing was also common to all the participants. The three participants were aware of the technical component though they were unaware of the non-technical component of the science classroom language. They considered non-technical terms to be English words with similar meanings to the technical terms. All participants considered the learners' beliefs in their teaching of the topic *evolution*. They were aware of the difficulties that learners experience with language in terms of technical terms and metarepresentational terms like *define, explain* and *discuss* though they did not bother to explain them.

In summary, this study has established that South African life sciences teachers who participated in this study were aware of the technical component of the science classroom language. As such they were aware of the difficulties that learners encounter with the technical terms. Participants in this study were of the view that the learners' difficulties with learning evolution are due to the difficulty of the content (terminology) rather than the non-technical component of the science classroom language. These results support findings in Oyoo (2012). However, these participants lacked awareness of the non-technical component of the science classroom language. Owing to this, they lacked awareness of the difficulties that learners experience with the non-technical terms. Hence, they did not bother to explain such terms. They perceived teaching of non-technical terms to be the duty of teachers of English. This deficiency in explanation of non-technical terms implies that the participants did not explicitly assist learners to understand the science classroom language. Thus a study conducted by Oyoo (2016) revealed that if teachers generally explained contextual meanings of words used during science teaching, learners would encounter fewer difficulties.

The strategies established from this study are cues and questions/question and answer, use of prior knowledge, probing, identifying similarities and differences/comparison, integration of content areas, lecture, read aloud, accountable talk, direct instruction, scientific storytelling, music and songs, stories, real life scenarios, and non-linguistic representations in form of images/pictures on PowerPoint/course textbook (Washoe Country School District, 2015).

Chapter 5 provides a general overview of the research findings based on the objectives and research questions of the study. It is in this chapter that recommendations, limitations of the study, personal reflections of the study by the researcher and areas for further study are presented.

CHAPTER 5: CONCLUSION AND WAY FORWARD

5.1 Introduction

This chapter is aimed at drawing conclusions from this study. Firstly, a brief summary of the study is presented. This is followed by a summary of the research findings presented in order as the research questions that guided this research. The interpretations of the findings, recommendations, limitations of the study and questions for further study are next presented. Finally, the chapter concludes with the researcher's reflections on the study.

5.2 Summary of the study

The purpose of this study was to establish South Africa's life sciences teachers' awareness of the difficulty of the science classroom language and the strategies they can use to assist learners to better understand it. The study adopted a qualitative case study approach in collecting and analysing data. This study was conducted with three grade 12 life sciences teachers from two public high schools in Johannesburg.

This research sought to address the following research questions as highlighted in section 1.4:

1. What knowledge do life sciences teachers have regarding technical and non-technical terms?
2. How if at all, do life sciences teachers assist learners to understand the science classroom language (technical and non-technical)?
3. How do the life sciences teachers perceive their role in assisting learners with the non-technical component of the science classroom language?

How data were collected and analysed have been discussed in sections 3.5 and 3.6 respectively. What now follows is a presentation of a brief summary of the research findings.

Results from this study show that South African life sciences teachers who participated in this study were aware of the technical component of the science classroom language which they commonly referred to as the scientific/biological terms. However, these participant teachers lacked awareness of the functions of the words of the non-technical component of the science classroom language. For this reason, all the three participating teachers regarded the non-technical component of science classroom language as English words. This implies that these participants lacked awareness of the difficulties that learners could encounter with this component of the science classroom language. As adopted in this study science classroom language comprises everyday words used in the science context, metarepresentational terms as well as logical connectives. The participant teacher unawareness of the functions of the words of the non-technical component was the reason they explained the science context meanings only, omitting the everyday or alternative meanings of words of the non-technical component of the science classroom language. The participating teachers did not even bother to explain metarepresentational and logical connectives since they assumed that by virtue of being grade 12, learners already understand these terms. While this could be a pointer to these participant teachers' inability to assist learners with the science classroom language quite ably, the teachers who participated in this study employed a variety of strategies to assist learners to understand the technical terms and the meanings of the category of words referred to in this study as everyday words used in science context. Due to lack of awareness of the functions of the words in the non-technical component of the science classroom language, participants perceived the teaching of non-technical terms as the role of teachers of English. The next section presents a summary of findings in order as the research questions that guided this study.

5.3 Summary of findings

5.3.1 What knowledge do life sciences teachers have regarding technical and non-technical terms?

Results from the interviews and classroom observations show that life sciences teachers who participated in this study were aware of the technical component of the science classroom language. However, they lacked awareness of the non-technical component of the science classroom language. This was evident in their practice of teaching everyday words used in the science context as technical words, and of metarepresentational and logical connectives as items for attention of the English language teacher.

5.3.1.1 Teachers' Knowledge about the technical terms

Direct classroom observations and interviews were used in this study to gather information on the participant teachers' knowledge about the science classroom language. This knowledge would be evident in the teachers' observed practice through the way they used and explained the words during teaching and interview responses. Results from this study show that the three participants were aware of the technical component of the science classroom language. The technical component was known as the scientific or biological terms/terminology. All the three participants were aware of the difficulties that learners encounter with regard to technical terms, when learning evolution. As observed, the participants ably explained and observed the technical terms using a variety of strategies as briefly discussed.

During the interview with Mrs C, she admitted that evolution has so many difficult terms that made evolution difficult to teach. She added that terms are also difficult to pronounce. As a result, she said that she keeps on repeating these words and encourages her learners to pronounce them the way they understand. Mrs C confirmed that learners do not do well in life sciences because of the difficulties that they experience with terminology (technical terms). As HOD of life sciences at her school (School 2), Mrs C said that analysis of final examinations further provides evidence for the difficulties that leaners experience with the technical (scientific) terms.

For Mr A, learners encounter difficulties with the science classroom language because every time the teacher teaches them, it is something new. He further said that regardless of the topic or grade being taught, the teacher will be teaching learners a new word. In other words a new word will be added to their vocabulary. As a result, learners have difficulties in understanding and using them correctly. He concluded his response by saying that many learners never get to a point of being totally comfortable with the science classroom language. Mr A’s response was similar to a statement made by one of participants in Oyoo (2012) who said it may take three years for learners to understand the science classroom language. Mr A and Mrs C concurred that assessments like tests or examinations can be used to detect the learners’ understanding of the science terminology (technical terms).

On her part, while being aware of the difficulties that learners experience with technical terms, Mrs B attributed the difficulties to culture as evidenced in the excerpt below.

Mrs B: Yes I do. I actually see it at the moment while dealing with evolution. Also a lot of their culture come into play there I saw it today when we were dealing with evolution, that culture plays a major role because they won’t believe anything you say you have to basically say, basically our time prove it.

Mrs B attributed the difficulties that learners experience with technical terms to culture and beliefs. She was of the view that learners need to believe what they are taught for them to understand the technical terms. In brief, all participants were aware of the technical component (scientific/biological terms) of science classroom language as well as the difficulties that learners experience with it.

5.3.1.2 Teachers' knowledge about non-technical terms

In this study non-technical terms refer to everyday words used in the science context, metarepresentational terms and logical connectives (see section 2.3). All the participating teachers lacked awareness of the functions of the non-technical component of the science classroom language. Although they considered non-technical terms to be English words, to be same level as scientific terms (technical words), they still maintained that these must be taught by teachers of English.

Teachers' knowledge about everyday words used in the science context

Results from this study show that all participants lacked awareness of the functions of the everyday words used in the science context. As such they treated them as technical terms. All participants explained the science context meanings of such words explicitly but never bothered to provide the everyday or alternative meanings to aid learner knowledge of the meanings of the words. Nonetheless, there was only one incident where Mr A used an example of car slowing down and waiting for another car to cross at a yield sign to explain the word *yield* as shown in the excerpt below;

T: *… What does yield mean? Yield…plants don't drive up to a sign… a yield sign and slow down and wait for other car to cross. Yield means how mu…how much fruit it produces.*

Even though they used in the science context words like *radius*; *natural selection, survival of the fittest, inherited acquired characteristics*, *yield, radius*, *humerus*, *variation* and *crossing over,* all participants lacked awareness of the difficulties that learners face with regard to these words.

Teachers' knowledge about metarepresentational terms

In this study metarepresentational terms refer to words that are commonly associated with assessment (*define, discuss* and so on). Results from this study show that despite using metarepresentational terms in their practice, this was only to teach learners how to answer questions using past examination questions. Participant teacher discussions never included explanations of metarepresentational terms. On being asked whether their learners understood words like *define* of *explain*, the common response was that they made assumptions that their learners understood these words. This was in spite of Mr A's testimony that assessments have showed him that learners did not understand these words. Perhaps this is the reason they do not create time but explain these words during revision of cycle tests and June examinations. Since the participant teachers lacked awareness of the metarepresentational terms, it implied that they also lacked awareness of the difficulty encountered by learners regarding these words.

Teachers' knowledge about Logical connectives

Despite using logical connectives (*if* or *however*), all participants lacked awareness of the functional value of logical connectives in the science classroom language. They regarded logical connectives to be mere English words. Owing to this they never bothered to explain the meanings of such words during their lessons. On being asked whether their learners understood meanings of words like *however* or *if*, Mrs B and Mrs C concurred that learners did not understand logical connectives but observed that their top learners understood them whilst Mr A was not sure. To sum up, the participating teachers lacked awareness of the functional value of logical connectives in the science classroom language and the difficulties associated with them.

5.3.2 How if at all, do life sciences teachers assist learners to understand the science language (technical and non-technical)?

5.3.2.2 Teachers' instructional strategies

In assisting learners to understand the technical terms and everyday words used in the science context (which they also treated as technical terms) the participants used a variety of strategies. One of the strategies common to all participants was the use of scientific storytelling. This strategy entails use of stories that pertain to the history of science in one's teaching. The popular example was the giraffe story. The three participant teachers used the giraffe story to explain the concept/term *inheritance of acquired characteristics.* All participating teachers coupled scientific storytelling with the use of the non-linguistic strategies in form of images of ancient giraffes with short necks and the modern ones with long necks. Mr A and Mrs B (both from School 1) used images on PowerPoint extensively (almost all terms/concepts were accompanied by images) whilst Mrs C (School 2) referred learners to images in the course textbook. While both strategies work for the teachers, each of them has advantages and disadvantages. For instance, relying on PowerPoint can be a problem because of load shading whilst relying on the course textbook may be a problem in that some learners leave their textbooks at home. On being asked why they used a lot of images in their teaching, both Mr A and Mrs B were of the view that learners remember words associated with pictures than just words on PowerPoint. In fact, a good picture is worth a thousand words. Consequently, context played a major role on the teachers' preferred strategy to language use during teaching.

The other common strategy was use of prior knowledge coupled with probing, where the participants solicited information from the learners' previous experiences and used it to introduce and build new concepts/concepts. For instance, Mr A coupled the above mentioned strategies with integration of content areas when he was explaining the term *fossil*. For instance, in one of his observed lessons; Mr A inquired from the class if there were learners doing geography and used cues to get information about sedimentary rocks from learners for use to explain the term *fossil*. This implied that teachers could employ a variety of strategies to help learners understand the concepts/terms.

There were strategies that stood out for me regarding the individual teachers. There were two incidences for Mrs C. In the first incident, Mrs C allowed her learners to engage in a classroom talk which is a strategy known as accountable talk, where learners are allowed to tell others their opinions (Washoe Country School District, 2015). So during this talk, learners took chances to air their opinions as they discussed the *Law of use and disuse*. The second one was the read aloud method where Mrs C asked her learners to read loudly passages from the course textbook and then explained words the way they are explained in the course textbook. For example, she asked a learner to read a passage on *inheritance of acquired characteristics* and explained concepts the way they were explained in the textbook. On being asked why she used that strategy, she said that she knew that her learners do not read when they are on their own. So she engaged this strategy to encourage them to read and rehearse the terms/concept. Furthermore, Mrs C said that *evolution* is a difficult topic to teach; therefore she had to stick to the course textbook so that she does not miss out on some of the content, while Mr A is no longer sticking to the course textbook for terminology. Mrs C also used songs and music twice during the observed lesson. She incorporated science words like *divergent evolution, convergent evolution* and *homologous* into a song as evidenced in the following excerpt.

T: *If you do not know the answer you going to need [Singing] divergent evolution, convergent evolution, homologous…yes.*

For Mrs B, the use of the comparison strategy (Washoe Country School District, 2015) was striking. She used it to discuss the concept of *theory* and *hypothesis*. She discussed the two terms using a table identifying the similarities and differences. Field trips/educational tours and practical were not observed directly in the classroom but came out of the interview with Mrs C, on being asked what she considered to be a good practice in the use of language when teaching evolution.

In summary, the following are strategies that the participating life sciences teachers used to assist learners to understand the technical component of the science classroom language when teaching the topic *evolution*; cues and questions/question and answer, use of prior knowledge, probing, identifying similarities and differences/comparison, integration of content areas, lecture, read aloud, accountable talk, direct instruction, scientific storytelling, music and songs, stories, real life scenarios, and non-linguistic representations in form of images/pictures on PowerPoint/course textbook (Washoe Country School District, 2015).

5.3.3 How do the life sciences teachers perceive their role in assisting learners with the non-technical component of the science language?

As already observed generally, South African teachers who participated in this study lacked awareness of the non-technical component of science classroom language. They regarded non-technical terms to be mere English words (see section 5.3.2). As a result these teachers maintained that it is not their duty to teach English to life sciences learners. However on one hand, Mr A and Mrs B shared the view that even though it was not their responsibility to teach the non-technical component of the science classroom language, they were obliged to for their learners to succeed. On the other hand, Mrs C maintained that it is not her duty to teach learners non-technical terms.

5.4 Implications

5.4.1 Recommendations to teachers

Results from this study have shown that teachers are aware of the technical component. Owing to this teachers explain technical terms explicitly using a variety of strategies mentioned in section 5.3.2.2. However, it has been shown that they are unaware of the functional value of the non-technical terms (everyday words used in the science context, metarepresentational terms and logical connectives). Lack of knowledge about everyday words used in the science context results in teachers providing learners with the science context meaning but omitting the everyday or alternative meanings. Science context meanings were provided using the same strategies used for technical terms because teachers treated everyday words used in the science context as technical terms. In terms of metarepresentational terms and logical connectives no explanations were provided. This points to a need to for professional development that focuses on the use of language in science classrooms in South Africa, both at the preservice and in continuing professional development. This can be done through training, short courses or workshops. Once life sciences teachers are well informed about the non-technical terms and the difficulties associated with them, they will find time to explain these words during their practice. Perhaps this will improve the learners' performance in life sciences and increase the number of learners enrolled in university to train in life sciences related careers.

5.4.2 Recommendations to Gauteng Department of Education (GDE)

District officials responsible for monitoring schools need to assist teachers in their districts to become aware of the non-technical component of the science classroom language. This can be done through workshops.

5.4.3 Recommendations to teacher training institutions

Teacher training institutions are encouraged to emphasise more on professional development that focuses on the use of language in South African science classrooms in their training programmes.

5.5 Limitations of the study

The interview schedule used in this study should have had more questions on personal details so as to collect more information about the participants. For instance when writing the report, I realised that I needed more information about the institutions where the participants obtained their qualifications. I therefore, had to contact the participants again to obtain that information.

During the week I intended to collect data, my car broke down such that I ended up having a challenge with transport to the participating schools. Therefore, instead of visiting School 2 three times, I ended up deciding to collect all the data in one day. So, instead of observing Mrs C from

School 2 thrice teaching different sub-topics in *evolution* to the same class, I found myself observing her teaching the same sub-topic in *evolution* to three different classes. Thus, if I had observed her three times teaching the same class maybe that would have improved my findings on her.

Financial constraints restricted my data collection methods to field notes and audio recordings. However, if I had used video recording as one of my data collection methods, I could have made my data richer by capturing the words, images and pictures used by the participating teachers during observations. Also the process of data transcription would have been easier when using a video since it is easily attach voices to their owners. Some of the conversations were not clear with the audio recorder, hence if finances were permitting, use of microphones during conversations could have improved my findings. Further, if had enough practice with the ATLAS.ti a computer program for qualitative data analysis, I could have wished to implement it for analysing my data as a means to more refined findings.

This study was restricted to three participants who were born and educated in South Africa. They were also trained in the same country, though they went to different teacher training institutions. Despite all this, these participants are life sciences teachers who are practicing in South Africa. Therefore, the deficiency observed in these participant teachers in terms of the science classroom language can be taken to the whole life sciences teaching population in South Africa. As a result, findings from this study can be generalised to life sciences teachers in South Africa.

5.6 Questions for further research

- What knowledge do life sciences South African pre-service teachers have regarding non-technical words?
- Are the district life sciences subject facilitators in South Africa aware of the non-technical component of the science classroom language?

5.7 Reflections

This research was associated with a lot of challenges. Firstly, the participating schools' timetables were not matching with my timetable, therefore I needed more time for data collection. Secondly as a full time teacher I was also supposed to meet my teaching goals during the time of data collection. At one time I visited one of the participating schools for data collection but could not collect the data as scheduled because the teacher was busy with administration work. Thus it was time wasted that could have been used for teaching. Load shedding was also a challenge in the sense that I could not conduct the classroom observation with one of the teachers as scheduled because all her work was in the laptop and that meant rescheduling again. During the beginning of week that I was supposed to start collecting data, my car broke down. This meant that I had to find alternative transport to take me to the participating schools.

It is in my hope that if teachers' become aware of the non-technical component of the science classroom language they will assist learners explicitly with the science classroom language. This may in turn improve the quality of passes in life sciences nationally and increase the number of graduating matriculants enrolling in university to train in life sciences oriented careers. Consequently, this may reduce the scarcity currently faced by the country with regards to science personnel like doctors, engineers and so on. Transcription of three interviews and nine classroom observations of which one was a double lesson (ninety minutes) was a very big challenge. Therefore, if I was to repeat this study I would use a video camera to make it easy for me to attach voices to their owners. Furthermore, the video would enrich my data because it captures pictures of words on chalkboard/slides and images on PowerPoint. In future if finances permit I will consider using microphones so that all conversations are captured during the classroom observations.

Participants in this study assumed that their grade twelve learners understood metarepresentational terms and logical connectives, hence never bothered to explain them. Therefore, if I were to repeat this study I would interview the learners or ask them to complete a questionnaire to find out if they understand the metarepresentational terms and logical connectives commonly used by their life sciences teachers. The data collection process has taught me how to design observation and interview schedules and use them in the field. Patience and tolerance of other people's views and respect for participants are some of the skills that I acquired through my research journey. Above all, data analysis and presentation taught me that the essence of research is those two processes. Though it was a mission, the transcription process taught me to be a good listener who is honest in writing. Data presentation taught me to be calm when being overwhelmed buy large volumes of data. The whole research process taught me to be a better communicator who always has the reader in mind. Also, it taught me be a better manager of time, who can set deadlines for herself and religiously follow them.

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APPENDICES

Appendix 1A: Information sheet for learners

10/04/2016
Dear Learner

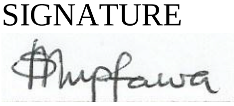
My name is Shungu Mupfawa and I am a student in the School of Education at the University of the Witwatersrand. I am researching the following topic: *Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms*. My research involves conducting observations and interviews with one matric Life Sciences teacher from your school. This will be done during school hours and the observations will be 35-45 minutes long for each class. The results from my study will be presented in a research report, journals or conference proceedings. The audio recordings will not be submitted together with the research report for examination.

I have chosen your school because it is easily accessible to me for data collection. I was wondering whether you would mind if I invite you to participate in this research. Would you please help me by participating in three lessons which will be audio recorded? The lesson observation will be conducted in a friendly and comfortable environment. Remember, this is not a test, it is not for marks, which means that you do not have to do it. You will not be paid for your participation in this study. Also, if you decide halfway through that you prefer to stop, this is completely your choice and will not affect you negatively in any way.

I will not be using your own name but I will make one up so no one can identify you. Your addresses and student numbers will not be needed for my study and all information about you will be kept confidential in all my writing about the study. Also, all collected information including audio tapes will be stored safely and destroyed within 3-5 years after completion of my project.

I look forward to working with you!

Please feel free to contact me if you have any questions.

Thank you
Shungu Mupfawa
SIGNATURE

Shungu Mupfawa
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Johannesburg
2094
Email-*744173@students.wits.ac.za* / shungumupfawa@yahoo.com Cell-0726339145

Appendix 1B: Information sheet for teachers

10/04/2016

Dear teacher

My name is Shungu Mupfawa and I am a student in the School of Education at the University of the Witwatersrand. I am researching the following topic: *Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms*. My research involves conducting observations and interviews with one/two matric Life Sciences teacher from your school. This will be conducted after school hours and the observation will be 35-45 minutes long for each class. The results from my study will be presented in a research report, journals or conference proceedings. The audio recordings will not be submitted together with the research report for examination.

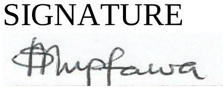
I have chosen your school is because it is easily accessible to me for data collection. I was wondering whether you would mind if I invite you to participate in this research. Would you please help me by allowing me to observe three of your lessons which will be audio recorded. Can you also help me by participating in an interview which will be 20 minutes long? The interview will be conducted after school hours at a time and place that is convenient to you. Remember, this is not a test, it is not for marks and it is voluntary, which means that you do not have to do it. Also, if you decide halfway through that you prefer to stop, this is completely your choice and will not affect you negatively in any way.

I will not be using your own name but I will make one up so that no one can identify you. Your address will not be needed for my study and all information about you will be kept confidential in all my writing about the study. Also, all collected information including audio tapes will be stored safely and destroyed within 3-5 years after completion of my project.

I look forward to working with you!

Please feel free to contact me if you have any questions.

Thank you
Shungu Mupfawa
SIGNATURE



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Appendix 2A: Learner Consent Form

Please fill in the reply slip below if you agree to participate in my study called: *Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms*.

My name is: ________________________

Permission to be audiotaped	**Circle one**
I agree to be audiotaped during the observation lesson	YES/NO
I know that the audiotapes will be used for this project only	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped.
- All the data collected during this study will be destroyed within 3-5 years after completion of the project.

Sign______________________________ Date____________________________

Appendix 2B: Teacher Consent Form

Please fill in the reply slip below if you agree to participate in my study called: *Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms*.

My name is: ________________________

Permission to be audiotaped	**Circle one**
I agree to be audiotaped during the interview and observation	YES/NO
I know that the audiotapes will be used for this project only	YES/NO

Permission to be interviewed and observed

I would like to be interviewed and observed for this study.	YES/NO
I know that I can stop the interview at any time and don't have to answer all the questions asked.	YES/NO

Informed Consent

I understand that:

- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I do not have to answer every question and can withdraw from the study at any time.
- I can ask not to be audiotaped.
- All the data collected during this study will be destroyed within 3-5 years after completion of the project.

Sign______________________________ Date____________________________

Appendix 3A: Letter to the principal

10/04/2016

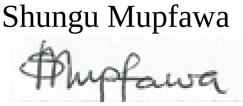
Dear Sir/Madam

My name is Shungu Mupfawa and I am a student in the School of Education at the University of the Witwatersrand. I am researching the following topic: *Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms.* My research involves conducting observations and interviews with one matric Life Sciences teachers from your school. This will be done during and after school hours. The observation will be 35-45 minutes and the interview will be 20 minutes long for each participating teacher. The interview schedule will consist of semi-structured questions, which would require more time for me to capture all the responses. Hence, the interviews will be audio recorded in order to capture all the participants' responses accurately. The results from my study will be presented in a research report, journals or conference proceedings. The audio recordings will not be submitted together with the research report for examination.

I have chosen your school because it is easily accessible to me for data collection. I am inviting your school to participate in this research. One matric Life Sciences teacher from your school will be selected on the basis of being a current grade 12 Life Sciences teacher. These teachers will then participate in classroom observations and interviews (which will be audio recorded). Three lessons will be observed and the interviews will be conducted after school hours at a time and place which is convenient to the teachers. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. The participants will not be paid for this study.

The names of the research participants and identity of the school will be kept confidential at all times in all academic writing about the study. Your school's privacy will be maintained in all published and written data resulting from the study. Therefore a coding system will be used to avoid the use of real names and no addresses or student numbers will be required for this research. All research data including the audio recordings and transcripts will be stored in a safe place and will be destroyed 3-5 years after completion of my project. Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely
Shungu Mupfawa



SIGNATURE:
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Appendix 3B: Letter to the SGB chair

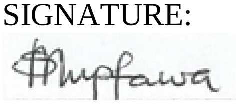
10/04/2016
Dear Sir/Madam

My name is Shungu Mupfawa and I am a student in the School of Education at the University of the Witwatersrand. I am researching the following topic: *Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms*. My research involves conducting observations and interviews with one/two matric Life Sciences teacher from your school. This will be conducted after school hours. The observation will be 35-45 minutes while the interview will be 20 minutes long for each participant. The interview schedule will consist of semi-structured questions, which would require more time for me to capture all the responses. Hence, the interviews will be audio recorded in order to capture all the participants' responses accurately. The results from my study will be presented in a research report, journals or conference proceedings. The audio recordings will not be submitted together with the research report for examination.

I have chosen your school because it is easily accessible to me for data collection. I am inviting your school to participate in this research. One/two matric Life Sciences teacher from your school will be selected on the basis of being the current matric teachers. These teachers will then participate in observations and interviews (which will be audio recorded). Three lessons will be observed and the interviews will be conducted after school hours at a time and place which is convenient to the teachers. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. The participants will not be paid for this study. The names of the research participants and identity of the school will be kept confidential at all times in all academic writing about the study. Your school's privacy will be maintained in all published and written data resulting from the study. Therefore a coding system will be used to avoid the use of real names and no addresses or student numbers will be required for this research. All research data including the audio recordings and transcripts will be stored in a safe place and will be destroyed 3-5 years after completion of my project. Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely

Shungu Mupfawa
SIGNATURE:



Shungu Mupfawa
126 9th Avenue Bezvalley
Johannesburg
2094
Email-744173@students.wits.ac.za / shungumupfawa@yahoo.com
Cell-0726339145

Appendix 4A: Wits Ethics Clearance letter

Wits School of Education

WITS UNIVERSITY

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

Date: 23 May 2016

Student Number: 744173

Protocol Number: 2016ECE019M

Dear Shungu Mupfawa

Application for Ethics Clearance: Master of Science

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

Fluency in science classroom language: Investigating teachers' use of language in SA Life Sciences classrooms

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

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

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

All the best with your research project.

Yours sincerely,

MMabeta

Wits School of Education

011 717-3416

cc Supervisor - Prof. Samuel Oyoo

Appendix 4B: GDE research approval letter

For administrative use only:
Reference no: D2017 / 106
enquiries: Diane Buntting 011 843 6503

GAUTENG PROVINCE

REPUBLIC OF SOUTH AFRICA

GDE RESEARCH APPROVAL LETTER

Date:	**13 June 2016**
Validity of Research Approval:	**13 June 2016 to 30 September 2016**
Name of Researcher:	**Mupfawa S.M.**
Address of Researcher:	**126, 9th Avenue; Bez Valley; Johannesburg; 2093**
Telephone / Fax Number/s:	**072 633 9145; 011 615 7594**
Email address:	**744173@students.wits.ac.za**
Research Topic:	**Fluency in Science classroom language: Investigating teachers' use of language in SA Life Science classrooms**
Number and type of schools:	**TWO Secondary Schools**
District/s/HO	**Johannesburg East**

Re: Approval in Respect of Request to Conduct Research

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

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

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. *The District/Head Office Senior Manager/s concerned, the Principal/s and the chairperson/s of the School Governing Body (SGB.) must be presented with a copy of this letter.*
2. *The Researcher will make every effort to obtain the goodwill and co-operation of the GDE District officials, principals, SGBs, teachers, parents and learners involved. Participation is voluntary and additional remuneration will not be paid;*

Making education a societal priority

Office of the Director: Education Research and Knowledge Management ER&KM)
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506

3. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal and/or Director must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
4. *Research may only commence from the second week of February and must be concluded by the end of the THIRD quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
5. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
6. *It is the researcher's responsibility to obtain written consent from the SGB/s; principal/s, educator/s, parents and learners, as applicable, before commencing with research.*
7. *The researcher is responsible for supplying and utilizing his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institution/s, staff and/or the office/s visited for supplying such resources.*
8. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research title, report or summary.*
9. *On completion of the study the researcher must supply the Director: Education Research and Knowledge Management, with electronic copies of the Research Report, Thesis, Dissertation as well as a Research Summary (on the GDE Summary template). Failure to submit your Research Report, Thesis, Dissertation and Research Summary on completion of your studies / project – a month after graduation or project completion - may result in permission being withheld from you and your Supervisor in future.*
10. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned;*
11. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director/s and school/s concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

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

Kind regards

....

Dr David Makhado

Director: Education Research and Knowledge Management

DATE: 2016/06/14...

Appendix 4C: Master of Science Faculty Title Approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 02711 7176029
Tel: 02711 7176006

Reference: Ms Mpumi Mnqapu
E-mail: #Fac-Science-PG@wits.ac.za

29 August 2016
Person No: 744173
PAG

Mrs S Mupfawa
126
9th Avenue
Bezvalley
2094
South Africa

Dear Mrs Mupfawa

Master of Science (Coursework and Research Report): Approval of Title

We have pleasure in advising that your proposal entitled *An investigation of teacher¿s use of language during teaching of evolution in SA life sciences classrooms* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Ms René Vosloo
Faculty Registrar
Faculty of Science

DATA INSTRUMENTS

Appendix 5A: Interview schedule for Mr A of school 1

Thank you for allowing me to observe your lessons and availing this time for the interview.

A. Personal information

1. What qualifications do you hold?
2. How many years have you been teaching life sciences?

B. Teacher's awareness/knowledge

1. Considering that you are a life sciences teacher, do you know that life sciences as a science subject is a language?
2. Are you aware of the value of the non-technical component of the science language in evolution? (Everyday words in science context, metarepresentational terms, and logical connectives)
3. Now considering your students and especially the fact that they are life sciences students are you aware of any language difficulties they encounter while learning evolution?

4 In your teaching you use words like *however* and *if* which we call logical connectives in the science language, do you think your learners understand such words? Do you find time to explain such words during your lessons?

5 During your teaching refer a lot to assessment, where you tell your learners that they can be asked to *explain* words or concepts. Do you think they understand such words like *explain, describe, define state, deduce or conclude* just to mention but a few? As a science teacher do you find time to teach learners the meanings of such words?

6 In your teaching you use a lot of pictures on PowerPoint, examples and stories to discuss concepts/terms. Why do you do this?

C. Teaching approaches/strategies

1 In the last lesson that I observed, you started by asking learners what speciation is? And you wrote their responses on the board. Why did you do that?

2 As a Life Sciences teacher what do you consider to be good practice in the use of language in a Life Sciences classroom when teaching evolution?

3. Considering your experience, how have you changed your teaching approaches with regard to language use in a Life Sciences classroom over time and why?
4. Have you ever encountered specific constraints in your teaching of evolution, particularly with regard to use of language?

D. Teacher's perceptions

1. Do you believe that it is your duty as a Life Sciences teacher to help learners with non-technical component of the science language?

Appendix 5B: Interview schedule for Mrs B of school 1

Thank you for allowing me to observe your lessons and availing this time for the interview.

A. Personal information

1. What qualifications do you hold?
2. How many years have you been teaching life sciences?

B. Teacher's awareness/knowledge

1. Considering that you are a life sciences teacher, do you know that life sciences as a science subject is a language?
2. Are you aware of the value of the non-technical component of the science language in evolution? (Everyday words in science context, metarepresentational terms, and logical connectives)
3. Now considering your students and especially the fact that they are life sciences students are you aware of any language difficulties they encounter while learning evolution?

4 In your teaching you use words like *however* which we call logical connectives in the science language, do you think your learners understand such words? Do you find time to explain such words during your lessons?

5 During your teaching refer a lot to assessment, where you tell your learners that they can be asked to *explain* words or concepts. Do you think they understand such words like *explain, describe, define state, deduce or conclude* just to mention but a few? As a science teacher do you find time to teach learners the meanings of such words?

6 In your teaching you use a lot of pictures on PowerPoint, examples and stories to discuss concepts/terms. Why do you do this?

C. Teaching approaches/strategies

1 In the first lesson that I observed, I understand you were starting a new topic evolution. In that lesson you started by defining terms which were presented on PowerPoint. Why did you do that?

3 In the second and third lessons that I observed, you started by recapping on the concepts/word that you had covered. Why did you do that?

2 As a Life Sciences teacher what do you consider to be good practice in the use of language in a Life Sciences classroom when teaching evolution?

3. Considering your experience, how have you changed your teaching approaches with regard to language use in a Life Sciences classroom over time and why?

4. Have you ever encountered specific constraints in your teaching of evolution, particularly with regards to use of language?

D. Teacher's perceptions

1. Do you believe that it is your duty as a Life Sciences teacher to help learners with non-technical component of the science language?

Appendix 5C: Interview schedule for Mrs C of School 2

Thank you for allowing me to observe your lessons and availing this time for the interview.

A. Personal information

1. What qualifications do you hold?
2. How many years have you been teaching life sciences?

B. Teacher's awareness/knowledge

1. Considering that you are a life sciences teacher, do you know that life sciences as a science subject is a language?
2. Are you aware of the value of the non-technical component of the science language in evolution? (Everyday words in science context, metarepresentational terms, and logical connectives)
3. Now considering your students and especially the fact that they are life sciences students are you aware of any language difficulties they encounter while learning evolution?

4 In one of the lesson you started by listing words on the board and asked learners to define them. Why did you do this?

5 During your teaching refer a lot to assessment, where you tell your learners that they can be asked to *explain* words or concepts. Do you think they understand such words like *explain, describe, define state, deduce or conclude* just to mention but a few? As a science teacher do you find time to teach learners the meanings of such words?

6 In your teaching you refer to the textbook and study guide and ask learners to read. Why do you do this?

C. Teaching approaches/strategies

1. As a Life Sciences teacher what do you consider to be good practice in the use of language in a Life Sciences classroom when teaching evolution?
2. Considering your experience, how have you changed your teaching approaches with regard to language use in a Life Sciences classroom over time and why?
3. Have you ever encountered specific constraints in your teaching of evolution, particularly with regard to use of language?

D. Teacher's perceptions

1. Do you believe that it is your duty as a Life Sciences teacher to help learners with non-technical component of the science language?

Appendix 6: Classroom Observation schedule

In this study, as a means to source answers to the research questions already listed, the specific concerns during the class observations and follow-up interviews included:

- Is there evidence confirming the teacher's knowledge of the science language?
- How does the teacher use the technical terms - how are these concepts explained?
- How does the teacher use non-technical terms (everyday words used in the science context, metarepresentational and logical connectives).
- Does the teacher consider contextual factors like, whether learners are second language speakers of the language of instruction or not and available resources?
- What are the teachers' perceptions regarding their role to help learners with language in the science classroom?

VERBATIM TRANSCRIPTS

Appendix 7: Classroom observations transcripts for Mr A of School 1

Appendix 7A: Mr A lesson 1 transcript (double-90 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: So Mrs Mupfawa is observing this lesson, both lessons, we will write the test first thing tomorrow. Okay… Jane [Not real name] there is a seat over here for and I have reserved it for you.

Ls: [Laughter]

T: Okay…so we starting a next topic and the next topic is the topic of evolution. Okay now… evolution is a very touchy subject for certain people…okay… and when certain people hear that word let see how many letter they are…1,2,3,4,5,6,7,8,9 that nine letter word it makes them feel uncomfortable. Okay…some of us have grown up in homes where we get taught certain things the all of a sudden in matric or in a discussion someone brings up this concept of…

Ls: [Chorus] Evolution.

T: Okay…now first of all, what do you understand, what is you understanding of evolution? So when see or hear evolution, what is the first thought and ideas that come to mind?

Ls [chorus]

T: Don't shout put your hand! Yes.

L1 We are evolving to like physintary environment.

T: First of all when you explain a word, like evolution don't use that word or variation of that word in your explanation, because when you say that its evolving into…you still using the word evolve which is evolution, so try to explain it without having that word in there.

L1: Chang…

T: …se…[inaudible]. That's the right word

L1: Changing in order to fit into our habitat.

T: So his understanding is that organisms change in order to adapt to certain situations, certain environments, certain changes within the environment, is that correct. Okay…evolution say it, anybody else, when you hear evolution. Come, you all sitting here with ideas, you all sitting with thoughts, you all sitting with things that you want to say, say that. Yes… Tshepo [not real name]

L2: Sir eem… what I know evolution is… is eeh… the growth of like entire species to be able adapt to like…eeh…like…

L3: Adapt

L2: Yaah… adapt and grow and sort of like eeh… in the environment that they are in to be able to you know be able to work and grow.

T: Okay… So what I'm hearing you say is that species want to successful…

L2: Yes.

T: In order for them to be successful they need to change.

L2; Yes

T: [Inaudible] …What is the purpose of getting species?

L2: To be successful.

T: To be successful, to be reproductively successful. We already know that in order to reproductively successful your offspring needs to survive to sexual maturity. Okay so that what are people's thoughts. What…what makes you uncomfortable about the word evolution? When I said it I was just looking around the room and I can see the people that are uncomfortable by it okay what about this word, this term makes people uncomfortable? Friendships have been destroyed…

Ls: [Laughter]

T: …by this word. What else do you feel like…yes!

L4: [Inaudible]

T: So your concern is that people were monkeys before and now are humans…

Ls: Yes…

T: …and it makes you uncomfortable to feel that I am here as a result of a monkey.

Ls: [Laughter]

T: Okay, that makes some people uncomfortable we'll leave it at that for now. What makes you uncomfortable?

L5: Religion… [Inaudible]

T: So the religious side of evolution, okay so what about the…what about evolution… makes you uncomfortable in terms of the religious aspect of it? What about… yeh…

L6: Like many people say God didn't exist and like [Not clear]…

T: Okay so you can say… [Inaudible] growing up you got taught that…this is what… I'm gonna use the bible for now because that's what most people are familiar with eem… I grew up in a Christian home, when I say Christian home it include… [Inaudible]…I grew in a Christian home one of the first stories that my mother and father read to me to bed was the story of Adam and eve. Explaining to me that the world was created by God as it is and that on day one He differentiated between night and day, day two land and sea, [inaudible]…and allowed Adam and Eve to name to name the animals[inaudible], now years later someone… is telling me that that that's not…

L: True…

T: True…right… Is there anyone from another religion instead of Christianity, that has a different… I don't know …but that's why I'm asking… is there another creation story… can I get another religion? No! … let me ask this question. Culturally…is there anything about evolution that makes you feel uncomfortable… from a cultural point of view coz you know there is a difference between your culture and your religion, okay and get brought up in way in a certain culture, and in this classroom we probably have five different cultures in which you may have been brought up in…is there any references ann…any stories that contradict evolution that motivates evolution from a cultural point of view? No! ...nothing? Okay so the…the only aspects that make us uncomfortable number one is that we evolved from apes and number two that I was taught something when I was growing up and now it's something. Okay, think about it this way, your friend comes to you and you have been dating this girl or boy depending on what your preference is for three years and tells you…I have got bad news but your boyfriend cheated on you.

Ls: [Laughter]

T: Okay, what's the first question you are gonna to ask?

L6: What?

T: What?

L2: Why?

T: When?

Ls: [Laughter]

T: Okay, how can ask your friend why?

Ls: [Laughter]

T: Okay… so you will ask… ask her questions, question you ask like, how do you know, what did you see? With who? So your friend tells you…your friend tells you know what I didn't see anything, I spoke to Suzzie this afternoon and Suzzie told me… that she saw your boyfriend cheating. So what's your next step?

Ls: [Chorus] Go to Suzzie…

T: Go to Suzzie… coz you just don't want to go to your boyfriend and start making aa…accusation you go to Suzzie and you ask Suzzie what's going on says…Suzzie says welll on Friday night we went for a party and you boyfriend was there… apparently you had some family function that's why you weren't at the party but Jenny told me…

Ls: [Laughter]

T: … She was also at the party that she saw your boyfriend behind the shade with wait…wait… wait… so your next step is you go to…

Ls: Jenny… [Coughing in background]

T: What…?

T: Go to Jenny…and ask Jenny look here… I spoke to…did I give the first person a name?

Ls: Suzzie…

T: The first person…The first one…?

T: Candice…

Ls: [Laughter]

T: Who was the first person?

L5: Portia…

T: Candice… I heard from Candice this…that Suzzie was the one who told me that you are the one who saw. Okay… so Jenny tells you this what I saw. Okay you don't want to go to your boyfriend and start making accusations, you wanna hear his point of view… so you go to him and you say… oh, so how was Friday night?

Ls: [Laughter]

T: And then he say it was cool just a place of play station you know .… Oh! Play station …so who was…were you play with? Jonny was there Pual was there, Tatenda was there, oh okay…so how did it go? [inaudible] for details…details so you saw that you don't say what's going on coz you just …you not sure, coz now he says he was playing PlayStation…you go to Jonny's, you meet with Jonny's girlfriend and ask Jonny's look here what was Jonny doing on Friday night? And Jonny is gonna be the girlfriend Portia…Portia will say ahh…Jonny was with me we went to the ci…cinema and we were watching a movie…

Ls: [Laughing]

T: …and this was… was happening now you starting to piece things together. And now you are coming to a conclusion. This is what is important about evolution…is that it's a theory… as a theory that scientists use to explain a phenomena that they observe, but in order to explain this phenomena that they are observing they need evidence, so just like you notice [inaudible]…look here what's going ah this… we…you were forced to go and investigate find out what had happened, who said what, what's the credibility of the person's opinion, haa…so that is what evolution is and that's what you need to take from. To weigh that someone is try…trying to explain something that they observe. So scientist are observing that species may be changing over time and this what they observe in order for them to think that this is happening. Do you understand?

Ls: Yes

T: What we are about to discuss is not to change your religious beliefs but it's for you to learn an explanation for something you may observe. Okay… when I did my post grad at university for example…I studied two tortoises, what's the plural of tortoise?

Ls: Tortoises…

T: I'm not asking so I have to tell you, I don't know…so there was two tortoises that I was studying okay… and I was writing a report on when were these two species actually were one species, and the question was brought about because they…they were very small tortoises [inaudible] they were in different environment this tortoise was found in very arid environment lots of rocks and sand and the rocks in the area where this tortoise was found was very dark okay was very dark colour and the environment in which another tortoise was found was very larshy environment lots of grass, lots of vegetation, lots of colour and this particular tortoise was sort of yellow greenish in colour, the shells were greenish in colour, so they looked a little different, so I had to look at the two tortoises from two different angles, I looked at morphology, so I looked at the physical appearance, and qualitative so can start to compare the number of scale the second part of my study was to look at their DNA…and when you compare their DNA you find out that their DNA were almost exactly the same and what exactly the same just because tortoises and tortoises must have the same DNA, I mean ridiculously the same. So it indicated that these two individuals, these two species were once the same species, but because the environments are different and because we want reproductive success organisms need to adapt and change to their environments and over generations morphological changes, changes in appearance can be seen but your DNA is not gonna change soon over time. So when we speak about evolution it's these massive changes from apes to man, it's these little changes is what evolution is. It about adapting to your environment okay, there is a misconception that evolution is implies that one individual can become something else, like an ape can go sleep one night and he wakes up in the morning and he is a man, this is not how things work, okay that is not how things work its things that happen over a long period of time. Maybe I should use this example, imagine this tree, very big tree 5metres to 10 metres in size and hundreds of thousands of years ago giraffes had a very thin… not a thin neck

L2: Short neck.

T: So what happened was that all these giraffes were competing with one another… for food because they were all eating on the leaves at the bottom of the tree…above where they can reach I mean, there is resources that is not being used and now I'm competing with a whole lot of individuals for only leaves on the bottom but there is leaves at the top that no one is using. So you know what happens two giraffes with short necks reproduce, do we look like our siblings and exactly like our siblings

Ls: No…

T: No, there is changes, there is differences these differences we refer to as variations. Okay, if you look at your siblings really looked at them you would see your ears may be different shape, the distance your ear is away from the head may be a little different from, your low attachment could be different, your nose shape and size could be different, your eye position and distance like all those little things there could be differences in them. So it's no surprise that two giraffes can have an offspring that has a long neck. It's just a variation and now have this population of giraffes with a short necks and this one young giraffe with a long neck. What is that giraffe going to be able do that others cannot?

Ls: [Chorusing] Reach to the braches that are…

T: Reach to the branches that are higher, does that individual need to compete with anybody…

Ls: No…

T: Is that individual borne predation, is that individual going to reach sexual maturity?

L2: Yes

T: Yes…Is that individual going to produce another generation?

Ls: Yes

T: Based on our knowledge of DNA… does that individual have the capability of passing on genes for long neck remember a long neck is a long neck it's a DNA sequence that codes for long neck. Is there a possibility that that individual is gonna to pass on the gene… for long neck.

Ls: Yes

T: So that individual has five offspring, will all of them have a long neck?

Ls: No.

T: No, one or two of them might be long neck but which characteristic is better for that population in terms of species success and survival. Which characteristics is better long or short neck?

Ls: Long neck

T: This is how evolution comes about… things don't change over time, mutations occur, long necks mutation happen before and that mutation was an advantage to that population in that environment and over many generations all those individuals with short necks will die out, no just die but over a period of time and that population is gonna end up with long neck. There are mutations that happen in populations that are not an advantage… to individuals in that population what happens to that individual, say for example a giraffe is born with extra short neck will it survive? It dies it doesn't reach sexual maturity. So is that change an advantage to the population? Will that be passed to the next generation?

Ls: No

T: Eventually will all giraffes have short necks?

Ls: No

T: [Slowly] That is evolution, evolution is not an ape waking up one day telling you I can speak a language…

Ls: [Laughter]

T: … walk on two legs and…do you understand what I'm talking about. so the first thing that we going to have a look at is evidence is there for evolution what evidence is there…because you can't say that…do you mind if I switch on the aircon mam in the corner just press the off button. emm…the evidence …The first piece of evidence that scientist use as evidence for evolution …

Ls: [Laughter]

T: … is the fossil record those who do geography what type of rock do we find there?

Ls: [Chorusing] Sedimentary

T: Sedimentary rock, what we know about sedimentary rock is that it is laid down in layers eeh…laid down in layers and pressuring causes them to harden in and form structure. What we also know about sedimentary rock is that if we look at the layers the bottom layer is that oldest in terms of time and the layers on top of newer, younger layers. Okay, so what they do is that they look at a piece of rock like that… and they find fossils in this rock, so if they find fossil in this low down it means that the animals are very… old, okay in terms of time, and lot of those species they may be find fossils in the rock they may be extinct now, so they no longer around. But aa…analysing these fossils they see that…individual of species that are extinct are similar to this that are extanct

L2: What's extanct?

T: Good question, thank you for asking. Extanct is the opposite of extinct so extinct means not one individual of the species left, extanct means the species is still alive

L2: Like a lot of them

T: Like a lot of them. Okay …so if…if according to scientists if older animals that are extinct now has similar animals that are alive now it must mean that these two species may be have a common ancestor. Okay, think of the tortoise for example, part of the story about the tortoise story I didn't tell you was before they separated into this arid are and before they separated into this larsh area they were one species together in the same place at the same time able to reproduce with one another. Some sort of separation took place…whether a mountain came between or an ocean came or something came between them so therefore this group could only reproduce with this group and that group could only reproduce with that group. Okay, so the initial group was the ancestor then you had these two groups that [Inaudible]… because of different ancestor make sense. So if they look at the fossil record and they see that the organisms that have similar characteristics to animal that are around now, it must mean that they have a common ancestor. Okay so you look at the fossil record, I'm not gonna go through all the details, just understand why the fossil record can be used as an…an indication of evolution. Okay the second piece of evidence there is…is descent by modification. And what this is… is that there are…okay, let's look at these five animals, one two, three, four, five. We have a bird, whale, horse, cow and human being and we are looking at the arm of these five species or okay group of animals. You will notice that all of them have a … biceps can you see a biceps there?

Ls: [Laughter]

[Disturbance from the intercom]

T: Okay there is no biceps [inaudible]…what we can see here if it's the arm it must be the… humerus which is the big bone okay, then we down to the elbow where the joint is and then we have the ulna and the radius from the grade 11 when you did the skeleton you know the ulna is the onethat lines up with the thumb and the radius is another side. So all these species have a femur, ulna, the radius. Which means that these species must have a common ancestor. Okay must have all evolved from a common ancestor… but each species has modified those characteristics to work for their advantage. Okay, so let's look at a horse for example, the horse the big, steady, strong, fast, animal. Okay, Its arms… front pair of limbs need to be strong and what we find in the human being for example there is a gap between the ulna and the radius and the ulna and the radius are not joined or fused at all but in the horse we find the ulna and the radius is fused together. What does the fusion do for the horse? Makes it stronger… cause its running, because its big, steady, muscular. So it has the ulna and radius but it's modified for what it requires so it has to be fused together. You notice in the whale that the ulna, radius and humerus are they very much shortened, they are thicker because are they holding weight? …are they holding any weight on those arms?

L2: Whales have arms?

Ls: [Laughter]

T: What do you think those fins are?

Ls: [Laughter]

T: So what do they use these for? For swimming, do they have to be large big strong to hold weight?

Ls: No.

T: So you will find that the structure is in such a way to help it get through water. Okay, then we have the structure of a bird here, obviously the bird also has humerus, ulna and radius [inaudible]…has a lot of light weight because [inaudible]. Okay, so scientist suggest that if these all species have the same characteristics but they are modified for what they require it for it must mean that there was a common ancestor where all these species evolved from, you get that. The next one is biogeography…bio refers to… living things, okays, living things talking about plants and animals, geography refers to its distribution. Millions of years ago all the planets…all the planets… all the continents were one ehee… all the continents were one and were referred to Pangea ehee…. There were no restrictions in terms of where animals could go. So there were confined by an ocean for example they could get from one place to another place freely. And when they started to separate they could find that there were certain species on the edges of these new continents that are now on opposite sides of an ocean that are similar to one another… but they don't look alike millions of years from [Inaudible] there still similarities between them but now they dealing with different environmental conditions so the use this as well. You also find that species always, or individuals of the same species always live in the same biomes. Desert biomes, ooh…desert biome, forest biome

L2: Savanna

[Bell rings]

T: Desert biome, grass biome, sa …all these. And you will find that similar animals in different continents were also living in similar biomes. Okay, so this is an indication of biogeography. This diagram that you see at the bottom here is one of the favourites diagrams for explaining evolution emm… from Darwin's point of view okay what he found was that there is a cluster of islands okay a lot of islands and on these islands there were different food sources for these birds, okay so think about it this way we have islands okay and then we have mainland, say it [inaudible]…okay I don't need details we will discuss this later okay you've got mainland and island what they find is that the same species found in the mainland is found on these islands but they are different because the food found on these islands are different. For example if you look at this individual over here what do you think that individual feeds on?

L2: [Mumbling]…

T: Yaah…What do they feed on?

L2: Worms

T: Okay, if you were to compare its beak to theirs how would describe it? It's big strong so it probably able to…

L2: Hunt

T: Hunt?

Ls: [Laughter]

T: It's gonna chase down a buck and kill it…

Ls: [Laughter]

T: These birds are this big…are this big

L2 Ha…

T: Okay well this particular bird will feed on nuts. You know when you buy petrol penuts and just eat it?

LS: Yes

T: Those nuts have a shell around them. Okay, if you have a small beak can you get through to the peanut in the middle of the shell?

Ls: No

T: So these ones are able to break the shells and eat it. And that was the environment they found themselves in in order for them to survive. That was the adaptation that had to take place. Okay, and then you find ones where they need to look for food in the crevices, in between rocks, in…in the barks of trees, little worms, little grabs, having a thick big beak will not help them, okay. So what they found is that your biogeography can be an indication that evolution has taken place. All over the world or scattered over an area you find birds that are similar, have a common ancestor have adapted to the environment and you see changes in them okay. Then we look genetics…genetics is also an indication of evolution okay… and the things we look at are things that bring about evolution. Remember evolution means change… one thing that can bring about change in terms of genetics is meiosis because we know during… there…there are certain things within…meiosis for example where genetic variation can take place, where genes are exchanged and at this points big enough changes can take place… your parents DNA crossover, randomly assorted themselves on the equator and you are now a self obviously. Okay is there any big changes? No but they can bring about big changes. Then we have got mutations remember we ta about different types of mutations. Mutations are changes in either gene mutations as in changes in gene sequences or we have chromosomal mutations where the chromosome is affected as a whole. So those can bring about changes big enough to bring about new species or to bring about changes within that population. Then we also have outbreeding… Have you ever heard of outbreeding?

Ls: No

T: Have you heard of in breeding?

L2: Yes

T: Never heard of inbreeding?

L2: No. yes…

T: Okay, so outbreeding occurs in most population where unrelated individuals of a population will mate and produce offspring with a greater genetic variation random mating incre…increases the chances of survival because it unlikely that both parents will carry a lethal allele, inbreeding is when individual from the same family group breed together, okay we discussed this before. If I have a weakness and I have a child with my sister and she has the same weakness because we related to one another there is good chance that she has the same weakness I have in terms of genetics. There is a good chance that the child if its fertile will… also have the same weaknesses but if I reproduce…I reproduce with someone that's not in my family and I have weaknesses and she doesn't have the same weakness and she has weaknesses genetically and I don't have those weaknesses, we put ourselves in a good position for our child not have those weaknesses. Okay, that is what is referred to as outbreeding, its random mating to increase genetic variation. Okay, a long neck came about because of genetic variation. And then we have genetic drifting aah… this is when some genes become more or less prominent in a population…aah…in the frequency of a gene in a gene pool where a population occurs this change in a genotype of a population will result in the phenotype of an individual or the su…successive generations, genetic drift tend to affect small populations, it another process due to change [Inaudible]…process over a more desired genotype. There was…I don't have details and the names and stuff, there was a famous and in this famous there were moths…peppermoths… okay the barks of the trees that these peppermoths lived were light in colour…so what colour do you think the peppermoths were? Light in colour but because of genetic variation in the population we have had those that are dark in colour, like brown and black same species [Inaudible]…just that they were that colour, which ones will reach sexual maturity?

L2: The light

T: The light colour, because they could use the bark as camouflage and hide away from predators. Could the moths with a dark colour do that?

L2: No

T: Is there good chance they will reach sexual maturity? No will they pass their genes for black and brown colour? No because they die before they had a chance to. Years passed and the area had a factory built close by the factory produced a lot ash, the ash started to accumulate on the bark of the tree, change the bark of the tree from a light to a dark colour what happened to the population over time?

L2: [Inaudible]

T: The population died out the black, so we the option that here that the population died out here we have the population evolved…evolved to black any other options? Any other options? [Silence] first of all the population won't die, because remember whe…within that population are dark coloured moths which ones were now reaching sexual maturity?

Ls: The dark coloured.

T: The dark coloured ones…Which ones are passing on their gene to the next generations?

Ls: The dark coloured ones.

T: So, sometimes you will find the changes are just genotypic, yaah...changes are just phenotypic… does that make sense? Because before the population was what… with predominantly light coloured moths because those were the ones that reached sexual maturity when a change occurred with now the environment favoured those with dark colour. They then flourished, they reached sexual maturity they passed the gene to the next generation. Okay so sometime gene… changes are just genotypic okay. Okay, emm…I have seen in the past that this is an essay question explaining the evidence for evolution, I don't think it's gonna be on its own like explain evidence of evolution, it will always joined with something else. Okay, are we all good can I carry on? Okay the next topic that we gonna look at

[Silence]…is a…. [Silence] okay let's have a look at the…and I have a video on this and I will show you the video probably next week sometime. We gonna look at these two people the people that came up with the two theories these two people That you need to know that you will be tested on. One of the gentlemen is called Lamarck okay ehh…Jean Baptista Lamarck okay, he was a French scientist who supported the theory of evolution. He believed that evolution was mostly due to inheritance of acquired characteristics ….characteristics which occur as animals adapted to their environment, okay. What does your parents do for a living? [Pointing at one of the learners]

L6: Accounting

T: Accounting okay, so her parents I'm assuming went to university they did a course or a degree in accounting and are now working in an accounting firm. Okay, we happy with that? When she was born, could she do tax returns, could she balance books?

L2: No

T: Could she do that?

LS: No

T: Can she still do that?

LS: No

T: Okay, the knowledge that her parents have… is knowledge that they acquired, so Lamarck's theory was that animals acquire characteristics, acquire behaviour and then pass that behavior to on to the next generations. Is there anyone uncomfortable with that? [Silence] No one uncomfortable with that? You all should be uncomfortable with that.

L2: Why?

T: This is why, her parents have knowledge of how to do accounting that they acquired, studied, learned through experience. Is it rated in their genes to… that knowledge of accounting?

Ls: No

T: Your parents only give two things, sorry one thing sorry, twenty three things

Ls: [Laughter]

T: That's what they give and I beg you one of the things that she got from her parents was not accounting. There wasn't an ACC…

Ls: [Noise]

T: There is a U, there is no N, there is a T, there is no I, there is no N and there is a G, but no one is accounting. [Talking slowly] so in the test you always gonna be asked why…I'm jumping the gun here, there a question in the exam where they always ask you about what Lamarck's theory was… and the a follow up question can be why is Lamarck theory is not widely accepted and the answer is because his theory on how genes or how characteristics are passed on does not have genetic basis, because that's how pass things genetically. Okay, [pointing to learner 6] whom do you look more like your mother or your father?

L6: My mother.

T: She looks more like her mother. Her mother could only give her fore head size…

Ls: [Laughter]

T: …nose with lip thickness, head thi…that's what she could give her, not accounting. [Silence]...do we understand. This was Lamarck so by this he meant if an organism uses a part often then it can or could be altered, my hands got the same things when I was born they little…I can use them a little better in terms of my fine motor skills they got bigger when I got bigger, but they still the same five fingers I was born with, I use them everyday. What he is saying is that if you use them more often they can be altered and become more well developed over its life time the offspring of these organisms they inherit this new body part, however if they do not use it may become smaller and disappear. I could say things now but [Inaudible]

Ls: [Laughter]

T: Lamarck's theory is termed…Lamarck's theory has a name okay… Lamarck's theory is termed The Law of acquired Inheritance. Okay, remember to acquired is to get over time and to inheritance means to pass on…okay, like. He also believe that organisms could develop new organs, you notice it says organism not a species they saying that an organism, me standing here, I can develop new a organ, you know what I want is to fly, I would love to grow some wings. Am I gonna grow wings?

Ls: No

T: No, lest my mother was a bird

Ls: [Laughter]

T: Or change the structure and function of the existing…of existing ones as result of use and disuse, so I explained to you what…how the giraffe actually got its neck, I actually explained how the giraffe got its neck. Lamarck said that the giraffe wanted to reach the leaves higher up in the tree as he wanted to…he then stretched longer and longer

Ls: [Laughter]

T: There was unilateral… so what he saying is that it stretched and that's how it grew, but now how do you pass on something that you acquire? You know people who do body modification so they have like eeh…loops [Inaudible]

Ls: [Laughter]

T: Are their children born with that?

Ls: No [Laughter]

T: This is why his theory…or…and its…its not to say the giraffes neck did not get longer I think…but the way he explained it… was wrong at the time let's not say it was wrong but what evidence is there for it, coz how do you pass on something that you acquire? How on you pass on accounting?

Ls: [Laughter]

T: So two ideas that Lamarck uses to explain this evolution… just because Lamarck's theories are not widely recognised dosen't mean that you don't have to know them. ahh … is use and disuse remember if use something it's gonna be available over time and if you don't use you may lose it over time and inheritance of modified characteristics. So I acquired something I'm gonna pass that acquired characteristics onto the next generation or my offspring. Okay, okay, so the gentleman that we… or the theory that is widely accepted is Darwin's theory of evolution. Darwin wrote a book many years ago called the 'origin of species', and you can actually download an e-copy of the book just down…google origin of species free copy, you will find it, and there will be copy somewhere. Ahh… I have a copy but I never gave it away

L2: [Whispering] Please sir?

T: Okay, so the way Darwin explained the giraffe's story is the way that I explained to you. I'm not gonna go through Darwin's life but I'm gonna speak about where Darwin's sort of got his ideas from. Okay, Charles Darwin spent five years travelling around the world and that was an indication of where he went, you can take that.

Ls: [Laughter]

T: And he was aboard the Beagle the HSM The Beagle the name of the ship, as the ship's naturalist Darwin went onshore to collect specimens of plants and animals, he found fossils in the several places they visited, in 1835 the Beagle arrived at the Galapagos which is … [pointing on the map on the slide on PowerPoint] here… there's the Galapagos island. Then Darwin spend five weeks recording the details of unusual plants and animal life. What he noticed there shaped the rest of his life. He documented what he saw with many accurate biological diagrams, and detailed notes. On arrival back in heam, Darwin spent the next twenty years developing his theory of natural selection.

L2: [Whispering] Shoo, twenty years

T: Science is not something that happens overnight. Okay, so what did he observe? First of all before you can make an apo…an opinion about something you need… lots of specimens…okay some of you are gonna go through a life on earth many boyfriends and girlfriends and hopefully by the end you gonna fi…end up with the right one, because you know that I dated with this one and we broke up with this one because he was too clinging to his mother, I broke up with this one because he was too overprotective and I could do anything, I couldn't be with this one with this one because he wasn't going nowhere he just wanted to sit doing nothing and eat off his parents. So you sort of found out what you like or don't like but you only know that because you been with different people. Just like Darwin needed a large variety of specimens for him to come up with a conclusion. You can't come up with a conclusion with one pattern. Like I can't say the genesis remote for the PowerPoint presenter is all black, I don't know I have one, may be it comes in red, maybe it comes in blue, maybe it comes in white, I don't know, coz I only have one. If I had a hundred and fifty of them and they all black… then I can may be say you know what maybe they all black. So he…eee…this what you need to keep in mind is that he went…was on the ship for five years. Seeing a variety of various organisms and then came up with his conclusion only twenty years after that.

L2: Shoo…

T: You notice the specimens he saw did not seem to support the idea that species were fixed and unchanged, at the time the thought was that species are always this way, they will this way and never change. The evidence that he collected pointed to the fact that species do change over time and they vary from one geographical location to another. Darwin noted three kinds of mocking birds living on four the islands that he visited. Two of the islands had the same type of birds and two other islands had each had a different type of mocking bird. According to the creation…nist theory of time each species fit perfectly into one environment. The different type of mocking birds contradicted Darwin's ideas that there should be only one type of mocking birds in this habitat from the Galapagos Island however these were also not three different varieties of the same species but three different species. I won't go through all the animals he saw I'm just showing you examples. So emm…this is called a extinct ammeter load okay, these are extinct animals, these are fossils but today living we have these organisms notice that [Inaudible] common ancestor. One thing that Darwin notated is that the Galapagos Islands were relatively ss…young islands eem…em…at the same latitude as Ecuador in South America. Okay so this the main island over here okay, there is Ecuador here is the Galapagos Islands over here, okay here is the Galapagos Islands. Okay in North and South America, okay so here is Ecuador, equator, it must Ecuador around the equator. And you find the Galapagos Islands were in line with Ecuador. If you blew up the islands this what you saw. Okay, it's not one island, the Galapagos is not one islands, its many islands, close to one another. Okay, so Darwin noted that the Galapagos Islands were relatively young okay, they have the same climatic conditions and habitat, they are on the same latitude, so they should have the same climate okay, he reasoned that plants and animals in this two regions would have been created the same as each species is created once to only match the habitat however, although the plants and animals on the islands resembled those on the mainland they were not the same species. What they are saying is, these are young Islands so if the theory that every organism is created for one habitat when were those animals created that are on these young islands? Where did they come from?

L2: Mainland

T: And if they come from the mainland or they adapted to that habitat because yes the time might the same and the conditions may be the same but the food source can be the same. And this is…these are the observations that he made that made him question what he already thought or was taught. And made him think about this concept of natural selection. So many things were taken into consideration. He returned in 1838 he wrote down his ideas in what eventually became the theory of evolution or the theory of evolution and change and it was only published in 1859 as the origins of species by means of natural selection. In 1871 his book the descent of man was published in which he argues that humans were no different from other forms of life and that we too have been influenced by the forces of natural selection.

Ls: [Chorusing] Natural selection.

T: Okay, so Darwin's explanation… [Silence] now you need to see where this Darwin… word of natural selection fits in. So here we have evolution right at to main heading evolution flushing lights, we know that that term means change, [Pause] Lamarck explain evolution by use and disuse and by inheritance of acquired characteristics, that's how he explained evolution, that's how he explained these changes that he observed, the way Darwin explained evolution is through the theory of natural selection, okay, that is the term used to explain the way he saw evolution, okay, so let's chat about what natural selection is. Natural selection will come about only under certain conditions, natural selection will only come about under certain conditions. Let's look at those conditions: overproduction of offspring, which means that there is more offspring produced than is going to survive to sexual maturity. We explained this point. There need to be a struggle for existence. Natural selection and evolution will not take place unless there is no struggle for existence. If the giraffes with short necks were not having to compete with each other and other herbivores at the time because would all be able to reach the bottom leaves, then half of the population would have had long necks and half would have [Inaudible] and because there is a struggle to exist, because there is only survival of the fittest, one needs to win and one needs to lose, in this case whoever is going to reach sexual maturity, whoever is going to reduce completion with other organisms is going to win. So there is need for struggle for existence otherwise evolution, natural selection would not occur. Number three there has to be variation within a population. What we see here is ladybirds; some people are sacred of them.

L7: Magogo [isiZulu for grandmother]

T: This is aah…ladybirds, [Bell rings] you notice they all the same?

Ls: No

T: Are these ladybirds?

Ls: Yes…No

[Intercom Announcements]

Ls: [Noise]

T: Shhhh…grade twelves!

Ls: Shhh…Shhh

T: Okay, so we gonna end there so we can start at natural selection, okay. A question was asked when is extra lessons? I don't have extra lesson but eem…Mrs Dale [Not her real name] has offering extra lessons for grade 12 on a Wednesday afternoon, eem…she tells me it compulsory for anyone that failed term two for you to go, but it is also volu…you can volunteer to go if you feel the need… was it a no? No! Where is that? [Inaudible & noise]

Appendix 7B: Mr A's lesson 2 transcript (single- 45 minutes)

T- Teacher

Ls –Two/more learners

L1/L2- individual learner

T: Morning grade twelves

Ls: Morning sir

T: Okay just very quickly, okay amongst scientists as in theory…scientist do not…as a theory scientist do not dispute that evolution takes place. Scientists do not dispute that changes happen in species or populations over a period of time. They do not dispute it. What they dispute amongst one another is how it happens? We looked at two theories there are others. We looked at two, we looked at Lamark who says that acquired characteristics can be passed on from one generation to another. We said that this is not wrong. Let's just say that it's not widely accepted because it doesn't have any genetic basis, because how do things pass on from one generation to another if not through its genes okay. So this is Lamark's way of explaining how evolution takes place. We are currently looking at natural selection. And natural selection is Darwin's explanation of how evolution takes place.is that clear? Natural selection is not evolution. So we currently looking at under what circumstances is natural selection going to take place. Because keep in mind that nature is selecting characteristics, now nature is not sitting in a meeting and saying look here long neck looks like a good characteristic let choose that one. When we talk about nature we talking about availability of food, looking at competition. When we say natural and nature we talking about all those things. And when all those things play a role certain characteristics make other animals better than others. So therefore nature taking all those things into consideration is selecting characteristics. When a giraffe is born with extraordinarily short legs nature decides looking at those factors not a good characteristic, you will die off before you reach sexual maturity that gene for short legs is never gonna be passed on the next generations are you okay with that? Okay, under what circumstance is natural selection is gonna take place? Number one there need to be an overproduction of offspring. There need to be an overproduction of offspring because not all individuals are going to reach sexual maturity. Many of them are gonna fall prey to other animals, many of them may die due to competition, many of them may die due to disease and only a select few will survive. There is a question in your exam that asks why is it that many offspring are produced but the population remains stable? This is because of overproduction say for example out of a group of offspring of 15 million say in fish for example and only a 100 survive, okay only a 100 will survive to sexual maturity. Why not just produce a 100 if only a 100 are gonna survive? If you produce a 100 only 10 will survive, you understand! Okay so overproduction plays a big role. Okay, if there is no overproduction there is no survival and there is also going to be less variation within the species because there is less individuals okay. The second thing is there has to be a struggle to existence. If there is no pressure on a population, no pressure on a population the giraffe with short legs reaches sexual maturity, he passes his genes to the next generation for short legs. Because there is no pressure to survive. So there need to be some form of struggle so that those characteristics that are not beneficial to a population is not passed on and those that are survive to sexual maturity and they passed on their genes. Okay now when we think evolution don't only think from one species changing into another species okay. The pepper moth story that I told you, about the moths and the bark and all that stuff that's referred to as microevolution. Those are minor changes within a population okay evolution does not only mean big change from one species to another okay. Thirdly there is need to be variation in a population. It's because there is variation that certain characteristics can be selected. If we all the…if…if…a population were all the same it doesn't give a species an opportunity to become better. In viruses for example many viruses are…they reproduce by asexual reproduction which means every individual within that population is the same. If some environmental condition come about that wipes out one individual it's gonna wipe out all of them because the all the same. When there is variation within a population if something affects that population and affects certain individuals with certain genes then a select few will die unfortunately, but rest because there is variation will be okay. So variation within a population is important for natural selection to take place. And then there needs to be survival of the fittest okay where the survival of the fittest means that the characteristic that you have is beneficial to the population, it's going to ensure that you reach sexual maturity. And that there is reproductive success and reproductive success does not mean that you just producing the next generation it means that your offspring is able to produce offspring okay we know this, so there need to be survival of the fittest. Do you think us as humans are influenced by natural selection? Is there an overproduction of offspring in the human population?

Ls: Yes

T: Yaah…there is.

T: Is there a struggle for existence?

Ls: Yes

T: No! No, there is no struggle for existence. And l'm… I'm… not talking about poverty and those things.

Ls: [Laughter]

T: Poverty can change, people can change and financial situations can change. I'm speaking about human beings as a species, if we were in the wild there would be a struggle for existence. Because I'm getting that buck I'm killing it, I'm braaing it and if you want it eh…you gonna have to kick my ass to get it. Okay there is a struggle for existence for you not here. Is there variation within the species? Yaah, is there survival of the fittest?

Ls: Yes

T: Is there survival of the fittest? No! [Singing] You survive…you survive, you chec…and che… you all survive.

Ls: [Laughter]

T: And you know who I blame for this, the fact that everyone survives, that every characteristic survives, do you know who I blame? Mrs Mupfawa just cut this out the video…of that eeeh… I blame women. In nature…in nature if we were in the wild, grade twelves, walking around in our loin clothes and our spear and everyone has a six pack because we don't eat carbs…if we walking around like that women are going to choose mates based on their physical stature and their ability to look after you. But in modern society, oh we…that guy has nice hair you know

Ls: [Laughter]

T: That guy his mommy has money, in ten years is mommy going to be supporting him. No! But I want that one, look how scrawl that guy is… but you know what…he dresses really nice, he's got all the latest fashion, he's got all the latest shoes. Do you see how in modern society we make decisions based on emotions not on I want my offspring to be strong and healthy? Now I want my offspring to be born with the pair of latest adidas please, that's why I blame you. Okay let's just explain this natural selection a bit more. If all of these conditions are not met, it may not lead to evolution, remember evolution does not just mean those drastic changes they can be minor changes as well. So we spoke about overproduction an example is that nature produces more offspring than can survive. However the population number remains relatively stable because many individuals will die of sickness, preyed upon, and can't compete with others. Struggle to existence, overproduction leads to completion among individuals, they compete for food, shelter for mates. And these environmental conditions will result in selective pressure and that pressure causes a struggle for existence. Because there is variation within a population, in any population there i…will be a considerable variation amongst the individuals. These variations due to genotype eeh… due to genotype this will as result in different phenotype. So are we all competing on the same playing field? No! My genes may make me better than you physically. Okay so we are competing on that level as well, what do I have that you don't? There is survival of the fittest, variation means some individuals will possess characteristics that are more suited to the environment. They will be more competitive in the struggle for existence, they will be fit to cope with the selective pressures. If all these conditions are met the end result is that if variation can be inherited which it is because it is genetic. The new generations will tend to contain a higher proportion of individuals suited to survival. Peacocks for example, female peacocks choose male peacocks based on colour? No!

Ls: [Laughter]

T: Colour play a role but it very small role. The main factor that causes a female peacock to choose a male peacock is the size of its tail. In winter they lose their tails, don't they? Males, they lose their tail, you don't know, you have never seen a peacock. They lose their tail, okay. But in spring or leading up to the mating season they grow again, but what does this mean? What does this big tail mean? Because big does not always mean better. A big tail means that I am stronger because I have this big tail that I am carrying around flying with, eem… still surviving and predators are catching me with this big tail. I must be strong, I must have good genes and females are attracted by that cause you can survive with that big tail, and no predator is catching you. It means you re stronger. And some dude is flushing his little slim fit tail.

Ls: [Laughter]

T: Okay do…does this make sense? Okay we look at a whole section where female select mates based on certain criteria. Like a certain bird that chooses a mate bases on how he dances will choose a mate based on how he builds a nest. All these are indicators to a female that he is suitable for her offspring. Not for her, for her offspring Cuase she wants reproductive success and re reproductive success means that her offspring is able to produce offspring. So I need to give my offspring the tools and the best chance to produce its own offspring, do we as females, I mean you as females choose mates based on the offspring?

Ls: Yes

T: No!

Ls: Yes

T: No!

Ls: No

T: let's not lie to each other. Okay this is the story I told you about the pepper moths. Eeh…the reason I told about that story a little earlier is that just I can use it as reference and things make just make a little bit more sense to you so I'm not gonna explain again but as you can see here [referring to image on PowerPoint] when the bark was very light these individuals were dominating the population where that characteristic was the dominant ee…wing col…wing colour for that population. But when it changed that then became the better colour to have therefore there was a shift in the dominant colour in that population from light to a dark okay. So what are the outcomes of natural selection? Number one the organisms in a population became better adapted to the environment because nature selects those characteristics. And if those characteristics stand up to the pressure of nature it's gonna make future generations better adapted to their environment that they are in. and you will find that a population can be very happy eem… within a certain environment and certain characteristics are dominant but when the environment changes, when climatic conditions change, when prey changes due to whatever reason, now it means that a different characteristic may be better. So it allows…it allows animals to shift dominant characteristics from what is better for us now, there is change what's gonna be better to us then. Okay, the species want to survive. Eem… will this change the population to a new species? No! It's just changing which characteristic is better.

Remember I said that evolution does not always mean this big ape to human thought okay. The nature of the population changes or evolve that's the story microevolution with the pepper moths, okay that's microevolution so you can just nature. A population sometimes evolve into a new species. This type of evolution has a specific name that is speciation, where a species will change into a new species. On Darwin's adventure, and I'm just gonna read this so that I don't miss anything out [Reading from slide on PowerPoint]. In Darwin's adventures he came across these finches that we briefly spoke about okay. The Galapagos finches are the famous example of natural selection from Darwin's voyage. Darwin found thirteen different types of finch on the Galapagos Island. Some had beaks adapted for eating large seeds others for small seeds, some had parrot like beaks for feeding on buds and fruits and some had thin beaks for feeding on small insects. One type of fi…one type of a finch used a thorn to pro for insects rather in wood like some peckers do. If …if you haven't seen this before this is what they do… [Demonstrating] Imagine this a thorn, so the bird will go to a plant where there is thorns on and bite the thorn off. Now they can't get into like a crevice, okay like a hole the larvae is in. You know larvae is those white things that [Inaudible]… so what they do is they will take a…they will take the thorn or the piece of branch and stick it in to the crevice. What happens is that these larvae have these mandible… [Silence] I don't wanna say teeth because they are not actually teeth but are teeth like. And want they is that they bite on the object. The bird then pulls the branch out and goes and eat the larvae. Okay so they have adapted abilities not only structural things but they can adapt abilities as well. Eem…Darwin was slightly modified or changed from an original finch. Probably the finch found on the mainland of South America… remember the diagram I showed you we were on the mainland and you could see the distance to the Galapagos and the Galapagos islands were very young islands. And when we zoomed in we saw that the Galapagos Islands are not just on Island its many small islands. So what they are saying is that some event must have brought the finches from the mainland to these various islands. And on these various islands the food source was different. A population of finches land on an island, so is variation within those individuals and there is a certain characteristic that going to benefit one individual over the others. They gonna reach sexual maturity and they gonna pass on that particular gene. So on one island there is certain beak size that's at…an advantage then will then dominate on that island. On the another island with small nuts you gonna find that even though there are individuals with big beaks the best characteristic to have there is the small beak and that becomes dominant on that Island and that goes on everywhere on those island. The finch beaks have evolved over time to suit their function for example the finch that eats small insects have slender sharp beaks to spear the insect. The finch will not be good for eating will not be very successful in an environment where buds were the only food source. Scientist think the fact that the different finches at different ecological roles or niches is necessary for the number of species to live today. So there was one species of finch on the mainland and because of them adapting to these various conditions. They evolved into several new species from that original species. Okay and this speciation, okay that's a popular example. Eem… when it comes to exam papers they like to refer to this example. They may give you just a story like this and ask you question on speciation, question on

Darwin voyage, and questions on Darwin's emm…theory of natural selection or they can just give the diagrams of the birds with a heading Galapagos birds and ask you the same series of questions. Okay now that's natural selection, are we all happy we understanding what natural selection is? As human we like to mess, we like to dictate, we like to choose what benefits us. So what we do is that we artificially select the characteristics that we have. Many of the species of dogs that we have now were not around hundreds of thousands years ago. What we as human do is we say we need a dog that can do this, that breed of dog has that characteristic that will help. So what they do is that they take that individual and that individual breed the together from the pups now. They will find may be some looks like that one, some looks like that one, has more of that one's characteristics but they are a couple of individuals that have the characteristics that they are looking for, the correct combination of characteristics. They can take those individuals and just breed them together to get more of the same characteristics. Okay, because I'm riding a horse and chasing foxes, I need a dog that has endurance, speed, lack of fear, aggressive. So I'm gonna find breeds that have those characteristics and I'm gonna breed them together. Did nature intent them to create animals with those characteristic. Maybe not! So sometimes we artificially affect what happens. Sometimes in a good way, sometimes we do it in a bad way. Artificial selection is very big in horse riding. Horse racing is a billion dollar industry all around the world. If you have a horse and it wins the like Durban July and stuff like that, that's a milli…. more than a million dollars in your pocket just like that. Okay, so what are breeders doing? Breeders are saying that that horse has good characteristics…that horse has good characteristics I want that so I'm going to deliberately breed them together. Have guys watched Jack ass, I don't know if it's one or two. How they actually harvest male horse's semen

Ls: Yes

T: Yaah…I'm not gonna elaborate but if you have seen it that's actually what they do. And they…they won't let these individuals ne…necessarily breed with one another. Okay they will harvest the semen from the male and artificially insert it into the female okay. Eem…I have a friend who breeds Rottweilers. Now he has a plot with cages with these Rottweilers and obviously can't let his dogs breed with one another because there not gonna be genetic variation within his breed of Rottweilers. Okay but what are we doing? We are selecting characteristics and making decisions based on that. When it comes to…so artificial selection or selective breeding means purposely breeding organisms with certain traits. Humans have been artificially selecting characteristics in animals and plants for centuries. For example animal breeders often change the characteristics of domestic animals by breeding individuals that have the desired qualities. Such as speed in race, horses milk production in cows and egg-laying in chickens and chicken that does not lay eggs is that a benefit to an egg-laying egg…chicken farm sorry? No! A cow that's not producing milk. No! You should not breed with them. For example a horse race…a horse breeder has four horses. Horse A is a fast male runner and horse C is the fastest runner she would therefore breed horse A and horse C. They even do this even if the fastest runners were brothers and sisters. Then she would cross breed the fast running offspring from A or C to produce more fast runners. So eventually all offspring will be fast running. Oh wha…let me just…I put this in the wrong order. In plants there is also artificial selection. Do you know what this is? It's a mealie. This is what mealies are naturally like. In our minds this is what mealies are cause that's what we see today. But this actually what mealies were. Remember each kennel is a seed. Each of these kennels can be planted to be another mealie plant but it is not why they are this big now. They are this big now because the bigger they are the more people it can feed, the more flour you can make. Because at this size they still producing seeds, they can still eeh…grow into other many plants. So naturally is not a concern this size but for human beings and for the consumption of mealies that's where the concern is. So what happened was this, there is a mealie field with all those four mealies but because there is variation within populations there were certain plants that had the bigger cobs, is it the right word? Cobs…and what farmers did was to cross breed those individuals so that they can produce crops with a bigger mealie. There is still variation within the population and the mealie tree like we have today. And then just started breeding those ones until we have what we do today. Okay, but we had selected for that characteristic and we selected for it to feed people. Many plant species have been artificially selected for characteristics or trash…traits such as fragrance, drought resistance, and yield. What does yield mean? Yield…plants don't drive up to a sign… a yield sign and slow down and wait for other car to cross. Yield means how mu…how much fruit it produces. So one tree may produce 6 apples and the other one may produce 15 apples. The tree that produces 15 apples has a greater yield than the one with produces 6 apples. The maize that we eat today comes from a plant which is indigenous to Mexico. Maize today has large soft kennels on cobs that are 15cm or longer. Maize's ancestor had small cobs that were about 4cm long with tiny hard corns okay, but we had selected for them. So what's the differences between…similarities between natural selection and artificial selection? Artificial selection is the rearing of plants and animals to develop a certain desired result. Humans determine which animal or plant will reproduce and which offspring will survive. They determine which genes will be passed on to the future generations. Humans do the selecting of genes compared to nature. In other words, the environment doing the selecting as in natural selection. Okay are we happy? We feel comfortable? Okay, natural selection plays a big role in your exams, massive role. It's either going to be a full on essay question with other aspects added to it. Or it's gonna be a good section of about 20 to 25 marks. Just on natural selection, Darwin's theory, Lamarck's theory of acquired eem…characteristics that can be inherited. It's a massive section. Okay hopefully you feel comfortable enough not to know everything but comfortable enough to go home and prepare for a test or an exam. Okay, can I carry on? Okay the last sort of major topic we touched on is speciation. Was producing enough of a change that new species came about. How does speciation come about? This will also help to understand what came first the chicken or the egg. What came first?

Ls: Chicken

T: Where did that come from? Okay I'm just…I'm gonna say…I'm gonna make a statement…I'm gonna make a statement but I'm not gonna explain any more than the statement, just for you to think about. If one species can become another species right.

May there was a time when there were no chickens and one bird species became chickens. Which means another bird must have laid an egg that the chicken was in before it hatched. So which came first?

[Bell rings]

T: Have an awesome day grade twelves we will start on natural sele…on speciation tomorrow. Thank you very much bye-bye.

Ls: [Noise]

Appendix 7C: Mr A's lesson 3 transcript (single-45 minutes)

T- Teacher

Ls –Two/more learners

L1/L2- individual learner

T: Okay good morning grade twelves

Ls: morning sir

T: Okay in the end of the last lesson we were looking at speciation. Right…

Ls: Yes

T: What does speciation mean? Microevolution maybe that goes for one term. Speciation what does it mean? Speciation… speciation? Okay speciation is the term that describes the formation of new species. Before we can discuss the formation of new species, you need to know what a species is. In grade 11 you learned about species, populations, eeh…population ecology and the term species was taught to you. Okay what is a species what makes individuals part of a species. For example we all species in here okay. What is the definition of the word species? Have you guys reached your word limit for the week? Its Friday now have so much left in you saving some for the weekend, species…question number one, where you taught this in grade 11? Yes… is there a consensus. So I don't have to get your grade 11 teachers in here, to find out if they taught this to you. What does species mean? What does species have in common? What makes individuals a part of a species?

Ls: Same characteristic

T: Put your hand up

Ls: [Laughter]

T: Yes

L1: They have the same characteristics

T: So they have the [writing on the board] same characteristics. What else? When you say characteristics are you talking about physical characteristics like morphology, behavior, which one?

Ls: [Laughter]

T: Okay, when…when we say same characteristics we can include morphology because all the same. Our head are in the same position, our arms are also in the same position, our behaviours are also the same. We okay with that? What else makes us the same?

L1 [Inaudible]

T: Sorry

L1: Reproduce

T: Able to reproduce

[Intercom interruption]

T: You are able to reproduce viable offspring. What does viable offspring mean? Viable offspring? Yes…your mouth was moving…yes

L: [Inaudible]

T: Capable of reproduction themselves. For example a horse and a donkey can reproduce and whoever the female is there the donkey or horse will give birth but the problem is that the offspring that they produce is not viable. What…what do we call aah…what do we call an offspring of a horse and a donkey. What is it name?

Ls [Chorusing]

T: It's a mule

Ls; [Laughing]

T: If you take mule and reproduce it with another mule. It's not going to make another mule they are sterile, they are not viable. Which is an indication that the donkey and a horse are not the same species. The donkey is a species on its own and the horse is a species on its own. The close…the closely enough related to be able to reproduce, but the offspring that they are reproducing are not viable offspring which makes a donkey one species and the horse its own species. Is that clear okay. So umber one there has to same characteristics and produce viable offspring is that all. Okay that is basically it. Now we gonna discuss speciation, which is the formation of new species but what we going to discuss is how…this happens. How new species are brought about. Okay, okay the reason I'm talking about species because you can't if a new species is being produced unless you know what a species is okay. So a species is a group of organism similar in appearance and behavior that can interbreed to produce fertile offspring. Organisms or closely related species that look similar may under certain circumstances interprod… interbreed and produce an offspring however the offspring are infertile because of mismatch of the different chromosomes. So a donkey has a certain chromosome number and a horse has a certain number of chromo…chromosome which is not the same. So how does that work? That's why the offspring are fertile, infertile. For example horses belong to the species and the donkey they look similar and do interbreed however, their offspring called a mule are sterile. These two species are therefore reproductively isolated because the offspring produced are sterile because of hybrid sterility. Eeh…reproductively isolated means that I'm a species, the donkey is a species and the horse is a species and we will ever never be the same species because the offspring we are producing are sterile. So we isolating each other sexu…eeh…reproductively. So let's have a look at speciation. Speciation is the evolution of new species from a parent species in such a way that…just an extra piece of information if you have a laptop, don't ever leave the plug in your laptop all the time. Okay, once the battery goes to seventy percent pull it out and then it runs down then let run up to seventy percent and then it runs down it keeps you battery healthy but if you keep that battery in and its always on hundred percent. Eventually the battery stops working okay, just for your interest. First of all, speciation is gradual it's not something that happens just like that. Natural selection is important in enabling organism to adapt to a changing environment. But this does not fully explain how one species evolves into another or one how species evolves into several different species called adaptive radiation that's a term that you can be tested on. Eeh…adaptive radiation is when one species will evolve into many different species. For example the finches that Darwin found on eeh…the Galapagos Island. There was one parent finch which was one from the mainland and that one evolved several species and we refer to that as adaptive radiation. Variation, natural selection eeh…natural selection of the fittest individual and inheritance of the fit genotype are only part of the process of speciation. Scientist now recognise that isolation plays an important role in speciation. Speciation requires a combination of geometric and reproductive isolation. In order for one species to become another species or for evolution natural selection must occur, but natural selection cannot in isolation, so cannot occur by itself to bring about new species. What also needs to happen is isolation. Because species remain species remain species if they can reproduce with one another. In order for a new species to come about a situation need to be created with these two groups no longer to reproduce with one another. Okay here we have just a very simple example of speciation. So here we have some fruitfies, so initially a single species of fruit flies. Half of them are put into a container by themselves and the other half into another container. In this container the group is fed on a starch based food, and here the group is fed on a maltose based food which is sugar okay. What happens over time is that they allow eight generation to pass. At the end of this, so they have been separated for a while now okay. At the end of this they won't necessarily mate with one another because now what has been created is that they have preferences okay, they have preferences. And that preferences can cause separation remember I said for new species to be brought about there needs to be separation. Separation is not only physical, separation can also be preference. Okay, in order for speciation to take place a small group of individual of species becomes separated from the rest. So here we find in this diagram on top here you have four individual of the same species. They are able to interbreed with one another there is no separation occurring. In the second diagram a barrier starts separating them in this case it's a physical barrier, the barrier is a lake, ocean, dam whatever the case may be. What happens is that this group is dealing with the environment that they are in and adapting to that environment via natural selection. So natural selection is happening there and natural selection is happening there. But the natural selection that is happening is happening independently. What is also happening is that these individuals can only reproduce with the individuals of this side of the lake, this side of isolation. And these individuals can only reproduce with those individuals on that side of the separation. Which means that whatever genotype, mutations whatever happens genotypically this side is only going to be shared amongst those on this side. Whatever changes happening on this side, whatever genotypic changes are happening this side can only ever gonna be shared amongst individuals that are on this side. So a reproductive barrier now exist between these two groups, they cannot reproduce with one another okay. One of the definition of a species is that they can reproduce with one another. The splinter group remains separated from the parent group, for an extended period of time. Now this doesn't happen over a generation of [Inaudible] this happens over a very long period of time. There is no exchange of genes between the two groups for many generations. So they will interbreed and exchange genetic information…eem… genetic material and these one will also do the same on that side. The parent population and the splinter group can become structurally different because remember now they are adapting to their environment. Natural selection is on-going, natural selection will happen independently on this side and independently on that side. Which means that structurally they may change differently to the way that group is changing. Behaviorally, behaviourly they may also change. And physiologically, physiological is not physical. Physiologically is the way the body works, okay morphology and anatomy is the physical body. Physiology…physiology is how the body works, how the body produces insulin. How is blood transported around the body, how is waste products remove from the body. Those are all physiology, how the body works so they can change like that. And they can become structurally and physiologically different that if you brought them together over a long period of time, they may not be able to reproduce because they are so different. A new species has evolved from the original parent population. So what you need to understand grade 12 is that in order for new species to be formed is that two things play a big role. Number one is that natural selection is taking place and we understand this concept of natural selection. But natural selection is not gonna to make a species on its own. There needs to be prolonged separation. So that natural selection can affect one group independently and affect another group separately. You can see in this diagram that this group looks a little different to that group. You get two types of speciation, the two types of speciation we get is sympatric speciation and allopatric speciation. Now if you ever get asked a question about explaining speciation and you will. This explanation will get you all the marks. The only different between allopatric speciation and sympatric speciation is this word here, the word separation will change and the word separated will change based on the type of separation. New species will form under the influence of natural selection and separation. The question you need to ask yourself is what causes the separation. And this is the two type of separation, allopatric speciation is a type of separation and sympatric speciation is another type of speciation. So this explanation will be same for both, allopatric and sympatric speciation except when you explain the separation that is where the difference is gonna come about. Allopatric speciation means home…other homeland. This occurs when there is geographical…geographic barrier which is physically separating the two groups. An example was the Galapagos finches. What was the physical barrier that sep… separated the Galapagos finches? Water…it's is a physical barrier. I' m not going to try that far…not going that far. A physical barrier can be a mountain, so there is an earth quake there is tech…tectonic plates that move. Those who do geography you know that mountains can form by…how many of you do geography here? How are mountains formed?

Ls: [Sounds]

T: So when plates start to heat one another, so they have got nowhere to go but up, okay that's a lame explanation, it moves go up. So say for example population living on this piece of paper they are living happily, everyone is reproducing with their mate because they are monogamous so they only they reproduce with their mate for the rest of their lives and all of a sudden an earthquake comes and disrupts their happy home. What happens is that eruption causes a mountain. Now there some individuals are on the left hand side and some individuals on the right hand side. Over time natural selection is gonna affect this group and natural selection is gonna affect this group. They gonna reproduce among themselves, and they all reproduce amongst themselves. Okay, this is a physical barrier, the changes can be so drastic that physically they can change, physiologically they can change, behaviourly they can change, to such an extent that if the mountain one day decided to move this species, this group will not reproduce with that group. That group is ones species and that group is one species. Is that okay, so pysio… a physical barrier if they say it's a physical barrier causing the separation we referring towards allopatric speciation. Sympatric speciation means…sympatric means same homeland, so other homeland means that they are separated somehow by something physical they are not living in the same area. Sympatric separation means they are in the same area, they are in the same area but something else is separating them. So sympatric separation is brought about by reproductive isolation. If individuals that are living in the same area, have a mountain coming between them and physical separating them. The physical separation is not going to bring about new species it's the fact that this side can't reproduce with that side that is what is bringing it about. You okay with that? So if you are living in the same area and there is no physical separation, no ocean, no lake, no mountain but something is happening that you guys are not reproducing with one another. If you are not reproducing with one another for a long period of time you can bring about new species where all the individuals are actually still in the same area, because its… the fact that they not reproducing with each other that the driving force here and that's sympatric speciation okay, that is brought about by reproductive isolation hee…okay that's sympatric. So like I said if you explaining speciation and they ask you to explain allopatric speciation, you when you discuss separation you either discuss allopatric speciation or sympatric speciation. So that isolation is either by physical barrier or it's by reproductive means but the rest will be the same. So what can bring about reproductive separation? If fish start to breed at different times of the year, are they in the same area? Are they in the same area?

Ls: Yes

T: But one group starts to reproduce in spring but one group starts to reproduce in autumn. Are they reproducing with one another these two groups? No! cause they now a preference for when they want reproduce, which means those reproducing in spring, they will exchange genetic information amongst each other and natural selection will affect them. Those reproducing in autumn they will exchange genetic information and natural selection will affect them. If that separation happens over a long period of time you see new species being brought about and you see this in trout there is brown trout and rainbow trout. They use…they had a common ancestor and all of a sudden they started breeding at different times of the year, okay. You can find mice living in the same field become new species, natural selection affects a couple of the mi…mice and they have the ability to see at night, they see better at night that they do during the day. So when do they going to hunt? At night! The others are gonna hunt when? When is the group that can see well at night gonna reproduce? At night…

Ls: [Laughter]

T: That's when they are active. Those that see better when are they gonna reproduce? During the day. So now they are in the same field but they are active at different times of the day. Therefore they are isolating themselves. One group that is active at night they are exchanging the genetic material at night and that group that's doing it during the day they exchanging genetic information during the day. And if this prolongs for a very long period of time that can bring about new species. Fruit flies for example, you may not know this but they can have preference to certain fruit. So say for example there is a group that prefer apples and there is a group that prefer mangoes. There is an apple tree and there is a mango tree, all those that refer apples are going to be where? By the apple tree. Those who prefer mangos are gonna be by the mango tree. Those by the apple tree are gonna reproduce and exchange genetic information based on their reproductive preferences for food. Are they in the same area? Yes! But what is isolating them? Their reproductive behaviours, what their preferences are. Okay, so I'm not gonna go through that I have already explained that. So these are just different examples of reproductive mechanisms that bring about separation. Okay, so breeding at different times of the year can bring about reproductive isolation and that makes sense. Ehe… courtship behavior, now in one pond there is hundreds of species of frogs. Why is one species not reproducing with another species of frogs, the all in the same area? Have you tried to catch a frog in a field, not even tried? It's very hard. You know what they do? They make a noise so we we…went on trip once when I was busy studying. And there is these frogs literally this small you can put them on a one ran coin, they are that small. And our lecturers said that he got had a price for whoever can catch one of them but you can hear them all over…you can hear them. So this field that they are in is a very sort of muddy that they don't necessarily live in water that they live in a very moist environment. What you to do is that you have to sit still and just listen and as soon as you hear one close to you… you mustn't move, you can't move. You have to look around and see if you can see him. As soon as you spot him there is a good chance you can catch him but if you don't spot him you not gonna find him. And what happens is as soon you start moving or get up they start making a noise Again and you will struggle very much to catch them. No one caught a frog that day. Emm…but frogs all make different a different sound and females of different species are attracted to a certain sound. Frog can differ…in pitch in tone in frequency and females are the attracted to tho…those calls okay. What we have here is that species have certain courtship behavoiur and that courtship beahavoiur that sound the frogs are making is separating the other individuals to that female that has a preference to that sound okay. If an animals has a mutation that result in an alteration in its courtship preferences. It will choose a mate based on these differences and the different behaviour patterns will be passed on to successive generations. So if a female has a certain preferences for a certain type of male or certain type of courtship behavior it will be able to pass that genetically onto its offspring and those female will have those preferences. And then you start a line of individuals that have a preference for a certain courtship behavoiur. And you can is…that will brings about isolation reproductively. And that line will reproduce, eeh…exchange information, evolve separately to the others that have certain preferences. In Tshwane in the Tshwane region of South Africa the mating calls of three related bullfo… species, these are bull frogs. Eeh… the females are attracted only to the mating call of their species. So the female of this species will only be attracted to males that make the sound [Inaudible] the female of that species will only…but now you need to imagine that used to be…the three species here used to be one species and due to natural selection or mutations that happened the females or the males sta…either started to making a different sounds and females were attracted to that sound which brought about up a new line okay. What we also find is that adaptation to different pollinators can also bring about speciation. In terms of preference of your pollinators. Flowers need to attract pollinators in order to successively reproduce, we all know this right. Those plants or flower that are less attractive to pollinators will not make seeds, so the plant population will gradually produce only those flowers that local pollinators prefer. There are many closely related plant species that rely on different pollinators, example one species if pollinated by the hamming bird that prefer flowers with a lot of nector eeh…these flower are long and tubular with large amount of nectar. Because the nectar around needs to feed that bird and the pl… plant want that bird to come to it in order to disperse its pollen. On the hand, bubble bees prefer a landing platform cause it can't hover like that to get the nectar out, it prefers a landing platform. So bubble bees prefer flow…flowers as a landing platform as it cannot hover and sip nectar as a hamming bird does. So different adaptations can also bring about different species because now we have certain preferences of food.

[Intercom interruption]

T: Okay, I just wanna look at one more way in which eeh… a species can be reproductively isolated and I have already spoke about it. It's the production of infertile offspring and example of the donkey and the horse. If they are producing infertile offspring they never going to create another species okay, because already they are separated species. Okay now eee…this gonna be in your September exam, it's gonna be in your final exam, they gonna ask you to explain speciation. They may… some of you are going to learn the steps of speciation and that's good. But whatever example they give you need to relate your explanation of speciation to that example given to you. So that if they talking to you on an example of flies then your explanation refers to the files then your explanation needs to refer to the type of speciation that is taking place. Sorry not the type of speciation, the type of separation that is taking place. Is the separation a physical barrier or the separation non-physical reproductive barrier where there is some sort of preference separating the individuals that bring about the new species? After speaking about speciation do you still feel like an ape can become a human being? Does it make you think that?

[Bell rings]

T: Have an awesome day grade twelves.

Ls: [Noise]

Appendix 8: Classroom observations transcripts for Mrs B of School 1

Appendix 8A: Mrs B's lesson 1 transcript (single-45 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: Come on guys we starting evolution, and the first thing that we need to know is what is evolution? What is evolution what is it? What is evolution?

Ls: [Chorusing, inaudible]

T: Evolve from what?

L1: Change

[Noise]

T: Decisively populations would adapt to the changes in the environment, okay one thing you need to realise I have used the word populations… I didn't say individuals why?

Ls: [Chorus & unclear]

T: Can't just be one… one thing changing and one it's on organism, its specific changes within a population, okay it's for survival and those organism if the population cant adapt it does out. Okay now another one I want to ask, what is a theory? What is a theory?

L1: Theory?

T: Yes

Ls: [Inaudible]

L1: A conclusion of research

Ls: [Inaudible]

T: Okay, what if I tell you a theory is based some evidence result, right and based on that evidence [inaudible, noise]…and these theories can change with time okay based on the certain evidence that is found [Inaudible]…any questions on it? Guys terminology is very important. Now we talking about evolution, what evidence do we have that evolution has taken place?

Ls: [Chorus] Fossils

T: fossils, what else?

Ls: [Inaudible]

T: Right what else?

Ls: [Inaudible]

L2: Bone structure

T: Bone structure, right what else?

T: What is palaeontology meaning [inaudible]? Guys what is palaeontology

L3: Study of fossil

T: [Inaudible]

L4: Where did you get that?

L3: I even got the answer.

L5: Jessica [Not her real name] where did you get that?

T: Study of fossils, yes so we really [Inaudible]…they actually give us that evolution has taken place or has occurred. Okay, so we gonna go through each one and I really want you to consider that, because it's gonna be terms that you not familiar with. Right first one is palaeontology…palaeontology study… is the study of fossils. How many fossils have been found, anybody has an idea?

Ls: [Inaudible]

T: Thousands, any idea where these fossils have been found?

Ls: [Chorus] South Africa

T: Or the African continent. Okay [inaudible]

[Interruption from intercom]

T: Okay what is the fossil meaning all about, guys can we have Silence. What is a fossil? What is it?

Ls: [Inaudible]

T: Remains of organisms, whether its plant and animal. [Inaudible]…and usually when you talk about fossils, what type of rock is that finally?

Ls: Sedimentary

T: Why do you say sedimentary?

Ls: Salt

T: Okay, first of all what happens when you actually a rock like compacted [clapping hands] what is your final rock there?

T: Igneous rock. Okay remember a lot of it happens with compaction animal dies, water comes down put mud on it okay now it's encased a lot comes now it's gonna be slight decomposition, it's going to be anaerobic why? It's gonna be no air in there. Okay, so I guess in a year and a half [Inaudible]… so you get beautifully preserved organism lying there or the bodies because they [Inaudible]… decomposed. Yes [Referring to leaner 1]

L1: Mam… [Inaudible]

T: emm…some of them you would find as fossils as well but yes you see that I may talk about fossil fuels because that actually your pre-cast decomposed if do break off some of the cores you will see plants, okay, so that why we prefer to use fossil fuels. Right… [Referring to an image on PowerPoint] nicely preserved fossil prehistoric bird okay, what is your …remains of it, basically here it's from the skeleton of it an animal dies as it is compacted in the rock, the bone becomes fortified…[Inaudible]…rock.

L1: What is it called mam?

T: Calcification

L1: Is it like calcium?

T: Yes, know more your …lessons to sci…science.

L1: Never

T: Okay, its why basically it's not just in rocks that you find remains. Guys…animal sitting on tree, tree gives of gum, do you know that?

Ls: Yes

T: The animal gets stuck in the gum can actually be… preserved. Have ever Jurassic park I think it's the first one they show a mosquito. It actually… [Noise]…now, okay so they can be… [Noise]...come on guys, come, come. The [unclear]…trapped in amber would use the gum to [unclear]…Okay it's not just animal remains, what about dinosaur footprints? Have you seen a footprint? [Referring to the image on PowerPoint] Have you seen a footprint? You can see the foot print? Okay [Unclear] Now, there are few places in South Africa where they found footprints. [Referring to the image on PowerPoint] You see they actually there in the rock. Come in, you people are extremely late for class you can sit on the floor, you can sit on the floor now. You can sit on the floor because you are extremely late.

L6: Mam they got lost

T: It's not my fault; the school is actually rectangular you can't get lost.

L6: [Laughter]

T: Come you wasting my time. Okay now the big question… is we already mentioned something about sedimentary rocks, most of them we gonna find in sedimentary rocks, why? We already mentioned salt. Oaky we can also find them in ice, trees we have already spoken about amber, volcanic rather, tar pits

L1: What are tar pits?

T: Tar pits, tar is naturally occurring, Okay, it's not artificial it's natural.

L1: Really

T: Yes. Okay, and of course we have some form of fossils that are alive today, like a coelacanth you know what a coelacanth is?

L3: No mam

T: You should have done this in grade 10. You don't know what a coelacanth is?

L3: No mam

T: It's a fish, a fish which actually [Demonstrating using the table] almost as the size of the table from here to about here Tarshima okay a few years ago, one was caught by a fisherman and was sent to university and was brought up to Johannesburg, It's actually at the museum at the moment.

L1: wow

T: The coelacanth

L1: Is it still alive?

T: deep freezer…it's still, that one died

T: However, we all know the Helberberg?

Ls: No

T: The Helberberg is the plane that went down somewhere in the ocean in the yooh

L3: Yes, yes

T: …in the 80s, 1980s okay people say there was an explosion on board plane got into the sea was about three kilometers down and they laid submersibles, they actually found some coelacanth because they are very deep in the ocean. They realised the animals do exist. We have evidence, we have fossil. The first one they ever found was in 1927, in a cave also a ship has hit it and they are kinda scattered. They are so down, [not clear] okay, they are actually organisms found deep in the ocean. I don't have a here guys I will remember I will bring one tomorrow but what I can tell you is that it's a ugly fish that I can tell you, it's not pretty. Emm…people I'm…I don't know

L1: Is it extinct mam?

T: No! It's a living fossil, it's still alive [Noise] [coughing] guys…

L7: It's the one with sharp teeth.

T: It's an ugly fish, I will bring a photo tomorrow, I will find one at home

L5: Hold on oh… hello…

T: I don’t know I [unclear]…okay guys

L1: Shhhh

T: Guys, Tshepo [Not his real name] matrics okay, guys…

L7: Shhh, shhhh

T: Right in your grade 10 year you should have had something about the coelacanth in your life sciences, because you started some part of evolution in grade 10. Right, I know because I teach grade 10 myself. Okay, now again [unclear] anaerobic conditions you all know anaerobic Charles [Not his real name] anaerobic means absence of oxygen. Okay, and of cause we have pressure how sometimes and most of the time you actually have these movements or pressure you can have the skeleton break or might have an animal that has died you can have a predator taking the bones somewhere else. Okay, so some of the fossils we have found is not complete there are pieces missing. But basically…they gone!

L1: Where?

L: [Laughing] They gone

T: Who knows…? Gone… May some of [unclear]…but I don’t know… gone! [Unclear]…However the most complete dinosaur has been found, the most complete dinosaur has been found, I don’t know what it was…[Unclear] but… when we do human evolution we gonna be looking at it [unclear]

L1: So mam [unclear]…

T: Some of them are [Unclear]…okay but it’s not [Unclear]…okay

L: [Unclear]

T: Crocodile…

L1: Aah mam crocodile [Unclear]…

Ls: [Laughter]

T: A crocodile is also another animal that actually has never changed from prehistoric times to now. Okay there is…well you get noth…crocodile you some very big ones…

L3: [inaudible]

T: Sorry…

L3: [Inaudible]

T: [Clearing throat] Okay guys there are a lot of things that we learn from dinosaurs, we know. Okay can I change?

Ls: Yes

T: Okay now what conditions do we need… to preserve [unclear]…in a cupboard they were actually preserved but [unclear] … by a rapid and complete period. Anaerobic conditions I have already mentioned this before, okay anaerobic conditions and of course how hard certain parts are, the harder the parts the longer it's gonna take to breakdown. Therefore, it has a better the chance of [Unclear]…any questions? [Silence] Okay what do we use fossils in our lives?

L: [Unclear]

T: [unclear]…but it also tell us what animals and plants were there before, information about the climate and even the environment at that specific time, okay as well as… somebody mentioned earlier on about fossil fuels. This coal that we use through our fire is actually fossils.

Ls: [Laughter]

L: [Inaudible]

T: What do you mean fos..?

L: [Inaudible]

T: Fossils… [Inaudible] okay, do you think its eee…quick to get [Unclear]

L3: No

T: No! It's not, it takes millions of years to get to that point. And when burn, we burn it.

L3: [Laughter]

T: So next time think before you put that little coal in the fire actually why it's a fossil, or it is a fossil.

L1: So mam what must we use?

T: [clearing throat] I don't know. Now basing on all this what is geological time scale? [Noise] What does it mean? Come guys, what is the geological time scale? Time scale?

L: [Unclear]…era

T: Okay and how do you think [Unclear]…

Ls: [Noise]

T: Excuse me I confiscate phones, now they will just be taken, they will just be taken.

Ls: [Noise]

T: Approximately, approximately.

L: Mam, mam how many years… [Unclear]…mam?

T: [Inaudible]

L: Why don't we… [Inaudible]…?

Ls: [Laughter]

L4: Yaah…

Ls: Yes…

T: Guys… [Unclear]…okay but we may not… [Unclear]…in our era. They are the ice age remember… [Unclear]…we postulate what could happen to earth… in our era. Cenozoic, Mesozoic and Cenozoic. And we gonna learn each of the periods in each of these eras because…remember that it took millions of years hee… okay, we talk about MYAs, we gonna see what happened in each one of these eras because organisms have changed. I will show a video clip later on [Inaudible]…about populations have changed [Unclear]…Now guys we know what a geological time scale is all about?

Ls: Yes

T: [Unclear]… okay we have a geological time scale is all about, we know that fossils have been found, some of the fossils are very old. How do we det…determine the age of the fossil. In fact if can't find the Meso…Mesozoic, Paleozoic era how do we know this? What do we use? How do we know the age of a fossil? Now please someone look at the next slide, science will know, okay… [Unclear]…How do you look at how long it takes… for uranium to decay… in [Unclear]… [Noise]

L: Oh my gosh!

L1: Ahh mam…

T: [Unclear]…will be all about how to determine how old the fossils actually are. [Noise] so how old the world then?

Ls: [Chorus]

T: Approximately five thousand million years ago. Approximately we gonna draw approximately…

Ls: Hundred thousand

T: Okay we don't know for sure

Ls: [Noise]

T: Come guys.

L: Shhhhhh

T: Okay, we looked at one part of evidence of evolution, that evolution has taken place.

There are many other ones… [Unclear]…let's look at the next one, comparative embryology. What does the word comparative mean?

Ls: Comparing

T: Compare, to compare, now there is…explain embryonic development [Unclear]...the problem is you are talking.

L: Shhhh

T: I said embryology

L1: What is embryology?

T: You did human reproduction didn't you?

L1: Oh! Embryo

T: Embryology, study of embryo, okay, as far as embryonic development this is called [Inaudible]…with all embryos exactly the same you cannot distinguish between cat, duck or human

L: [Inaudible]

T: [Coughing] Sorry…

L: [Inaudible]

T: Phylogeny what's phylogeny?

Ls: [Unclear]

T: Okay, don't worry about it, okay. [Coughing] basically what… we don't actually do anything about [Unclear]…nothing it's not part of our study, alright it's just happens to be in there. First of all we gonna look at developmental stages of all vertebrates. And one of the big thing in…guys can we have you shushi now. In ahh… development okay when they look at what is happening in this bottom stage, it actually suggests one thing… that all these organisms are somehow related, that they have a common ancestor.

Ls: [Inaudible]

T: Right, common ancestor, and likewise you gonna see we gonna refer common ancestor quite a lot okay, when especially we talk about human evolution. Okay, they believe that all organisms are related [referring to the image on powerPoint] so I want you to have a look here, okay have a look at especially to top one, number one. You have a fish, you have a salamander, a tortoise, a chick, a hawk, a cow, a rabbit and a human, okay you have to see they all look basically the same. If you were given that…

[Interruption from the bell]

T: Okay, you basically see in number 1, first embryonic stage, you cannot distinguish it all and that suggestion that all organisms are very highly related to fish, what is the reason that makes them say that? Could you people shut up here! That… they have a common ancestor. They believe that [Inaudible]…and I'm not saying you must believe that. Right but basically my point I'm making is that in your first part of embr…embry…embryology all your organisms look exactly the same if you look at them and as development goes you can actually see there is changes so your, this the first month hee…the first month of embryonic stage, the first trimester, it doesn't matter [Inaudible]… what organism it is. It is the first part of development, the [Inaudible] the first trimester, okay, you all see that, aah…your textbook does this diagram in it, I'm not going to make copies of this diagram. Now we now looked at fossils, now we have looked at comparative embryology. But there are other ways as well… [Bell rings] there is common ancestor, comparative anatomy but tomorrow we gonna continue on that point [Noise].

Appendix 8B: Mrs B's lesson 2 transcript (single-45 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: We actually going to be looking at the fore arm of different organisms or the fore limbs rather. And again we talked about closely related. Look at the bat same structures but look at the phalanges, long to accommodate the wings. Okay, so the reduced the [Inaudible] but here you have wax in between. Okay, then have a look at the frog and of cause bird where the phalanges are fused to make a little tip of the wing. Okay, basically those are the phalanges. So basically yes, structure they look similar but function they can be different. Okay, do you get it?

Ls: Yes mam

T: You all good?

Ls: Yes mam

T: Okay this diagram is all similar, you have it in your textbook I'm not gonna read all of them, please use of your textbooks. Next one…now we had homologous now we have analogous. What does analogous now mean?

L1 Different

T: In this case we will look basically at the wings of insects and birds, alright and even though things look…have the same function, they look different. Take the wing of a bird and the wing of an insect, to they look the same? Definitely not. So we talk about convergent evolution. So divergent is similar and convergent is different. I'm looking for some diagram, no I don't have a diagram. [Silence]. It looks like your textbook gives diagrams on birds and insect for okay for convergent evolution and analogous structures. Okay can I change?

Ls: Yes mam

T: The next thing we are going to look at is the vestigial structures. Structures that are there but have no function. They are part of the evolution process but in our lives they have no function. For example the appendix has got no function but we still have it. Okay, other structures were found are in the whale between the pelvic bone and the femur they are structures that are present but have no function. Okay, any questions from that? Okay basically it still comes down to common ancestor [Inaudible]. The next one when we look at biochemistry. Okay, then we look a biochemistry what do we look at? DNA, [Inaudible] proteins, sequences of genes. Most organisms a large number of primates are a similar [Inaudible]. For example humans and primates, humans and the chimpanzee for example [Inaudible] they are closely related to the primates again there is common ancestor. Our DNA structures are basically similar and sequencing of the genes are also similar but there is a slight variation. Okay that's I'm gonna do about biochemistry, there is a very short section in your book although it might not be mentioned. Okay, then what about biogeography, now we have looked palaeontology, you have looked at comparative embryology, comparative

L1: Anatomy

T: Sorry

L1: Anatomy

T: Now we have been looking at comparative biochemistry. Now the last one, biogeography. Anybody has an idea of what biogeography is?

Ls: [Chorus]

T: Sorry

L2: [Inaudible]

T: Earth before, all the continents were one big Pangea, am I right? It has broken up into different structures, we now have little continents. Each continent is unique to its own animal and plant life? For example we don't find Marsupials here unless they bring them in…Marsupials

L2: What's that?

T: Kangaroo… animals with pouches okay!

Ls: Hooo

T: I thought you know all these terms. You did do animal biodiversity haven't you?

L2: Grade 10

T: Okay, okay so for example we won't find here Marsupials unless they have been brought in, where would we find those animals?

Ls: Australia

T: And New Zealand. Okay, what are you gonna find in Africa?

L2: Lions mam

T: The big five

L1: Zebra

T: Okay, what are gonna find in America?

Ls: [Chorus, inaudible]

T: Haa-haa

Ls: [Laughter]

T: Haa-haa…you gonna interestingly you gonna find the wolf [Inaudible]…

L3: You can find a white tiger

L2: Asia

T: Okay, [Inaudible]… yet Asia the place if tigers, China the Panther

Ls: [Laughter]

T: Geez okay, I'm not gonna carry on with this. Okay that is something called biogeography guys

[Intercom interruption]

T: Okay guys, now as it says we look at the distribution of plants and animals on the earth. Okay now we were now coming to Darwin just now or may be in this lesson or Wednesday next week. Darwin actually looked closely at Biogeography of specific…

L2: Is he alive?

T: He is dead!

Ls: [Laughter]

T: In fact I will tell now exactly when he died…he died in 1882

Ls Haaa…

L2: He died in 1882

L3: Who

Ls: Charles Darwin

T: Okay, he very was fascinated with this spot where he did most of work on the Galapagos Islands of the South American coast. [[Inaudible]…each island is unique in the animals which it has. For example he would find on the white island the tortoise with a long neck the other island with short neck. However they will all be related, but now they are two different species [Inaudible]…when we talk about speciation. Okay and what I mentioned before when I talked about the Pangea breaking up, the continent drifting apart. Okay so that's where we get all the diversity from. [Referring to the images on PowerPoint] there you have one example of the Asian links North American links okay, you got two different animals. Northern American would this on here because it is snow. Okay, up Canada's veld, snow is.

L3: Mam isn't that a Bob cat?

T: No, that's a slinks

L3: Its two different things?

T: Bob cat…right then you actually… now take a close look there please…closely to those animals there now I'm actually gonna show you. Where would you find this one?

Ls [Chorus]

T: In southern Africa

L2: Where?

T: In the Game parks

Ls: [Laughter]

L2: Not in the…

T: Kruger National park

L2: Not in the…

T: They are protected animals

L2: What is called mam?

T: slinks, slinks

L3: What the difference…from the links?

T: I think it's the structure, no for the… remember now even if we call them slinks some of the will not be able to interbreed because they have become new species. Because of the continental drift animals adapt to their environments, okay these adaptations are now in the genes. They cannot interbreed anymore. It's a very beautiful animal hey. Okay now, last year we did this and this is just to recap again on phylogenetic trees. What do they show?

L2: Families that are related

Ls: [Laughter]

T: Evolutionary relationships and the word evolutionary is actually here. So whenever get something and they ask you what it shows. In your question… or your answer you should have the word evolutionary relationships between whatever groups they give you. Between trees between plants whatever the case may be. And it's almost similar to a cladogram.

L2: What?

T: Yes! What? You have done this, all of them were done last year. In actual fact you gonna draw some as well, cause you need to know this.

[Intercom interruption]

T: Okay, have… we going to look at this things again as we go with the work aa… cause it gonna come up in quite a few questions. We gonna look at relationships…evolutionary relationships. You gonna see them between the human and the primates, you ganna see them between eem… basically between other different organisms as well. So please know them be able to read them. There is one other problem we notice is that you people can't read things. If now you have done this before when you come to this level suddenly that prior knowledge is gone. Okay we need to work on this guys. And as I said already we are three weeks away from prelims. And there is a huge amount of work that needs to be done. Are there any questions?

L2: Man are we gonna do this in class?

T: We will be looking at them in class. They gonna come up in various things from now on especially we look at Darwin's work as well. You gonna look at Darwin's finches for example and you gonna see how they differ from island to island.

L2: Will this be in the cycle test?

T: Yes!

L2: Eish

T: I'm gonna switch of this off.

L2: Why?

T: Cause I' done with it.

L2: Mam… [Inaudible]

T: Never mind what? You know my question is done. I wanna show you quickly aah… video clip… the sound is not that great okay, but if you follow the diagrams or pictures they will actually show you one organism and a way it's adapting, in other words the evolutionary process is taking place. Okay here we go there some of the slides I'm gonna go through you gonna see some cladograms and phylogenetic trees. Okay we are going to look at the two guys at the bottom especially de Lamarck and Charles Darwin himself okay we going to later on look at the scientific theory. I'm gonna to do that now, I'm gonna do that once I start Charles Darwin's work okay. So I'm not going…now I have to go three photos, okay now we gonna go…no I don't want those ones, I want the ones on the memory stick. Here we go slide show…sorry here we go. Right next one what I just spoke about, the breaking of the continents okay of the Pangea into different continents, continental drift

L2: Ah mam what's up?

T: It's now on slide show DNA sequencing right differences

L3: How is it mam?

T: Then I have to keep on changing it, okay… okay this what we have just looked at. Comparative anatomy. Is this homologous or analogous?

Ls: Homologous

T: Homologous, okay what is this?

L: [Chorus]

T: [Inaudible] Please hurry up guys…that one thing in your textbook…coelom…coelom your cartilaginous fishies… the bones are not true bones its cartilage. Okay you done?

Ls: Yes

T: What is this now? What is it?

Ls: Cladogram

T: Phylogenetic tree. Isn't it a phylogenetic tree?

Ls: Yes

L1: Is it the same?

T: They more or less the same, they almost similar. Guys does this one show you now? Okay, it's not just a mammal, I will show you it's not just mammal. It shows you from here that all animals are gonna have the spinal cord, notochord beginning first development. You have the spi…you have the formation. When you actually at the embryonic photograph we see actually the indentation, you see the space where the brain is actually gonna form. We call that now, and it starts from the notochord. In other words it forms the spinal cord. Okay your relationships is your chordates, okay if…what does chordate mean?

L1: Spinal cord

T: Okay all these form the spinal cords, now the vertebral column is the first thing. As they actually go up here we still don't have eeh…limbs. The fishes were the first group to start with the spinal cord. Then as the initial process goes on between fish and amphibians we start getting four limbs so here is your first or your second point. Okay, amphibians have for limbs. Guys, so they start developing and their eggs are [Not clear] they lay eggs in water that are jelly less, it not a proper egg with a shell and stuff it have a jelly like [Not clear]. Okay so now what's gonna happen if more relationships aah…evolution taking place? We now gonna get the amniotic egg, reptiles lay eggs with a [In] casing birds lay eggs with a calcium casing, alright calcium! The egg shell is basically calcium. Okay so it doesn't have an amniotic eggs and as goes alright we don't lay eggs but we have eggs, we have sperm cells. And as it goes on from the reptiles came to the skin the change is happening and you gonna go to mammals which of cause is now your higher order organisms the more complex. You have [Not clear]… what's the difference here? From this point on, you feed your offspring [Not clear]…but then other animals don't feed their offspring. The birds could be put in here, they could have put birds here as well. Reptiles don't feed their offspring.

L2: What happens mam?

T: They actually capable of feeding themselves once they hatch, okay are they precocial or altricial?

Ls: Precocial

T: Aright they are they can feed themselves. All these organisms here don't feed their organism. The offspring are precocial, they actually need two versions of the parents. Once the tadpole is in there water they hatch from the eggs they feel what's in the water larvae, algae whatever the case may be. They would go through meta… metamorphic processes get their limbs then they leave [Inaudible]…they don't see their parents ever again. [Inaudible] remember when we did that, large numbers of eggs okay. Crocodile, reptiles' large numbers of eggs, humans?

L2: One egg or two or three or four or five or six…

Ls: [Laughter]

T: Our average is one

Ls: [Laughter]

T: It's usually just one and sometimes two

L2: Mam how do you get six kids?

L3: No way!

L2: There is…

T: There is artif…that's actually people are being super ovulated.

L2: Six mam?

L3: How do you fit six babies in the…?

T: They are very tiny…but we… [Inadible]

L2: So mam do they like come like premature or like..?

T: Yes they are very tiny, but we are not doing that anymore guys, we done with reproduction. Right lets go to the next one, see now it doesn't wanna run anymore, okay that one, we gonna start there soon, looking at the T. Okay Cradle of Humankind, we gonna look here as well, I wanted to go here but time is…time is on us we can't go.

L2: Oh wena [isiZulu word for you]

T: Can't. Okay again we not gonna go through all this again.

L3: When do we finish the syllabus?

T: Okay, syllabus in the next two weeks.

L3: Yes then we can go.

T: Alright, I'm gonna go through all of them again, some of them we are gonna do as we go through them. Short video clip

L2: Yes mam let go

L3: Yes

T: What?

Ls: [Laughter]

T: You guys think life is easy.

Ls: [Noise]

[Intercom interruption]

Ls: [Noise]

T: I'm just looking for that video clip quickly…I don't know if I have taken it out. Okay guys I may have deleted it.

L6: Man are we going to have an SBA task for life sciences this term?

T: Yes, next week.

Ls: [Noise]

T: Guys unfortunately I don't know what I did with that video, I had it I saw it in the week when I was actually looking at it.

L2: [Inaudible Tshamani]

T: Eem… [Not clear]… evolution through so many mi…MYAs, millions of years where they take on organism and show you all the changes that occurs. So all the adaptations and it comes right abou…just about to modern day. Remember this how it they thought of it as a theory. A proposed or postulated theory of that organism took place. Are they any questions so far on the work? Nothing! I thought I had it, I don't know what I did with it.

L2: Its fine mam

T: It's not! Because I want it now.

Ls: [Noise]

T: Okay guys I need to carry on I don't know I have done with it, I have to find it, I might have to re-download it. I will show it to you in next week. Let's actually start with…excuse me… excuse me…

L3: Shhhhhh

T: We start today with Darwin and Lamarck.

L3: Darwin and..?

T: Lamarck

T: Okay…

L3: Shhhh…shhhhh

T: Okay, Charles Darwin grandson of E…Erasmus Darwin

L2: Hee!

T: Is Erasmus Darwin's grandson, Charles Darwin. Okay what basically happened that Erasmus Darwin was very involved in looking at changes in nature and his grandson Charles Darwin took over when he died

L2: She…

T: and some of the theories we still use today is based on Darwin works because he was so meticulous same a Mendel very meticulous. You know… he actually eem…there is a movie called at… I think it's the commando that basically deals with Darwin's life on the Galapagos Island. But he was basically almost crucified because of his views. Some ar…artist predicted him as a human with a monkey's body, the human face with a monkey's body because he stated common ancestor. Church, everybody was on him. Okay, and he was basically thrown out from church because in those days church ruled. Okay, they ruled and because of his theories they threw him out it never stopped him from doing his work. Because it came out that a lot of things that he stated is actually true about what we a…see today. The changes that's happened over thousands of years and where science stands today. Because basically it' a scientific inquiry okay it is a science it's not just someone who's trying to be funny or thinks its science. Even though he didn't have a doctorate he was a scientist because of his interest. [Whispering] In actual fact I'm gonna go to… right, okay some of the things we gonna go through again, some terms are gonna come that are expect you to know…come now. Right here we go what is the difference between a hypothesis and a theory because we not going to use Charles Darwin's theories?

L2: We gonna use what?

T: Okay, but what is a hypothesis? You actually have been taught a hypothesis since primary school

Ls: [Chorus]

T: But some of you still don't know, you still write it down, when you are asked to give a hypothesis you give us a question. A hypothesis is not a question okay, it's a testable statement. It's never a question. And basing on the statement you would either say it is accepted or rejected. It's never false and I have repeated that since grade 11. Hypothesis is never false, it's either accepted or rejected or true or not true for whatever you are resting. A theory on the other hand okay, is a substantiated explanation of some aspect and it basically incorporate some evidence as well okay. If you look at the example I give you about the egocentric theory. The sun is at the center of the universe and the planets revolve around it. Do we know that we turn around the sun?

Ls: Yes

T: Who tells us that?

L2: What mam? Teacher

T: Teacher?

L3: Day and night

T: Day and night yes. But how do we know that we revolve around the sun

L2: Seasons

T: Seasons

L2: Thank you

T: Okay, so e…people please you have to be able differentiate between…between a statements now. If you don't know what a hypothesis is, it is a statement. Okay a theory is based on some evidence and you then actually now give us theory saying that this could have happened whatever the case maybe. Okay I'm not gonna go through these definitions again. Okay we know about evolution now, we have done all of that. Here we go, this is where I want to go. Okay, you can actually see how small Charles Darwin was when his grandfather passed it was still in the morning. The two that we gonna work with are these two. These I'm gonna mention…some of them I'm just gonna mentioned because actually there was some controversy between the two of them. They were not actually good friends at the end.

L2: Why?

T: I will talk about it when I get to there, I'm not gonna jump the gun now. We will look at Jean Baptiste Lamarck and Charles Darwin. Now, Lamarck basically gave his two theories, use and disuse and inheritance of modified characteristic. We will look at why those theories are not accepted.

[Intercom interruption]

T: Okay Charles Darwin had to say to Lamarck ehe-ehe change are not rapid like Lamarck said they are actually gradual process and is based on the environment. So organisms will actually change or adapt to the environment. Okay, those are two important ones that we gonna do extensively. Okay the two laws, the law of use and disuse and the law of inheritance. I'm gonna show you a diagram how he state organisms in this case the giraffe. First of all let's quickly use what he state here. [Reading] use and disuse is change in the environment create new needs that mod…cause organisms to modify their existing organs. There is one point in here that's correct anyone wanna tell me that point?

L2: Changes in the environment.

T: That the only Part of this whole theory that is correct. Because what he basically states is that aah… organisms say for example, [Raising voice] I don't need this hand

L2: Why?

T: Eventually okay, because I don't need it will disintegrate. It doesn't make sense, does it?

L1: No

T: Okay, and he basically stated in this one giraffe stretching their necks, you gonna see that just now, and because they stretched their necks, they eventually got long necks. Okay his next one acquired characteristics. Okay modification of an organism's acquired during its life time, okay so whatever you acquire, if you have a wound growing on your fore head, it can be passed onto your offspring.

Ls: Hmmm…

T: That's what it states, okay that what he basically states. Right, how did he now explain how giraffes got their long necks? Okay true, all giraffes could have had short necks, they stretch their necks so they could reach

L2: The trees

T: Okay, because they stretching their necks, the necks are going longer and now their offspring is gonna have the long necks. Does it make sense?

Ls; No

T: Don't tell me it did. How do you think Darwin is gonna explain this?

L2: Genetics

T: But genetics didn't exist, what do we say? No, come think…if you look at this now how do you think Charles Darwin explained the process of how giraffes got their long necks? Okay, basically he stated that some giraffes had longer necks than others okay. Those with longer necks could reach and feed. Those with the shorter necks could have died.

Ls: Hmmm…

T: So those with the longer necks or because they now be breeding they mating, they having babies and because their parents have long necks they live, genetics plays a big role. You see how simple it is, very simple hey. What about snakes? Why do we actually say snakes [Inaudible] …

L2: [Inaudible]

Ls: [Laughing]

T: No they don't! Guys let's keep religion out of this? Alright, right at the end we will deal with the other facts about how things happened on earth. Right now let's keep religion out. How would say a snake came about [Inaudible]…if you use Lamarck's first law?

L2: Lamarck would they didn't use their legs so they degenerated

T: Basically correct!

L3: Wow!

L2: Uya phapha [Zulu phrase for being forward]

T: What about what Darwin stated?

Ls: [Noise]

L1: Shhhh

T: Guys, what would Darwin stated if he looked at this

L2: [Unclear]

T: Is it? Right, I'm gonna show Darwin now… now, but first of all, I'm gonna give you reasons why Lamarck's theories are not accepted. Then we go to say what he said about Darwin's theory is accepted okay. Basically acquired characteristics are not inherited. They are not in the DNA okay and he believed internal drive causes organisms to change [Inaudible] acquired characteristics are not inherited, acquired doesn't mean it's in the DNA. You can acquire a skill…that skill is not in the DNA it's a learned behavior, okay. [Inaudible]… okay, I wanna change quickly let me change, it doesn't work that way anymore, okay. And of cause can imagine an animal's internal drive saying I wanna change. And please remember what we said before, let me just reiterate on that. It's not an individual that change it a population. Alright let's quickly look at Darwin, okay where is Darwin thing about the…it's some of his things based on… its quite interesting when look at what was observed about his theories that we are using today still [Clearing throat]

L2: Mam

T: Yes. Come I wanna go to Darwin's story about the giraffe's long necks. Okay, where I basically mentioned about the giraffe survivor as a result of natural selection those with longer neck will obviously survive okay. [Bell rings]

Appendix 8C: Mrs B's lesson 3 transcript (single-45 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: Come we were busy with this. This is quickly recap again. Eeh… Lamarck's two theories for use and disuse. Basically stated if an organ is not used it will degenerate remember that.

L1: Ehem

T: And acquired characteristic, he basically states that if you leave some characteristic or acquired skill it will be immediately be given to your offspring. And we know that is impossible. It's not, can't do it. Why are people so late? I'm trying to get work done for your cycle test, then we looked at his giraffes. He basically said that giraffes with short necks as we mentioned, the necks became longer…acquired [Coughing] excuse me this characteristic and now will pass it to the offspring. Sounds too good to be true isn't it? Okay said I stretch my therefore it longer [Inaudible]… the lessons have started sit on the floor. Okay same applies to the snakes because snakes don't need legs [Inaudible]…use and disuse. Okay we gonna look at why his theory was disregarded. Okay we know that acquired characteristics cannot be inherited, okay and the of course he had this whole idea that organisms can choose if they want to change or not, the organism chooses but we know that evolution takes place not for organisms but for the population. Okay let's quickly look before we go how Charles Darwin will do this, a quick background about his theory. Okay this theory was based on the following let me just call them up okay here we go. That organisms, variation you already know about genetics and variation what determines in genetics variation? Think about your punnet square, think about meiosis. How do we get genetic variation in offspring? Gift give an answer? I'm busy teaching I have a cycle test [Inaudible]…gift my last question how do we get genetic variation in my offspring, you don't look the same with your brothers and sisters? Okay how did you get the genetic variation?

L2: Crossing over

T: Crossing over, what else, what else in meiosis results in variation?

Ls: Random Independent assortment

T: Random independent assortment. Great! Okay and off course now comes his little eeh… theory survival of the fittest. Of a large number of the offspring only a few will survive, large number of offspring only a few will survive. Not everyone survive, that is actually to say the best adapted will survive, the other ones will die. The last matter is basically that survival that we talking about it is what is called natural selection. Guys best fitted do survive member we talking about populations… guys, not individuals. Okay and his theory of evolution by natural selection which we spoke about we talked about last time completion. Offspring are gonna complete for resources

Ls: [Laughter]

T: What's so funny there? Survival we spoke about, genetics I spoke about and of cause what is natural selection? Organisms with the most beneficial traits will reproduce. In other words they are the survivors. And those traits will be passed on to the rest of the population. Okay now have been about natural selection from generations to generations. People [Inaudible]…okay nice exam question to compare I can give a question on elephants trunks some elephants have long trunks some elephants have a short trunks. What is Lamarck's theory on elephant's trunks and what is Darwin's theory on the elephant's trunks. Similar sort of thing, are you okay? I first where is the dis…oh okay this is not unfortunately, okay here it is…I don't have a diagram, I'm not gonna put up some diagram. How did Lamarck or Darwin explain the long necks in giraffes? Okay [Inaudible]… for genetic variation some giraffes had longer necks than others. Remember trees can grow quite big as the environment changes we can have competition and those with shorter necks won't be able to feed, why? In an environment the trees are growing they don't stay short. Now giraffes [Inaudible]…just take not they can't graze they are browsers they bowsers not grazers if you [Inaudible]…you can't drink water they had to stretch their legs to get under water.

Ls: [Laughter]

T: Okay eem…basically what he is trying saying is that as the environment changes those with longer necks are surviving because they are feeding and those with shorter necks are dying out. That is natural selection. It's a natural phenomenon occurring. We can take this into our own lives now we go back to 70, 80, 90 years ago, premature babies they don…also survive if your baby were born very early would they survive?

L2: No

T: Okay what did we do? They have artificial selection, start using incubators. [Inaudible] what did we start doing now? Artificial selection. We have an incubator, we put into incubator, immunize and [Inaudible] government yes of cause cheaper that private hospitals. You can actually see we are taking natural selection…

[Intercom interruption]

T: Okay now we already know the genotype for long necks is in the genes obviously that's going to be given to the offspring. Guys you [Inaudible] natural selection you know Lamarck's theory, use and disuse and inheritance of acquired characteristics [Inaudible]…you compare the two, guys where is Ruth? [Not her real name].

Ls: She was running

T: And you guys you need to think about and I want you to think about to compare Darwin's theory from Lamarck's theory. Who has the actual theory that mostly can describe natural selection?

L2: Darwin

T: Darwin, how do we know that? Quickly have a look at this. Okay, first of all he says there are variations from the offspring. Right Individual need to change Darwin says ahaha… [Inaudible]… variation okay individuals want to change.

L2: No

T: [Inaudible]… adaptation cause… adaptation to the environment okay, but we say natural…natural selection for Darwin to they survive the environment upon which it's best suited for. Okay, we actually see mistakes, Lamarck individuals change, Darwin's it can't be individuals. It's got to be a population. Within a population [Inaudible]… [Coughing] and basically the last point changes brought about by the environment are inherited from parents to offspring. Thought it's important for you should know this because it can be an exam question. To explain the differences between Darwin and Lamarck's theories. It very important that you understand the differences between the theories. Right you are not chatting you are quiet. You are given an opportunity to copy this, it is very important. Okay while do we actually…while are waiting for others to eeh…complete, think about this…what source of variation can we get in populations? We already know about crossing over, we know about random assortment what else can contribute to variation, think about that… [Silence] are you done? Have you ever thought about sperm x going to fertilize ovum x? Is it gonna happen? No it is chance or random as well. It's not say that every sperm is going to fertilize an egg, it's by chance. What about mutations? Now think about if we actually have related individuals breeding would we have variation. That's what human population actually do. You don't marry your brother or uncle or your cousin. You actually use an unrelated person. Outbreeding, bigger genetic variation. You people you gotta…I'm trying to set your cycle test and this is all in the cycle test. And you do know your cycle test is on Tuesday next week. It will plant mechanisms, so all the hormones, it will be homeostasis and of cause this first part of genetic aah…of evolution eeh…evidence and natural selection and I'm not even done with natural selection yet. Come people can I change now? Okay basically, here is your reasons or your sources for variation in populations, we already know about meiosis, here we talk about chance and random fertilization. Guys we have sexual reproduction, mutation and outbreeding or gene flow. Okay, you don't have not…you don't have to write this down. Right [Clearing throat] Now we gonna look at several example of natural selection. One of them is Darwin finches of the Galapagos Islands. First all he thought it was a common ancestor, but in this case it was the middle one seed-eating, but somehow [Inaudible]…but the finches start changing their beak shapes. Some of them would eat butter and fruit you can see they have a larg… much bigger beak. Then the [Inaudible]…insects and leaves you can see there is a big differentiation in the beaks if one cross to the other side. You can see they are all related. However, natural selection took place. Those one on the specific Islands ahaa…having traits to survive. Actually, [Inaudible] Why? The beak is too big to fit into the wood on the tree trunk. Okay, so you ganna imagine…sorry…

L2: [Inaudible]

T: Nectar, the long ones is nectar and also digging out insect from tree trunks usually [Inaudible]…the very long one that's nectar the other one is slightly bigger you see the top one slightly thicker that will be to try get insects out of trunks. Okay that's basically your first example of natural selection in the Galapagos Island. Let me just [Inaudible]…here is a few photographs okay for different finches. And remember this happened all the Islands, okay there are quite a few eeh… if I'm not mistaken there is something like over sixty smaller islands. The next on is actually an exam question, this was a question in three years ago. It's also natural selection [Referring to image on PowerPoint]. We actually have a cacti lot, we have some with deep roots and some with shallow roots. As time went on okay, we are now using Darwin's theory, those ones with shallow roots could not obtain water in the dry seasons they died. Remember goes down deep in the ground. Those with the longer roots managed to get water they give off offspring with longer roots. It's not this characteristic of long roots but its natural selection. Than now we have already talked about vestigial organs but I'm gonna show you this. This is actually in the snail and in the whale…now come sit down…right everyone we start with this we looked at evidence remember in the whale we get the pelvis and the femur. Where is your femur? Right okay [Inaudible] that suggests that whales were land living with us before. Similarly [Inaudible]…in the snakes again pelvis and the femur, pelvis and the femur. Okay it could be what how would de Lamarck explained why snakes don't have legs and why snakes don't have legs. May be the snakes environment changed so much that it was easy if it moved on its belly. So it was easier to move on the belly because the environment allowed. Therefore those organisms with shorter necks survived [Inaudible]... Another exam question, how would eeh… Darwin explain how tortoises eeh…were different on the Isla… we talking about speciation right each one of these is different species now they cannot longer interbreed? Okay so its continental drift, geographical that has occurred…

[Bell rings]

T: In this case you use continental drift…we carry on, I don't see you tomorrow I see you on Friday.

Appendix 9: Classroom transcripts for Mrs C of School 2

Appendix 9A: Mrs C's lesson 1 transcript (single- 45 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: She has come to see what we are doing in terms eem… the theories of evolution because they know that it was quite a long time it was introduced in our syllabus some sort of verification. So that is the theory of evolution where yesterday people, we have explained the biological evidence of evolution. I have explained to you that before we can say that eem…something is a theory we must do emm… hypothesis testing. That's why the theory of Charles Darwin was accepted by many because of eem… it was based eem…on hypothesis testing, it was based on laws, it was also have some eem…facts. So that's why his theory of evolution was approved. So the other thing we have done yesterday remember I have explained to you the eem…the divergent and convergent eem…evolution, the homologous structures and analogous structures to say that eem… if we have eee…these organisms that are from the common ancestors eee…having eee…similar characteristics they will be referred to as what eee…the divergent eee…evolution whereby I gave you the example of the fore limbs of bats, eee…the fore limbs of eem… horse, of the monkey, of the seal and of the mole to say that eee…. when we look at those fore limbs of different animals eee… they are from a common ancestors but the problem is that those fore limbs perform various eee... functions for example eee…ul…the fore limbs of the horse it can be therefore for running. We look at their ulnas and radius we found that all of them they are from eee…common ancestors. And then eee…homologous structure are similar to divergent eee…evolution where we are saying that they have what eee…similar characteristics but performing different the functions. So we are continuing [unclear]…ee…origin about ideas about origin, your textbook in front of you , your study guide in front of you… origins about origins. Origins of ideas about eee…origins.

L1: 196

L2: Yooh…

L3: Sten [Not his real name]

T: So we have people 12 key 1[Not the real name] we have eee…the two scientists here, eee… who came up with eee…this story of evolution, but before that, we have to understand that em…these were not ee…the only two ee…scientists who came with the theory of evolution. We have people eee…like Wallace who came up with the theory of evolution, but now for our syllabus they use only ee… Jean Baptista de Lamarck and also

Charles Darwin and the reason for them eee…to use eem… these two people eee…Charles Darwin and Baptista ee…de Lamarck, is that eee...because de Lamarck, his theory of evolution it was not eee…approved eee… Sten [Not his real name] …because you find that there was insufficient ee…details and they use that as a comparison looking at ee…what Charles Darwin is saying about this ee… theory of evolution based on natural ee…selection. Remember at the beginning I said that Lamarck was someone who was saying that eem…if ee…any species or organism does not want to use a certain organ that organ will end up doing what…disappearing. And then ee…we also used the example of eee…the snakes, we used the example of the giraffe to say that the giraffes used to have ee…short necks, ancient giraffes used to have eee…short necks but now because they wanted to eat high up in the ee…trees and then their necks becomes eee… long because they are used ee…each and every time. So that is the first law of Jean de Lamarck that is the law of use and disuse. In your textbook that is page 197. Eee… Lamarckism, is the idea that organism can pass ee…characteristics. we said that ee…in the evidence of ee…evolution, we have the fossil record neh…ee… whereby scientists are using radiometric dating to look at the age and also ee…the age of the fossil and the… the dating of the rocks. And then these fossils were found where ee… in those sedimentary rocks and the biogeography, e…also that eem…population in mainland 1 and mainland 2 where you find that ee… they are not going to do what…to interbreed because ee…Charles Darwin is saying that ee…more offspring they are going to be produced but those ones with ee…favourable characteristics will survive and then embryology, that is another way that is evidence on eem…evolution that they were looking at the embryos of ee…different organisms. And evidence from molecular biology and genetics. So I have said to you yesterday that there will always be variation in a population and what brings about ee… variation? What brings about variation Tshepo [Not his real name]? [Silence] In meiosis we were talking about what… the crossing over neh…that will bring about what…ee…variation to the organisms, and then, passing of characteristics isn't it? So when we are passing ee…our characteristics ee… from parents to the offspring, so we end up seeing what…that ee…variation so here in the evidence of molecular biology and genetics we have what… the identical splatter of DNA, of which all of us we know that structure of DNA we know the protein synthesis and similar proteins and also the sequence of the ee…the genes. That again is used as evidence of …evolution. So going back ee… to Lamarckism who is saying the organism can pass on characteristics that is acquired during its life time to its offspring. So if we have these ee…certain characteristics, they will ee…never end up on us but will do what…will ee…pass those to our children. And it is named after a French biologist Jean Baptista de Lamarck. Eem...Sten [Not his real name] can you read the first paragraph page 197 eem…Lamarckism

L4: [Reading] Lamarckism is the idea that organisms can pass characteristics that it acquire during its life time to its offspring. It is named after the French Biologist Jean Baptista de Lamarck born in 1744 to 1829. He incorporated the idea of inheritance of acquired characteristics to explain how organisms became complex over time

T: eem…Lamarckism is the idea that organisms can pass characteristics that it's acquire during its life time to its offspring and it's named after the French Biologist Jean Baptista de Lamarck born in 1744 to 1829. Who incorporated the idea of inheritance of acquired characteristics to explain how organisms became complex over a time. So he then introduces [Emphasing] people! This what you are going to get in the exam. The two laws that ee…de Lamarck came up with. The two laws that are very much important that aah…you have to know. When you come tomorrow and I ask you about ee…these laws of ee…de Lamarck, you must be able ee…to answer that. So Jean Baptista de Lamarck tried to explain. Remember that ee…as I have said earlier on that before we can say that eem…[Emphisising] this is a theory neh…we need to do what…to go…to do that hypothesis testing. Do you still remember?

Ls: Yes mam

T: What is the hypothesis testing? Hypothesis testing? I'm not a priest. Yes [referring to a learner]. Hypothesis testing?

L5: It a proposed solution to a problem.

T: A proposed ee…solution to a problem. I give example of learners at school B [Not real name]. We cannot say that ee…okay all learners at school B [Not real name], they are eating food from the tuck shop neh... So it's what… it a hypothesis because ee…we are not sure of what we are saying until it is proven that ee…all learners at school B [not real name] they are eating what...food from the ee…tuckshop. So which means that we have to do what… to validate neh… and to check what… the reliability of the…of our… our investigation. [Writing on the board]. Reliability… and also validity. So if we are saying aah…we want ee…the validity of whatever we are saying …of whatever ee…experiment or the investigation that we are doing, what are we supposed to do there? We are going to keep on using what?

Ls: The same materials

T: The same materials. Very good! And then ee… reliability?

L5: Is to repeat

Ls: We keep on repeating.

T: We keep on repeating neh...so before they can say eee… to Lamarck… thank you! Eeh…Your theory of evolution neh… is not well taken by other scientist is because they found that it lacked information. According Jean Baptista de Lamarck tried to explain how animals change over time by means of what he called the two laws, you know I like these two laws of de Lamarck, the laws of de Lamarck. The first on madam

L6: [Inaudible]

T: The law of use and disuse

Ls: Disuse.

T: The law of use and disuse. What do you understand about this statement? Hee…the law of use and disuse

L6: Like…

T: Ehem

L6: …like mam you like use the most important things in your body and the ones that you don't use will vanish away.

T: In our study guides that's p78, Page 78 Lesedi [Not her real name]

L5: Mam

T: You read that first paragraph for me… a brief history of the theories of evolution.

L5: [Reading] A brief history of the theory of evolution [Noise]

Ls: Shhhh

L5: [Inaudible] the origins of life as well as the reasons for last diversity of living organisms.

T: eehem…continue

L5: Lamarckism, Jean Baptista Larmarck was a French naturist who believe that individual organisms have the ability to change their appearance and that these changes could will also occur in any offspring they produced. Lamarck proposed two laws to explain how these changes cause species to evolve. The law of inher…inhe…hee…

Ls: Inheritance

L5: Inheritance… of acquired characteristics. The characteristics acquired by organism during its lifetime are passed on or inherited by its offspring, for example if a giraffe continually stretches its neck for… to reach leaves at the top of a tree its neck will become longer than the other giraffes in the population. When the giraffes breeds it offspring will also have longer necks than the average giraffe

T: Read that law again

L5: The characteristics acquired by organism during its lifetime are passed on or inherited by its offspring, for example if a giraffe continually stretches its neck to reach leaves at the top of a tree its neck will become longer than the other giraffe…giraffes in that population. When the giraffes breeds it offspring will also have longer necks than the average giraffe.

T: Thank you. That is eeh… his first law. [Writing on the board] The law of inheritance of acquired characteristics. The law of inheritance of [Noise] acquired eeh…chara…cteristics. So we have the two laws. He gave us an example of what…the giraffe and he is saying that these characteristics will be passed to the… offspring, the characteristics people will be passed to the offspring. So if this ee…giraffe is ee…going to breed we are going to see ee… the young ones with what…ee…long necks. That is the law of inheritance of acquired characteristics. People do not forget this… we are writing, our prelims are around the corner. So if you find this question just think of the giraffe neh…just think of the passing of the characteristics. If you are asked about what…eeh… the laws of Jean Baptista ee…Lamarck, that is Lamarckism, and the second law of Jean Baptiste is the law of use and disuse. Eeh… the parts of the body that are used regularly the parts of the body that are used eeh…regularly will become eeh…better developed while the parts which are not used will shrink and may disappear altogether in the offspring. So Lamarck use the fact that eeh…snake no longer have legs, which means that eeh…earlier in those millions years ago neh…the snake used to have legs according to eeh…Jean eeh…Baptista eeh…Lamarck. So he is saying that because the snakes didn't want to use eeh…eeh…those legs then they end up eeh… doing what…eeh…disappearing. So Lamarck's two laws have been rejected. You understand what I was saying earlier on that emm… other scientist they find that eeh… because there were no eeh…sufficient facts. Remember we are talking about facts, we are talking about generalisations neh… we are talking about eeh…the hypothesis testing that have to be done, before you can say that eeh…this is what… a theory. So his theory of evolution was rejected by…by [Unclear] because there is no sufficient evidence.

L6: Evidence

T: You understand!

L6: Yes

T: Just like someone who has committed crime neh…and you know that you… I have committed this crime, but as long as the law do not have what?

L6: Evidence

T: Eeh…evidence there is no way you can be where… at Sun City, only if they have what…evidence. So here eeh…Jean Baptista de Lamarck, eeh…his eeh…theory of evolution eeh…it was rejected because there was no eeh…evidence, the evidence was insufficient, let me just put it like that. The evidence was so insufficient that they cannot really accept his eeh… theory of evolution. I mean we are just saying [Singing] the snakes used to have legs the giraffes wanted to eat high in tree and then those characteristics and then started to develop and eeh…the long neck then when they breed they start to have what… and then the long… necks. So his explanations are incorrect, are we still together John? [Not his real name].

Ls: Yes

T: So Lamarck is included in the study of evolution, because … [Pointing to a learner] you read for me.

L7: [Reading] He was meticulous in collecting [Inaudible] gathering information and analysing his data about many organisms. His method of scientific inquiry was excellent, more scientific theories develop and change over time as more evidence becomes available and better investigative technologies are developed. During that time Lamarck's explanations made sense. Scientist need to know that ideas also evolve. Reasons eeh…for the rejection of Lamarck's theory of evolution, there is no evidence to show that acquired characteristics are inherited, there is no evidence that structures used more often become more developed, nature allows organism to change and not because organisms want to change, as suggested by Lamarck…Lamarck.

T: okay thank you. Reason for rejection, eeh…there is no evidence that eeh…acquired characteristics are inherited, there is no evidence that eeh…structures used more often eeh… more involved. Nature allows organisms to change neh…so that eeh…why Charles Darwin, there is history of evolution on natural selection, natural eeh…selection. So what is important for the examination people is eeh…the two laws of eeh…de Lamarck. The law of use and disuse. So whenever you are asked this question, eeh…where you have to describe neh… eeh…the two laws of de eeh…Jean Baptista de Lamarck do not forget of it that de Lamarck based his theory of evolution on the law of use and disuse, inheritance of acquired eeh…characteristics. The law of the inheritance of eeh…acquired characteristics that so is very…very much important. So in your study guide, in your textbook you write NB! The two laws… the law of use and disuse. And the law of inheritance of acquired characteristics. So that was all about de Lamarck. Then we have Charles Darwin who travelled all over using his eeh…Beagle page 198. [Noise] Darwinism page 180…198 eeh…who explain eeh…his theory of evolution on natural selection [Noise continues] so why did they accept…I want you attention John [Not his real man]?

Ls: Shhhhh…

T: Why his theory of evolution was accepted… by many scientists? It was… yes [Referring to a learner]

L8: It was because he had evidence…

L6: Have evidence

T: He have what? The evidence. So his theory of evolution was supported by what?

Ls: Evidence

T: A lot of evidence neh... and then eeh…there was facts, generalisations and that his theory of evolution was accepted by many scientists so that is why today we are studying his theory by natural eeh…selection. You know I like this man because you can't be in class and think that eeh…everything is going to come to you neh... You are a learner go to the library neh…do research of what you are studying. So you cannot just be sitting in class [Bell rings] and say I'm waiting for mam she will help me to pass. No! So Charles Darwin also he was going all over nee… using the HMS Beagle, the HMS eeh… Beagle you find this in eeh… multiple type eeh…question neh…multiple type question you will find this HMS eeh…Beagle that Charles Darwin was using. So you go and read eeh…that session and tomorrow when you come then we continue, thank you very much.

Appendix 9B: Mr C lesson 2 transcript (single- 45 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: Okay eeh… remember that I'm not using the same eeh…intervention it's not the same when it comes to all the four classes you understand. So the other class I have to keep on repeating and repeating and repeating and repeating. So what I want to know from you, you are going to…define what you understand by divergent evolution, we have done this eeh…yesterday, eeh…the convergent eeh…evolution, the homologous structures that we talked about them yesterday, the analogous structures and then you tell me if someone can say eeh…define the word eeh…population because I discovered something this morning with the 12 key 2 [Not real name]. That sometimes you keep on talking there and then you find that you did not eeh…put everything in your cerebrum. So population, species, the fact of evolution here you just quickly only two minutes. If you do not know the answer you going to need [Singing] divergent evolution, convergent evolution, homologous…yes.

[Learners writing definitions]

T: Alright eeh…divergent evolution, convergent, homologous, analogous, population, please its [Inaudible]… [Silence] Lesego [Not real name] if it's raining it's not the end of the world you still come to school. Alright let's start with the first one…

L1: Eem mam I'm not done writing.

T: Eeh…divergent evolution…divergent evolution…yes ehhe…

L2: Occurs when different species have common ancestor and have adapted to their particular characteristics to suit various ecological niches.

T: Divergent evolution

L2: [Inaudible]

T: Divergent evolution…Yes… Paballo I see you have written something already

L3: [Inaudible]

T: Aah… hehe…yes…

L4: [Inaudible]

T: Yes eeh…Caleb [Inaudible] you are not writing anything, yes Trust…who must write that for you? Take out your textbook, take out your textbook. Eeh… divergent eeh…evolution as she was saying now that eeh…divergent evolution we have new species that eeh… that develop from a common ancestor… [Principal of the school enters] mam I'm coming neh…

[Teacher goes out]

T: Similar eeh…organs eeh…performing what… various [Intercom interrupts] eeh…functions for fore limbs of the bird and of the mole neh…they are performing what… different eeh…functions and then convergent evolution…

Ls: They don't share a common ancestor

T: They don't share what? A common ancestor neh… and then homologous structures…

L5: Homologous structures

L6: Traits of a common origin and share the same function

T: Yes…and then

L5: Its different function

T: Different function. Homologous is nearly the same as what… as the divergent evolution because we have similar structures and then performing what…eeh…the different function. And then analogous, analogous…

Ls: Different structures with Similar function

T: Eeh different structures with eeh… similar eeh… functions

L: What's an example of..?

T: And then here we are given the eeh…the wings, wings of the insect, of the birds. And then population, population people I'm not addressing a choir here you rais up your hand if you want to say your answer. Tatenda [Not his real name]

L: Aah… it's a group of organisms living in the same habitat, same habitat, at the time able to interbreed and produce a fertile offspring.

T: We don't have at the same, same there neh...Same species found in the…eeh…occupying the same area that can be able to do what interbreed. You know specifically that eeh… those organisms must do what…must occupy the same area, the same time and eeh… so same area, same time neh… being able to do what…to produce the…the fertile offspring. So as was saying to you yesterday that eeh…you find in you exam paper whereby eem…they ask you to differentiate eeh… between the species and the eeh…population, the species and population, so we are moving on people. Field of evolution, you still remember them neh…, fossil record, the palaeontologist and then eeh…using eeh…the radiometric dating, we had done this yesterday neh…eeh…embryology we have done that eeh…yesterday… and also comparative eeh…anatomy, evidence from molecular biology and genetics. So aah… we have eeh…these two gentlemen, we have the eeh…two gentlemen here, that I have requested you that you must go and read so that eeh…we must be able eeh…to compare eeh…between eeh…the theories of eh…Lamarcksim and also the theory of eeh…Charles Darwin, you understand. Eeh… the two gentlemen they have come up with the theories of evolution and the unfortunate part is that the theory of Lamarckism was not accepted by many eeh… scientists, because they have realised that his theory of eeh…evolution that is based on the two laws, that is only based on the two laws. Remember when we have eeh… explaining what eeh…the theory is, do you still remember, if they can say you define a theory, what are you going to say aah…right…theory…

L5: A theory

T: Theory?

L5: Is a suggestion or idea that [Inaudible] proven by scientific facts [Inaudible]…

T: Heeee… heemm… hem…hem. Eeh… theory people…can go back to your notes books…you mess up. Michael [Not his real name]…theory

L6: [Reading] Theory a [Inaudible]…explanation that is supported by numerous observation, experiments and scientific evidence.

T: so when we talk about a theory eeh…it's something that is supported by eeh… facts, rules and generalisation neh…and tested eeh… hypothesis. We cannot just come up early in the morning and say that eeh…this is a theory without having what…a concrete evidence. That is why the theory of eeh…Baptista de Lamarck was not accepted because they realised that eeh…there was no sufficient neh…evidence since he based his theory of evolution on the two laws, that is eeh…the law of eeh…acquired inherited acquired characteristics. To say that eeh… the offspring are going to eeh… acquire characteristics form the parents and then law of use and disuse. If an animal or an organism is not using its part of the eeh…body continuously. So that part of the organism is going to do what… to disappear. So there was this kind of argument you understand. But we saw that aah…if I have aah… legs and I decided not to use my legs, so it means that my legs will end up disappearing. So that is what…the law of use and disuse and we then made mention of the giraffe, to say that eeh…the gira…the ancient giraffe aahha… the short neck but because eeh…eeh…the giraffe decided can you imagine the eeh…one that used to eat up high in eeh…trees they start to develop what…the long neck. And that aah…characteristic of long neck then it was passed to where…to the offspring. Eeh page one eh…ninety eeh…seven of our text book eeh…Brendon [Not his real name] can you quickly read for me there.

L2: [Reading] Lamarckism, Lamarckism is the idea that an organism can pass on characteristics that it acquires during its lifetime to its offspring, it is named after the French biologist Jean Baptista de Lamarck who incorporated the idea of inheritance of acquired characteristics to explain how organism become complex over time. Jean Baptista de Lamarck tried to explain how animals changed by means what he called two laws as follows: According to the law of use and disuse organs became modified of adapted according to how frequent they are used. If they were used more frequently they became bigger, stronger or changed so that they could work better. On the other hand, if organs were disused they would be smaller until it ought to disappear.

T: Aah…you know I like this…the law of use and di…disuse. Organs become what… modified. Remember we talk about what…modification, eeh…modification neh.... So modification so he also touched eeh… this word here of organs being what…modified and or adapted according to how frequently neh…eeh…they are used. Organism will be modified, and I mean organs will be modi…fied. And then, how frequently they were used and if they were used more frequently, if they were used more frequently, they will do what…they will become bigger, they will become stronger, or change so that it will works better. They will become stronger and they will become bigger if eeh…they are aah…frequently used. Others will say haaa…wena [isZulu word for you] there is a problem here neh… [Singing] they become bigger, they become stronger.

Ls: [Start debating, all speaking at once]

T: Aah…okay…

L2 The use part of eeh of Lamarck's aah…

T: Can you listen…so he is sharing this with everyone

L2: I think aah…the use part makes sense where the fact that in my situation I use my left hand and since I use it way more it's actually bigger than my right hand or if you look at someone's chest like righ…the hand that you use is actually bigger than the other but then in the part of disuse where it actually disappears becomes aah…fishy if I should say.

Ls: [Noise]

L2: Not disappear as such cause remember didn't we get the example….

T: Aah…anyone…anyone this is becoming so interesting

Ls: [Noise, debating and talking at once]

L4: What happens to you if you have one foot that is bigger than the other one?

T: Can we say that if someone is having two eeh… normal eeh…parents and that it happens that eeh…you are only one with the other leg being eeh…smal…small can we say it's the problem of use and disuse?

Ls: No!

T: Neh…it can be what…eeh…eeh…mutations neh…we cannot basically say that eeh…because you are born with eeh…that kind of deficiency or you are disable and then you say that no, it's because of the law of us and disuse. And then when you disuse that other small leg…

Ls: [Laughter]

L7: Mam, I don't wanna ask a question but I just wanna add on what I think…

T: Yes, mam can als …also assist us.

L7: I think going to the point on coming to one coming bigger than the other, think that that characteristic can be passed because remember what alters your…your genes is the environment right, so if like the environment can alter your genes you can pass the characteristic from generation to generation.

L6: Mam can I comment on that

L7: It's a comment

L6: Mam can I comment on this comment, may I comment on this comment, may I comment on this comment.

T: [Inaudible]

L6: Okay, I agree on the part where the organ becomes stronger and more efficient that's understandable, it's like a muscle reflex if you think of it, but then now here is the problem, you can pass it down genetically, genetic variation comes about from what we did in term one. Remember that random assortment and crossing over and homologous… all that stuff comes into play, that's where genes start changing. I can't just suddenly develop a very strong [Inaudible] and then my child is born with that muscle [Inaudible]…

Ls: [Laughter]

L6: It don't work that way, it do not! It's not part of my gene yet, it's just me as an organism and how I have adapted my physical body but my genes have not altered themselves in any way.

L4: How does…

L7: Now my question how did you develop or did you eeh…inherit those shortness characteristics… how…?

L6: Because it's genetic they have been passed on!

L7: From where?

[Noise]

L6: One mutation, way back up there is someone who had a mutated gene didn't allow me to be tall so I'm short because of that [Inaudible]…

Ls: [Talking at once]

T: [Inaudible]…know my time

L7: You see I will make example with Carl…you see Carl [Not his name] like has a certain body structure which his family does it meant for him to actually grow big like, like everyone in the family has that obviously that means his dad has that. Now if you think that how was…like what was grandfather like that he is no way to change, [Inaudible] now applying to him right now. Do you understand what I mean?

Ls: No [Noise]

L7: He has a different body structure than from everyone…

L4: Yes!

L7: Because o…

L6: Everyone who…in his family

Ls: [Noise]

L7: No even us here like no one…

L6: That doesn't count though…

Ls: [Noise]

L7: Okay in his family the like father has the same structure as the brother, all the boys and him right. So now in his body structure he is kinda like having broad here, like meant to be actually muscular. So now his I'm saying his granddad probably wasn't like that but now his dad had to like change like he had to change…

Ls: [Noise]

L6: [Inaudible]…remember the chromosomes will not be the same me, Thato and Refilwe [Not their real names] will not be the same as my parent Tshepo and Lerato [Not their real names] coming together [Inaudible], so it's totally a different genes…

L7: Not in terms of that, in terms of the environment…

Ls: [Noise]

L4: [Inaudible]… Of course I mean its inside I mean I don't understand.

Ls: [Accountable continues all speaking at once.]

T: [Inaudible] alright law of use and disuse hee…organs became so smaller… [Laughter] yes…

Ls: [Accountable continues]

L4: Mam… [Inaudible] what Jim was saying that eem…when he had asked that question that how did you get shorter isn't it? The fact that it happened to someone out there it means that if let's say you don't use your right hand and I gets shorter. It's not to say that your child is gonna come out is gonna have a short hand, it's gonna develop, it's still there, they have that gene in there. And then it goes on and on until it disappears it doesn't happen right now.

Ls: [Noise, learners speak at once]

T: Alright…alright…alright, eehh…

L6: Mam can I raise one last point?

T: Time…time…time…time…time…time…time…yes aah…people think of the genotype neh… that is the genetic makeup of organisms. Eeh… before we can look at someone, eeh…the phenotype, the physical appearance of someone remember that eh…it's only the genotype that brings about the pheno…eeh…type. And again you must also think of eeh…the variation. You find that by eeh…Peter's [Not real name] family. He can be short but then the other one in the family is tall. So as I have said to you that variation ehh… will always be there in the family. What brings about that variation remember of the crossing over, remember of the eehh…random eeh…assortment neh…in metaphase eeh…eeh…two. So we cannot basically say eeh…look at me like this, big as I am you say that eeh… it's because of evolution. It's because of my genetic makeup. And you find that my children she is only one who is big like me. The other ones they are so [Singing] [Inaudible]…

Ls: [Singing]

T: They are just like Palesa [Not her real name].

Ls: [Noise]

T: So… eeh…Lamarck was just saying this people that eeh…organs that not eeh… frequently eeh…used. So that's why there was this debate to say that we cannot exactly do what eeh… accept this eeh…theory. So

Ls: [Talking]

T: So he is saying ehh…that organs that are frequently eeh…used, they will became eem…stronger neh…and then they will eeh…become eeh… large because they are forever used. So the second characteristic, the second characteristic that is according to his law of inheritance of modified acquired characteristics. Law of inheritance of acquired characteristics. Anyone to read that paragraph for me? Read… [Referring to a learner]

L6: [Reading] The modifications brought about by the frequency of use or disuse were able to be transmitted to their offspring .in other words felt that animals deliberately made changes to become adapted to their environment. These structural changes were then handed down to the next generation. Lamarck gave the following as an example how his theory worked. The long legs of the heron were a result of its effort to stretch and lengthen them in order to survive in a [Not clear]…habitat. The long neck of giraffe came about because it wanted to feed on tree tops where it would have less competition from other herbivores. The legs of the snake disappeared because it did not use them in its gliding movement. Also its body became thin and long to allow it to crawl through narrow spaces. A seed of a meadow plant blown by wind to dry and stormy ground gives rise to a poorly developed plant which is very small and well adapted to drought. Its descendants will all give rise to similarly dwarfed plants and adapted plants.

T: Okay so…aah… alright…eeh…

L: Not in this life

Ls: [Laughter]

T: Let me warn you neh…if you get this eeh…question and you will get the question where you have to explain eeh… these two laws of eeh…use and disuse and the acquired characteristics. Please don't come up with something else

Ls: [Noise]

T: Because they will give you zero you understand. That I am thinking you know, there are people [Bell rings] who just write start the question I think, I don't want to see I think People. No! So we are going to follow what inside the book, we will follow what is inside the book. Eeh…whether for now we believe…eeh people it's still my time, whether for now we believe that eeh the snakes. You know I like the word deliberately, deliberately hee…

Ls: [Noise]

T: let us go back to genetics people neh…phylogenetic trees neh…we don't know the heart of… [Inaudible, noise]

Appendix 9C: Mr C's lesson 3 transcript (single- 45 minutes)

T- Teacher

Ls -Two/more learners

L1/L2- individual learner

T: And then eeh…evidence from palaeontology that is eeh…the fossils eeh… Tshepo [Not his real name] eeh…evidence from comparative anatomy, modification by descendants. Eeh… we are given examples of the fore limbs of different mammals which I said you must master. Eeh… those eeh…four limbs and also the different eeh…functions that they eeh…perform. Trust, Paballo [Not their real names] the mole you must know what they are using their fore limbs for. Eeh… the bat what are they using eeh… their eeh…fore limbs for. The horse the seal and also the eeh…the monkey. Then I also mentioned that eeh… we have eeh… divergent eeh…evolution four limbs of all mammals that arose from the common ancestor…common ancestor, immediately you just see the word divergent or you just see the word eeh…common ancestor think of what… divergent eeh…evolution neh...and then when you come across eeh…the eeh…word eeh…convergent ehh…evolution just think of what…eeh…different… ancestors [Inaudible]…Dee

L1: Yaah… mam

T: Ehh…divergent convergent homologous structures which are eeh…similar and performing different eeh…characteristics. Same, homo means same, homo means what? Same neh…homo and then homologous structures. So these structure are the same but they are performing what? Eeh… different eeh…functions and then the word population and then also the species I was telling the classes since morning to say that eem...there are things as learners you are taking for granted. Remember that you will be writing out of hundred and fifty neh…and then I have said to you that in your paper two eeh... We have what…we have eeh…forty five percent of the question paper that is from eeh… evo…lution. That means to say that in paper two the junk of the questions will be coming from eeh…evolution neeh…so things like population some of you will say [Singing] eee…the examiner will not ask us define eeh…evolution, you find them in the exam, you understand so you have to know these things neh… Thulane [Not his real name]. And then the species again, the difference between population and the species you have to know. And then the [Inaudible] of evolution what…eeeh…we have done this yesterday. The fossils the embryology, looking at the embryos of different animals neh… the embryo of the fish neh… the embryo eeh…of the eeh…chicken, eeh…the fish, the chick and also eeh…the embryo of the human. And I have asked you this question eeh…your June exam. That you must know yourself, before you can be an embryo neh… after fertilisation. We cannot just say you see the development of the embryo, it a sequence development but then [Inaudible] of the comparative embryology eeh…they have used embryos of different vertebrates. So origin of ideas about origin, origins of ideas about eeh…origin…Eeeh origin…origin of ideas about origin…origin of ideas about origin. So we know how eeh…the earth is originated eeh… I want us to forget little bit about that one. Eeh…starting with the ultraviolet light, light and lightning change eeh…these gas if we have time after or when you finish or before you write then we can visit Maropeng. Where they are showing you how ehhh…the start of how eeh…the earth began. Remember I have said that when we are doing evolution I know that you are belonging to various eeh… religion. And then we know that in most cases ehh…religious people they are against evolution. What is important for us is that eh…we are doing it as a… part of our eeh…syllabus neh... Not that eeh… after we have done evolution you go back home you are going to say that madam C [Not her real name] said that eeh… there eeh… Jesus Christ is not in existence.

[Intercom interruption]

T: Eeh…scientists have tried to provide an explanation of how life itself began about three point four eeh…billion years ago. So you ask yourself that question that eeh… how the come up with that eeh… years. So according to this hypothesis, remember what a hypothesis stand for neh…and the earth began as a ball of fire with rocks and burning gas about four point six billion years ago. As it cooled gases were released ehh from inside and these gases formed the earth atmosphere. And then we have the inorganic or the organic molecules such as the proteins, and such a…of…eeh…the fatty acids but most of the time people that's why I don't want to get deeper into that you will never find this in the exam neh...so we need to be eeh…exam orientated. So the ideas of origin about origin. As I want us to speak about two men, I want us to learn about eeh… the two which are very much important that if after you finish your matric and I hope that some of you next year when you go to Wits, eeh…you will be studying Anna you will take that field of evolution too. So you will know better the findings of Charles eeh…Darwin. Isn't that here we are just giving you the basic neh... That his was travelling, he went as far as Galapagos. You know I like this man, he was a traveler. Remember of those finches he discovered at eeh…Galapagos and he was talking about what variation but then EE…de Lamarck was not talking about variation. de Lamarck was talking about what eee…the two laws that is the law of use and disuse to say that eeh… if you are not using this organ frequently that organ will end up doing what…being…eeh…disappearing. Because ehh… you don't like neh… you don't like to use that organ. So but then what I like most is that you can't just say that learners at school B neh…all of them everyday are coming to school late. You understand! There must be what…we have to do that investigation, we must write your names there to see on Thursday or on Wednesday how many of you, until we come up with the eeh…solution to say that okay what can eeh…be done is one, two and three. So with the theories we have the laws, they are supported by the laws neh…they are supported by the facts, they are supported by eeh…the hypothesis testing we keep on doing what…the reliability we forever talking about there is no way Sten you find a life science paper without being asked about the reliability and the validity neh…the independent and dependent variable of the investigation. So say that eeh…this is reliable they were keeping own Charles Darwin and de Lamarck maybe they were keeping on to do their investigation. And the unfortunate part is that de Lamarck

[Interruption]

T: So eeh…we have the two theories of evolution that I have explained, and then one is based on facts not opinion neh…not on opinions we cannot say that theories of evolutions they are based on eeh… opinions. So you are not as eeh…on page 197

Ls: [Interruption, Noise]

T: You are disturbing us. Alright grade 12 Key 2 [Not real name], eheh…Lamarckism neh…Lamarckism you know I like this man don't you like this man, why?

Ls: [Noise]

T: Eeh… alright Lamarckism people your textbook…anyone with a textbook. Eeh…can we just read about this man.

L2: mam you have a crush on the man…

T: Hee…

L2: You have a crush on this man

T: How can I have a crush on a man are you sick?

Ls: [Laughter]

T: Eeeh…you read, shhhhh…

L3: [Reading] Lamarckism is the idea that an organism can pass characteristics that it acquires during it life time to its offspring. It is named after the French biologist Jean Baptista de Lamarck 19…from 1944 I mean 1744 to 1829. It was inco…it was incorporated…who…who incorporated the idea of inheritance of acquired characteristics to explain how organisms become more adapted over time.

T: Continue

L3: John…Jean Baptista de Lamarck tried to explain how animals change over time by means of what we call…what he called two laws of…two laws as follows according to his law of use and disuse. Eeh…step one; organisms, organs become modified or adapted according to how frequently they we…were used eem 2: If they were used more frequently it become bigger, stronger or changed so that it could work better. Point 3: On other ha…on the other hand if an organism was disused it became smaller until it disappeared.

T: Alright, organs become eeh…modified neh…organs became eeh…modified or adapted according to how frequently eeh…they were used. Organs became eeh…modified that is his first law neh. When they say okay eeh…Baptista de Lamarck tell us if you want us to accept your theory of evolution. Then eeh…which laws or what ee… evidence are you bringing to us to say that eeh…we must accept the…your theory of evolution. So he decided eeh…to have eeh…the two laws. That is the eeh… the law of use and the law of disuse, and also the law of disuse, the law of use and the law of disuse. Thandi [Not her real name] … the laws of use and the law of disuse. Marjory… the law of use and the law of disuse neh… the law of use and disuse. And you leave those blank eeh…space when you are asked… I will kill you. The law of use and disuse. So in a law of use and disuse he is saying that eem…that organs were modified. Remember that we have talked about what modification, so organs were eeh…modified or adapted according to how frequently neh…organs were modified according to how frequently… Mkwanazi [Not his real name] have been used.

L4: Haaa

T: And if they were used more frequently, if they were used more frequently, eeh… it became what…bigger, eeh…stronger or change so that eeh… it could work better. If they were used more frequently it became eeh…bigger and stronger or change so that it could work proper…eeh…better. And on the other hand, if an organ was disused it became stronger until it totally eeh…disappeared. Jane [Not her real name] can you repeat what I have just said now.

L5: Eeh… mam you have just said if organism do not use their organs they will disappear.

T: That chappies you must go and throw it in the bin because it's disturbing you that's why you can't talk…and then aah…

L5: Aaam if an organisms use their structure they become more enlarged then they go…they disappear, if they don't use the structure organically they disappear.

T: And we call that law…

L5: Disuse and use…law of use and disuse.

T: Law of use and disuse. Don't forget this.

L6: It's not true for example we don't use our [Inaudible]…but they are not disappearing.

T: They are not disappearing

Ls: [Noise]

T: Alright eeh…we are all discussing isn't it?

L4: Eem… in terms of the body since they are say that [Inaudible] and it doesn't get used over a period of time and it's gonna disappear according the law of use and disuse how come it doesn't refer to us.

T: Maybe its…may be its occurring we don't know.

Ls: [Laughter]

T: But according to eeh…to…to Lamarck if they are used more frequently will forever see them but if they are not used eeh…frequently they will do what…they will disappear. So that is why I said to you that have eeh…these two men, eeh…Charles Darwin by his theory of natural… remember what Charles Darwin is saying that many offspring are produced, many offsprings will be produced, but only eeh… the one with eem… favourable characteristics will do what…will survive. But then eeh…Jean Baptista de Lamarck is saying that these organisms page 171 I mean 197. It says that in other words Lamarck felt that animals deliberately neh…so those animals that we see eeh… some changes so maybe as … [Intercom interruption]. Alright eeh… Floyd…

L7: What scientific evidence supports Lamarck's theory?

T: So that is why Lamarck's theory neh…it was rejected because they eeh… thought that there was no sufficient evidence to support whatever he came up with that is to say that alright eeh…snakes were having what eeh…legs and they decided not to do what…eeh…not to use eeh… those legs. They were enjoying eeh…what…eeh…crawling so that's why they were so eeh…thin. So they can move so swiftly neh…and then legs do what…disappear, but according to him Jean Baptista de Lamarck eeh…the snakes they have what… legs… at…I don't know

Ls: [Laughter]

T: Yes… [Referring to a learner]

L7: Is snakes and lizards of some sort, are they common ancestors?

T: I don't know [Laughter]

Ls: [Laughter]

T: Hee… [Laughing] are they not all reptiles people? They are all reptiles hee… [Laughter] Hee…so Lamarck, Mandy [Not real name] gave eeh…probable examples of how eeh… the theory went [Inaudible]… so that when we get out of this classroom you don't have to go home and report say that madam C is saying that the snakes were…no it's not me it's eeh… the theory of eeh… Jean Baptista. Eehem…yes…

L: Lamarck gave the following as an example of how his theory works. The long neck of the hero …heroine was result of having to stretch and lengthen them in order to adapt to a changing habitat. The long neck of a giraffe came because it wanted to feed on the tree tops where there would be less competition from other herbivores, the legs of the snakes disappeared because it did not use them in its gliding movement. Also its body became thinner and long to allow it to crow in narrow spaces. A seed of Hawthorne plant blown by [Inaudible] gave rise to a poorly developed plant which is well adapted to drought. Its descendants will all give rise to similarly dwarfed and adapted plants. According to Lamarck's theory organisms…organism are constantly trying to evolve and that new characteristics obtained through use and disuse are passed to their offspring. Today Lamarck's theory is rejected by biologists since they say that organisms evolve not because they wanted to evolve. These theor…these changes took place randomly in response to the environment. There is very little evidence to support Lamarck's idea that changes brought about by adaptation to the environment are adapted from them to the offspring.

T: Thank you, eeh…the two laws, the first law; the law of use and disuse neh…law of use and disuse. Whether it or not, whether you believe or you don't believe, just know that as long as you are doing grade 12 you are going to write about those laws neh…eeh…the law of inheritance of acquired eeh…characteristics. That is the characteristics acquired by an organism during its life time which are passed eeh… to the offspring. For example we have a giraffe that is continuously stretching eeh… its neck to reach eeh…the leaves at the top of the tree. So because eeh…you know there is what…eeh…completion. So the giraffe did not want to compete eeh…for the same resource with the other eeh…herbivores so that's why eem…it decided to what…stretch, stretch and stretch until it reaches eee…higher in the eeh… tree so it can feed on those leaves alone. Can you see inside your study guide neh…eeh…that diagram they show you eeh…the giraffe with a… the ancient giraffe with eeh…a small nyana [isiZulu term for small] neck and then so another giraffe there with a long eeh…neck. So before it decided to eat high up in the trees so it means that it was looking like that eeh…that diagram in your eeh…stidy heads. So that is eeh…the law of inheritance of acquired characteristic… the law of inheritance acquired characteristics and the law of use and disuse. [Noise from outside] the law of use and disuse. So that is why eeh… his theory of evolution it was not accepted by many biologists because they realised or they find out that the evidence was not enough neh…evidence was enough that's why they did not take the theory of Lamarck. Reasons for the eeh…rejection on page eeh…78. There is no evidence to show that eeh…acquired characteristics are inherited neh...there is no evidence to show that structures used more became more developed. There is no evidence that structures used more often become more developed…developed. So nature allows organisms to change…nature allows organism to change. That is why eeh…Charles Darwin came up with the theory of what…natural eeh…selection. He believes that eeh… things they are done eeh…evolution is based on what… on nature you understand! Not eeh… if I like…if I don't like… you understand!

Ls: Yes

T: So that is the two laws, the law of use and disuse, the law of inheritance of acquired characteristics which are important for your exams [Inaudible] so that is eeh…all about eeh…today so what I want you to do…eeh…we are not finished. Eeh…just like other classes eeh…you write down this… [Referring to words on the board] eeh…divergent. Convergent, homologous, analogous, population, species, field of evolution and then you define then what you understand by those terminology

Ls: [Noise]

T: Yes! [Inaudible]… Inside your classwork books eeh…divergent evolution, convergent evolution, you [Inaudible] now people now that's what I want to everyone doing. Inside you classwork… this is not homework…Yes!

Ls: [Noise]

T: Ha...ha now you are copying them now Andy? [Not real name]. [Bell rings]

Appendix 10: Interview transcripts

Appendix 10A: Interview transcript for Mr A of School 1

Participant- Mr A

Researcher- R

R: Okay em... morning sir.

Mr A: Good morning mam

R: I won't be using your, your… your real name in my research, I will create a pseudo name for you for the purposes of confidentiality and anonymity. Emm… firstly I would want… like to thank you aah for… for this time that you have aah allowed me to interview you and also for allowing me to observe you in the three lessons that I have been sitting in your class.

Mr A: It's a pleasure mam.

R: Ah… Sir what qualifications do you hold?

Mr A: Well I have a…Bsc Degree in biodiversity and conservation Biology and l have a… hoo…honours degree in biodiversity and conservation biology as well and I have a PGCE in teaching life sciences and natural sciences.

R: Okay… so how many years have you been teaching life sciences?

Mr A: I have been teaching life sciences since two thousand and ten so that is …sss…

R: Six

Mr A: Six years… I have been teaching life sciences

R: Okay. Now aah…considering that you are a life sciences teachers…a life, sorry… life sciences teacher do you know that life sciences… aah as a science subject is a language?

Mr A: Am… I am aware that… life science has its own… language… aam… one of the first lessons when I teach a new class is to explain to them that life sciences like… Afrikaans, IsiZulu, ah… English, there is a certain way of speaking… and there is a certain waay… to respond…, certain terminology that needs to be used and certain sequences in w…which words go and the understandings thereof, so I think that life sciences is… a subject that…that has its own language in the way that… we speak 'coz there is no other subject that would you go to and use the terminology that we use here except for…in a life sciences classroom.

R: Okay. Aah… are you aware of the value of aah…the non-technical component of the science language?

Mr A: The non-technical component?

R: Yes…

Mr A: So…that's like the non…the non-scientific words?

R: Yah…like the non… yah the words that eee…like we…we borrow form everyday language then we use it in the science con… aah…context and you find they normally change their meanings.

Mr A: Yah!

R: So that's on type, the other type is the logical connectives I think that one you know the one thee…the ones that we use to connect… or to link up sentences like the…

Mr A: Yah!

R: The if's…, the however's…

Mr A: Okay! I think sometimes as teachers we use those non-technical… terms to help our learners understand, so you normally… or I find you would… would give them the technical term but that means absolutely nothing to them, you need it to relate it to a term they understand. So you relate it and explain it in… a term that they understand and say that the term is similar to… the scientific term. But I am also aware that sometimes the terms that we use its… doesn't have the same meaning that but I would rather have word that they understand that's close to the scientific term than them not knowing or understanding the term at all.

R: Okay…now oh co…considering your students especially the fact they are life science students are you aware of any language difficulties that they encounter while learning evolution?

Mr A: Amm…language difficulties you talking about the… the… the terms being used in them understanding mam?

R: Yes.

Mr A: Aam… I think when you teach a subject like life sciences it doesn't matter if you grade 10 all the way up to grade 12 it doesn't matter what topic you teaching. Every time you teach them something, it's something new to them, for most of them it's something new, so I think regardless what topic you teaching, you are teaching them a new word aam…with a new meaning aam… adding another word to their vocabulary, so most of them aam…will have difficulty under …understanding the term and using it in the correct context aam… until such a point where they feel confident with the topic, feel confident the subject itself as life sciences, so… learners do have… great difficulty with using the correct language for a specific topic until they get to a point when they are quite comfortable [not audible] many learners never get that… that point where they are totally comfortable and I think when you mark their tests and essays aah… that's when it becomes very clear their understanding of the terminology and the language they are using is not correct.

R: Okay. Aah…I must admit that your…your lessons were very interesting.

Mr A: Thank you.

R: Aah… in one of the lessons you…[inaudible]…amm [inaudible]…in one of the…e…[silence] okay in your…your teaching I… I discovered that you…you use word like 'however', 'if' which we call logical connectives in aah… in the science language, do you think that your learners understand such words?

Mr A: l think when learners get to grade 12 we just make the assumption that they understand what those words mean, so I don't ever make a conscious des…decision to teach them that this is, when I say if this is the circumstances under which I am saying it or the word however, so l am not sure whether that they understand aah…connecting words like that but I make the assumption that grade 12 learners that they have encountered the word enough to know what I mean when I use it.

R: Okay. So you have answered the second part of my question [laughing]. Ok moving on to question 5 during your…your teaching I…l found out that you… you refer a lot to assessment especially exams aah…where sometimes you…you tell learners that they will be asked to maybe explain…aah…explain amm… the...the… theory…the evidence…the… e… evidence for ah… for evolution or you asked to explain amm… the last thing that…that we did…

Mr A: Speciation.

R: Speciation.

R: Aah… and you use… you…you were actually repeating the word explain do you think your learners understand words like explain, define, state, conclude, infer and so on, the words that we use in science?

Mr A: Amm…because I have taught grade 10, 11 and 12, previously I know in some grade 10 textbooks there is a section on scientific method and if I recall correctly there is a list of these words and what the mean and what its expected of them so like the previous question I think because they grade 12 learners I do amm…make an assumption that they understand what I mean by those words that if you say explain you need to elaborate, if you just say list its point form amm… and just based on the group I am working with now amm… I can see that some of those words they don't understand based on their assessments aam…but previous groups that I have had amm… I haven't had a problem with them understanding those… terms.

R: So do you take time… en… like now you are saying your… your previous current…your`current… emm… group of learners don't understand those terms?

Mr A: Well I don't make specific time to teach them these words but when we go through theee cycle tests and when we go through the June exams and the question then says explain and I explain the question to them I do also speak to them about what's expected and what the structure is and under those circumstances I may explain what explain means that you give more detailed information but I haven't had a lesson where I have just taught it to them.

R: Thank you. Amm…then last…last question in this section. In your teaching eish like I told you, your…your lessons are very interesting aah… you use aah… your powerPoint your slides and I have seen that you include a lot of pictures, it's like every concept, every term comes with a lot of concepts a lot of pictures to support the concept and you also use a lot of examples your examples are so striking in the sense that amm… they relate to the learners' lives, I…l was struck by the example that you used about aah …the learner having account… parents who do accounting but the learner… the…the children, the learner didn't…didn't acquire the skill of accounting. I found that very…ahh…very interesting. Amm…why…why…why do you do that?

Mr A: Well I have been teaching grade 12 life science for about four years now, and I found that the learners understand better when you relate something to them and then take it back to the content that needs to be taught, because the can…if can understand the concept and a situation that pertains to them the now interested in it and then when they understand what concept you trying to get across then take that same concept into a scientific scenario or explanation then their understanding is better that's what I feel. aah… and learners are not interested in words if you put a whole lot of words on a slide they don't see it, they don't read it but when you show them a picture they gonna remember that picture for a very long time and hopefully when they see that picture they will associate it with the information that has been given. Mmm… I also try to use as many various scenarios as possible because I can't …can… can I can prepare my learners for a certain type of question but I can't always prepare them for the scenario under which it's going to be asked, so I try to give the as many scenarios as possible just to increase the chance of getting a scenario that we have covered in class. Amm… also repeating the same concept using various scenarios will help the learners understand it more and various scenarios may…may make more sense to some learners than other learners so the more the scenarios you use the more aah… possibly the more learners you gonna reach in terms of them understanding the content that you trying and the concepts are trying to teach them but it comes with years of being busy with teaching that same content aah…coz when I started teaching grade 12 life sciences I wasn't like that it came with… experience

R: Experience. Okay. Aah…in the last lesson that I observed, you started off by asking your learners to define the term speciation and as your learners were answering you were writing their responses on the board .Why were you doing this?

MR A: I think…think the question was actually what's a species …?

R: Okay…

Mr A: Yaah… the question was what's a species? And the reason why I ask them what a species was is …firstly because its a concept they were taught in grade 11 life sciences so I just wanted to see… how much of it they can remember and because the definition of a species has like four components to it… so I wanted to find out whether the kids could recall those components that make up a species eem…and I write down what they say just so that they can see what they are saying aah… and compare that to… my explanation so the term need to watch the terminology that they using compared to the terminology emm…scientifically expected from them.

R: Okay. [Silence] Right emm… the second question, l am trying to get the strategies ehh…ehh…that you use ehh…during your teaching. So as a life time…sciences teacher do you consider… what do you consider to be good practice ahh… in the use of language in a science classroom because I see you…you engage a lot of you know approaches or strategies?

Mr A: Emm… I know that my primary job is to teach the learners the scientific language of life sciences but I first have to meet the child at the point of their understanding in terms of the language. Emm… it's sort of comparing, this is what you know, this a new term but it is very similar to that term emm…so always just trying to make sure that the kids know where I am and to keep them engaged because once they are… once they fee… start feeling lost with all this terminology that they get given emm… its very hard then to get them to concentrate and be interested in the subject ,so I use a lot of informal language just so that they understand sort of the basic definition of the word and then throw in the scientific terms emm… and scientific language that's actually required by the subject. so you must be a little bit responsible that, yes l'm using this emm…non-scientific language but ensure that you explain to them that this is why you using it and this what it actually means scientifically eeh… many at times I have to tell my learners, I only use that example I only use that language for you to understand so that I can teach you another concept that links to or is very similar to the one that I just explained, and you have to tell them do not use this word that I just helped you or that I just used to help you understand something use this word so that's also something that I try to do 'coz you need to be responsible also, coz learners just hold on to what you say and what they remember and what they remember is mostly informal

R: Yah

Mr A: …language most of the time.

R: Yah…Okay. Then the last question of this session emm…so we have ehh…scientific terms right the ones that most of the people are aware of we also have logical connectives they are part of the science language, we also have what are known as the emm…metarepresentationl terms the ones that we use in assessment the define…

Mr A: Yah

R: …the state, ahh and we also have words… everyday words that are used in the science ahh… in the science context. So now ahh…do you believe that it is your duty as a life sciences teacher to help learners with these non ehh… non-technical terms?

Mr A: Emm…I think that… I think we don't consciously take on that responsibility, like we are not like oh my kids are coming in today I need to teach them these non-technical words but as you explaining various concepts you using the non-technical words and if you see that they are confused you explaining non-technical words because there is no way they are going to understand the technical scientific words unless they know the non-technical words because we use them together we link them together so is it my responsibility to teach it them I don't think so but if I want my learners to be successful, I am obligated to ensure that when non-technical terms are used with these technical terms that I explain how they work together in asking a question or in explaining a concept, so I don't feel like I should but I am obligated because I want my learners to succeed.

R: Okay, thank you so much sir.

Mr A: It's a pleasure mam.

R: Enjoy your day.

Mr A: I think you missed these two.

R: Oh, Sorry okay I had…ehh… I missed those two questions like you said let me just go back to them, ahh considering your experience how have you changed your teaching approaches with regard to language use in the science classroom?

Mr A: I… I think when I started, started teaching life sciences, life sciences grade 12 I was learning the curriculum with the kids amm…yes I…I knew the content , I knew the concepts from university but obviously now I'm learning it in terms of constraints of a curriculum and in the constraints of a CAPS document. So as I'm teaching these concepts to the learners I'm teaching myself as well. Emm…I found when I was new at teaching it I would just use the scientific terms as they were laid out in the textbook.

R: Okay.

Mr A: And with time I realised that the learners don't always just understand them and I am assuming that they understand them so with the more experience I have learned to explain the non-technical terms whether the learners ask me or not and use non-technical terms in order to explain those terms to them.

R: Okay. Have you ever… eee…encountered specific constraints in your teaching of evolution particularly with regard to language?

Mr A: Emm…ahh…I don't think I have had any constraints, I have been very aware of peoples beliefs more than the capability of understanding the language, emm…so I have just been very conscious of the peoples' religious beliefs, their cultural beliefs emm… more that I would the language…

R: Okay.

Mr A: …of that.

R: Thank you very much sir.

Mr A: It's pleasure mam, I hope you got what you need.

R: I did…

Appendix 10B: Interview transcript for Mrs B of School 1

Participant- Mrs B

Researcher- R

R: Afternoon mam.

Mrs B: Good afternoon.

R: Emm I won't be using your… your real name for my research, I have created a psudo name for you for the purposes of confidentiality and anonymity. Firstly, I…I would like to thank you mam for this opportunity and also for allowing me to sit in your classroom and allowing me to observe you whilst you were teaching.

R: Emm… the first question, what qualification do you hold?

Mrs B: [Inaudible]

R: Okay and how many years have you been teaching life sciences?

Mrs B: Many… many… over twenty years

R: Over twenty years okay. Now considering that you are a life sciences teacher are you aware that life sciences as a science subject is a language?

Mrs B: Yes, yes definitely

R: Okay are you aware of the non-technical aah… non-technical component of the science language?

Mrs B: [Laughing] we deal with it everyday.

R: You do it everyday. Okay emm…now considering your students especially the fact that they are life sciences students are you aware of the difficulties aah…that they encounter whilst learning evolution?

Mrs B: Yes I do. I actually see it at the moment while dealing with evolution. Also a lot of their culture come into play there I saw it today when we were dealing with evolution, that culture plays a major role because they won't believe anything you say you have to basically say, basically our time prove it.

R: Okay. So in your aah…in your teaching when I was observing I heard you use words like however which we call logical connectives in the science language. Do you think your learners understand such word as however, if, in order to?

Mrs B: Yah your top learners would… and then your top learners…the bottom class maybe not but your top do that because they are your 80 to 90 percent… they would actually understand the however if this happens whatever the case may be they would understand they may be able to follow.

R: Okay…So do you find time to explain such words to your learners since you are saying that some of them do understand but some don't.

Mrs B: Yaah… you have to look at the [Inaudible]… you have reached [Inaudible]…and then if they do ask I would explain that I think in my common English words this is the question. But matric level you need to know that…I cannot teach you English in matric [Pause] however you need to take into consideration that for a lot of these learners is not a first language… however you know English medium school with home language English therefore you need to understand it.

R: Okay. Aah… during your teaching you refer a lot to assessment where you actually tell your learners that they can be may be asked to define, describe or explain. Aah…do you think your learners understand these words?

Mrs B: Yes they do because they have been practicing them a lot [Inaudible] a lot of the activities we did we actually [Inaudible] and as you have seen some of the presentations I have …I mean this is an exam question that they answered where they are asked to explain how Lamark would describe whatever the case maybe… and I show them how the explanation should be done.

R: Okay. Aah… in your teaching aah…I see you use a lot of pictures…

Mrs B: Yes…

R: …like almost every slide has a picture on it, why…you also use examples like the example of the giraffe thing, you also stories like used that story of aah…Charles Darwin. Why do you use such things?

Mrs B: It's easy for them to relate when you start telling them a story and pictures …come on the kids are visual…more visual than auditory, they see and its easy for them to see what you are talking about than just sitting and [Inaudible] at the back and they have no clue of what you are talking about. You show them a picture they will know what you are talking about.

R: Okay. Then in the first lesson, I understand you were introducing a new topic…

Mrs B: Yes…

R: …evolution and you started off by listing ahh…listing down words and started discussing them. Why did you do that?

Mrs B: So that actually when I get to that point they know exactly what I'm talking about because that's all based…based on terminology, if you don't understand what palaeontology is… how can you how are you gonna know when I talk about a fossil. Life sciences terminology is one of the most important component.

R: In the second and third lessons that I observed you started off by repeating or recapping on the terms that you had covered before. Why did you do that?

Mrs B: Reinforcement! If I reinforce the term, they are inclined remember it.

R: Okay as a life sciences teacher, aah…what do you consider to be good practice in the use of language in a life sciences classroom when teaching evolution?

Mrs B: Its not just evolution, its every subject. You know eem...you got to simplify things for especially for the weaker kids I can simplify a things so that they understand but then I will say, this is the proper way to…to use the term, so you simplify and then you define actually the context you use it you tell them, if you use it like this it's wrong… if you use it like this that's right… [Inaudible] but stress down the levels.

R: Okay. Now considering your experience, how have you changed your teaching approaches over time and why?

Mrs B: Why?... And all the time why do we change, if we keep on talking to the high we actually gonna use... [Disturbance] okay emm… we gonna teach… [Inaudible] English teacher…we have got to consider that for a lot of these kids English is not their home language or this biology, so we have to teach language skills with teaching actual content, that what it comes down to… if you keep on using life sciences using high sounds word you actually have to English to teach the subject so we all English teachers as well as life sciences teachers in essence… although I don't teach language as a language teacher.

R: Have you ever encountered any specific constraints in the teaching of evolution, particularly with regard to use of language?

Mrs B: Not really it's a [Inaudible]…language it's more content wise where they actually would have a block, but not really language… and have you… actually… take a term and describe a term they know what you are talking about that's what it comes down to. However you use proper English… now that's one thing I stress in class that you do have to use proper English… because these kids also have a problem expressing themselves in English if you use proper English in class, reinforcement, learning takes place… as the command of English language not necessarily the scientific language.

R: Okay. Last question, do you believe that it's your…your duty as aah…as the life sciences…as a life sciences teacher to help learners aah…with the non-technical component of science language?

Mrs B: Yes! [With soft voice] We have to… we have to help these learners… we cannot to leave them… [Inaudible]… if they do not understand what you are talking about… if its non-technical… if you take…make it…take any term and make it non-technical for them to understand, and then I do it basically on a daily basis…using a simple way to explain the concept that they can understand the concept but then bring in the technical term while the concept is the wording… that they can actually follow through and learn the concept the way you want them to learn… it's no use learning a word that they don't know what it means, [With a soft voice] you've got to simplify for them.

R: Okay, thank you mam.

Mrs B: Okay

R: Enjoy your day.

Appendix 10C: Interview transcript for Mrs C of School 2

Participant- Mrs C

Researcher- R

R: Morning mam.

Mrs C: Good morning madam.

R: I won't be using your…your actual name for my research, I have created a psudo name for you for confidentiality purposes and as well as ononim…anonymity. Emm…I want to start by thanking you mam for your time I know its…this time of the year is hectic allowing me to observe you and as well as having this interview. Emm…thank you so much mam. Emm… what qualifications do you hold?

Mrs C: I have higher education [silence] a diploma in life sciences.

R: Okay. Aah…how many have you been teaching life sciences?

Mrs C: Aah…18 years.

R: [Whispering] 18 years that's a lot, very much experienced. Okay e…considering that you are life sciences teacher, do you know that life sciences as a science subject is a language?

Mrs C: Yes because isn't that whenever you are teaching life sciences there is many concepts that learners have to know and define them, the definition so… I think that it's incorporated in the language.

R; Okay. Are you aware of the value of non-technical …of the non-technical component of the science language… beside those technical terms… because we have words that we normally use words like… I heard you…you know say that word several times describe,

Mrs C: Yes…

R: When you were teaching, define... A…Are you aware of the value of su…such words in science language.

Mrs C: Yes because isn't that they are going to be looking at the levels of the questioning so its very much proper for the learners to know that whenever the…those focus areas neh… that's the blooms taxonomys when they have to approach… the approach of the question… course always the have to that if… I have been asked about to analyse to analyse to describe and then the synthesis of… they have to have that knowledge of what they have to do in that case.

R: Okay fair enough…and also are you aware that eee…words like however, if … have do…do…are you aware of the value of such words in…in science, however, if…?

Mrs C: Emm…do I nor… I don't normally use those words [laughing] because immediately you keep on using that if …these…however…you know… for me… I don't see any [Inaudible]…maybe you can… because isn't that all of us we are learning all the time [Laughing].

R: Okay… [Laughing] …

Mrs C: …but I normally don't use these words…

R: Yah…yah

Mrs C: …yes you know if…if…aah… eeh… so that's why I always tell them that you know what when you you write a question don't start your question a question with I think…you understand…

R: Ehem…

Mrs C: …if you have an answer just write that answer… because we… immediately you just say I think then it give us some doubts… that whatever you are saying… you are not sure of…

R: Okay…aah now considering your students especially the fact that they are life sciences aah…students are you aware of the difficulties that they face… in terms of emm…in terms of the… of language… when they are learning evolution in particular?

Mrs C: Yes…you know emm…you know evolution has so many difficult emm… concepts some of them they… they are not able even to pronounce eeh… to pronounce them… so that might also be a challenge eeh… for them so most of the time when we just do evolution and then they come across those eee…difficult words to pronounce…

R: Eehm…

Mrs C: …and then we also check on their performance when… they are writing especially their final papers when we do analysis of question papers…

R: Eehm…

Mrs C: … we still find that it's still find it's a problem with the learners they can write those word, they can't pro…pronounce them so you keep on repeating saying one thing all the time and then I end up saying to them that… it's better they pronounce something or a word the way they will understand.

R: Wow, wow…wow. Aah…in one of the lessons you started by listing down words on the board and then you asked your learners to define those words. Why did you do that?

Mrs C: Emm…isn't that it was emm… what do we call this…we had done the work the eee… the …eee other day neh…

R: Okay…

Mrs C: …so just wanted to find out if they still remember…

R: Okay…

Mrs C: …what we did and knowing again that eee…those are… biological terminology of which they are not doing very well…

R: Okay.

Mrs C: … again!… in biological terminology if you can just go through the papers and things like that and then you check most of the learners in section A of the question paper, biological terminology is a problem.

R: Ehem

Mrs C: So for me to do that… is just to keep on reminding them that eee…know these the definition because we…we cannot look only for emm… more content eeh…questions so even the multiple choice type questions… they have to accumulate lots of them.

R: Okay…aah during your lesson you refer a lot aah …to assessment where you tell your learners that they can be asked to like say…describe or explain. Do you think your learners understand those words like define, explain and explain, confer, conclu…e sorry infer, conclude and deduce those words that we use in science.

Mrs C: It depends on the type of the learners mam…

R: Okay…

Mrs C: …there are some when you like you tell them neh…

R: Ehe…

Mrs C: …that okay when I say you explain,

R: Yes.

Mrs C: …what is it guiding you if I say to you that emm…list… the mark allocation will tell you that there is only one mark you list one example [Inaudible] but… explaining and describing a process it means that I need a full explanation! [Emphasis]

R: Okay…

Mrs C:…of what happened so… but…as you know we are not teaching kids with the same…

R: abilities.

Mrs C: Aah…Abilities. So some they still struggle but… they will get there

R: Okay

Mrs C: Yes… because what is important [Silence] whenever you are giving them questions or eeh… maybe the activities…

Mrs C: …include them all the time… to say that don't just give them a level one questions so all the levels of Bloom Taxonomy must be included so that they know… okay if the say I must analyse what is to analyse… ?

R: Okey…

Mrs C: …if they say I must describe eee…what must I do?

R: Okay

Mrs C: So… you find that some they…they are able to answer those kind question and then that is the higher order level questioning so but some still have some challenges.

R: Okay…so do you find time to explain… such words?

P: Yes! [With emphasis] like isn't…that when they are writing…

R: Aaha…

Mrs C:…and then we go back we do a feedback

R: Ooho okay…

Mrs C …so in the feedback or during my teaching then if I say okay describe eeh…let's say for example …describe eee…evolution by natural selection…

R: Eehe…

Mrs C: neh… and then what do I really want…

R: Okay…

Mrs C: So what are the key words…?

R: Eeehm…

Mrs C: that you can use and then you just incorporate them in the same sentence

R: Okey

Mrs C: So it is what I normally do

R: Okay

Mrs C: …saying that eee…summarise, identify all those eee…key words

R: Ehm…

Mrs C: and then so that you are not going to forget okay they said I eee…must describe eee…natural selection

Ehem…

Mrs C: …what are the most important words the key words in natural selection

R: Yes

Mrs C: what must I know…

R: Yes

Mrs C: …that I know alright with these words then will be able to describe the whole process of natural selection. [Laughter]

R: Okay

Mrs C: [Laughter]

R: Nice. In your teaching you refer a lot of…aah you refer a lot to…to the textbook and the study guide, and you ask… you actually learners to read and then you explain. Why do you do this?

Mrs C: You know my understanding is that if I keep on reading and then they don't read… at the end of the day they are not going to gra…grasp anything. So for them to read I think it's going to be even easier… for them do what…to emm…to… to learn on their own because I always say to them that eee…when you want know a song of your favourite artist, you keep on playing the song time and a… you listen… you imitate neh… so imitate

R: Wow!

Mrs C: …yes…is what I am telling them that you know what… you keep on imitating and then I am using both the study guide and the textbook

R: Ehem…

Mrs C: eeh… because sometimes you find that okay one is a study guide, this one is a textbook with full information to say that we don't have to leave other things not done and then focusing only on the study guide so they have to use both and then as I have said to you that we have different learners that eee…for them I say okay you we focus on the study guide and then the other ones textbook but I like them reading you know… because my understanding is that if I read something its not easy for that thing to…

R: Yes.

Mrs C: Eeh

R: So it's an approach, its strategy.

Mrs C: Yes it's my strategy [Laughter].

R: Aah…wow… [Laughter]. Okay so as life sciences teacher what do you…what do you consider to be a good practice in the use of language which one do you think is a…is a good approach in the use of language aah…when teaching evolution?

Mrs C: Emm…I don't understand the question.

R: Like ahm…you have a lot of experience from eee…your experience which strategy do you think would be the best aah…for…for the learners to understand aah… concepts in e…evolution?

Mrs C: I think eee…practical eee…practical so sometimes when you teach them and then also you make…I mean they see those things

R: Aham

Mrs C: e…I think it's very much better because when you are teaching and then it's only about a theory and no experiment sometimes it's difficult for them to…to understand the…the concept it's just that this year because of time we were supposed to come to Wits eeh… paleontology is there and then they study more because when they see…eeh they understand better unlike I stand there for 45 minutes explain and explain and at the end of the day not all of them get what I wanted to say

R: Ehm

Mrs C:…but when you say okay we have this eem…Australopecus *africanus* and then they have those examples of Mrs Ples…

R: Ehem

Mrs C: …they see them and then they see everything how the earth has stated at Maropeng…

R: Ehem

Mrs C: Can you see

R: Ehem

Mrs C: … and then those things they will never make them to…to forget so for me if co…incorporate practical and the theory and then it will make them to understand this evolution much better [with emphasis].

R: Okay. So considering your experience mam, you are very much experienced, aah…how have you changed aah…your teaching approaches with regard to language over time and why? [Emhasisng]

Mrs C: [Laughter]

R: [Laughter]

Mrs C: Yohwee what can I say? [Laughing]

R: [Laughter]

Mrs C: What did I…?

R: Aah…have you changed your teaching approaches?

Mrs C: Yes! [With emphasis] you…you can't be sticking to… to one approach because it is going to give you a problem like for example you end up not preparing the lesson because you know okay when I get to class I'm…I'm going to…to do this and that…

R: Ehem

Mrs C: … and then… but if you change the app…your approaches how do I approach my lesson, I think in that what it's much better because at the end of the day isn't that the main goal is for them to understand…

R: understand…yaah

Mrs C: …what…yaah…

R: So have you encountered any specific constraints in your teaching of evolution, with regard to language?

Mrs C: Yes! [With emphasis] as I have said to you that eee…especially when we started teaching eee…evolution it was not an easy concept to teach…

R: Ehem.

Mrs C: …wee…eeh we had to go you know you have to come up with come up with a strategy where these learners they will exactly find out what you are talking about

R: Ehem

Mrs C: …so it was not an easy task to teach eee…evolution at first

R: Ehem

Mrs C: it was just a difficult concept to teach but in anyway because we need the most important thing when teach evolution is all about the approach,

R: Ehem.

Mrs C: Its is all about approach right how do I approach them, eee…these learners because at the same time we must think that we are teaching different learners with different belief

R: Ehem

Mrs C: …so the approach is very important and also English as a language and there is no way that I can be able to explain evolution like in my own mother tongue and looking at the eem… the diversity

R: Emm

Mrs C: …so you just have to stick to…to English

R: okay

Mrs C: …difficulties were there mam

R: Yaah

Mrs C: Eem…It was not an… an easy task even now some of the teachers they still have a problem

R: Ehem

Mrs C:…emm…of teaching evolution.

R: Okay. Last question.

Mrs C: I'm sure it is the last question [Laughing].

R: Okay, wee…we have words like the ones you, I liked the way you… you do it that you used like define, describe during your teaching and we also have those words that I talked about like the if, the howevers, do you think emm…it's our…its our duty as life sciences teachers to teach learners or help learner to understand those words?

Mrs C: No! [With emphasis] I don't think so neh…

R: Ehem

Mrs C: …because my understanding is that eem…we have an English teacher there who is supposed to during their gramma period,

R: Ehem

Mrs C: …they actually learn those words, so mine what I have to do in life sciences is if they are using those words answering question based on life sciences.

R: Ehem

Mrs C: Not that eem… I'm like okay spend my time saying that alright now I'm going to explain eee… what the meaning of describe what …what…no! The approach will be when I'm teaching life sciences and how will they answer my question in life sciences, because let's say for example eeh…we are using the mind eee… mind maps

R: Yes

MrsC: English is also the English lessons they are also using the…

R: Mind maps

Mrs C: but my mind maps, but my mind maps and my mind maps of English as a gramma or language they will not be the same,

R: Okay

Mrs C: You understand

R: Ehem

Mrs C: Because eee…they will be describing something of English nature, here in life sciences they will be describing a process [With emphasis]. You understand

R: Ehem

Mrs C: but even though English is very im…Eng actually it is very much important because they have to know from the class and then when because all these learning areas they are incorporated, ehem…

R: Okay. Thank you very much mam.

Mrs C: You… [Laughter]