A SURVEY OF LIFE SCIENCES TEACHERS' UNDERSTANDING OF THE THEORY OF EVOLUTION

By

GUGULETHU PRIMROSE MAGUBANE

A Dissertation submitted to the Faculty of Education of the University of KwaZulu-Natal

In partial fulfilment of the requirement for the

Degree of Master of Education

(Curriculum Studies)

Supervisor: Dr E.R. Dempster

December 2012

DEDICATION

This thesis is dedicated to my late father Bongani E. Magubane and my late brother Bongumusa Magubane.

PREFACE

The research project described in this dissertation was carried out with 70 Life Sciences teachers falling under the Vulindlela Circuit, in the Umgungundlovu District of KwaZulu-Natal. The project commenced from May 2009 to May 2012 under the supervision of Dr E.R. Dempster of the University of KwaZulu-Natal, in Pietermaritzburg Campus (Life Sciences).

This study represents the original work by the author and has not been submitted in any form for any diploma or degree to any other tertiary institution. Where the author has made use of work of other authors, it is duly acknowledged in the text.

.... Date: ....

Gugulethu Primrose Magubane

Student Number: 200402301

As the candidate's supervisor I agree/do not agree to the submission of this dissertation.

.... Date: ....

Dr E.R. Dempster

Supervisor

Pietermaritzburg

ACKNOWLEDGEMENTS

First and foremost, I would like to give thanks to God Almighty for keeping me alive and helping me through this dissertation especially during the times when I thought of giving up and tended to lose hope.

Among the people who helped me in completing this dissertation, particularly, I want to thank Dr Edith Dempster for her guidance, continuous encouragement and the role she played as my supervisor. I would also like to extend my genuine appreciation to the Grade 12 Life Sciences teachers of Vulindlela Circuit who participated in this study.

My genuine gratitude also goes to a special friend Sizwe, who has always been beside me, encouraging me to continue with this project. I would also like to express my thanks to Sikhumbuzo, Tsepang and Mrs P. Majozi (subject adviser) without whom the study would not be possible. Finally, special thanks go to the rest of my family members: Mom, my sisters Xoli and Nonhlanhla, my brother Sfiso, and my two sons, Thulani and Sphesihle, for their continuous support.

ABSTRACT

The theory of evolution is relatively new to the majority of teachers who teach Life Sciences in South African schools. It was introduced into the Grade 12 Life Sciences curriculum in 2008.

The purpose of this study was to examine the subject matter knowledge of Life Sciences teachers regarding the theory of evolution. Furthermore the study aimed at finding out about the challenges that the Life Sciences teachers encounter during the teaching of evolution to their learners and how they deal with those challenges. This study also aimed to contribute to the field of research regarding Life Sciences teacher's understanding of the theory of evolution in a South African context. The focus of the research was on the teachers who were teaching Life Sciences at Grade 12 level in 2008. This study was underpinned by the conceptual framework developed by Lee Shulman (1986; 1987). Shulman (1986; 1987) argues that the subject matter knowledge should be the foundation for teaching.

The research was conducted within the pragmatic paradigm. The data was collected from the Life Sciences teachers under Vulindlela Circuit in Pietermaritzburg, KwaZulu-Natal. The methods of collection included questionnaires and individual interviews with selected teachers. Quantitative data were analysed using SPSS while qualitative data were analysed using thematic content analysis.

The findings indicated that the Life Sciences teachers who were enacting the new curriculum do possess some knowledge of the theory of evolution. However there were some gaps in their understanding of the concepts related to the theory of evolution by natural selection. Probably Life Science teachers will also increase their knowledge and levels of understanding of evolutionary concepts as they teach these year after year. This was evident from the scores of the teachers under the section of genetics. They scored high marks in this section because genetics was introduced into the Biology curriculum more than twenty years ago. Fossils, biogeography and natural selection were introduced in 2008, and teachers had much less knowledge about these topics than about genetics. This study also found that some teachers do encounter problems such as the views of students which contradict with that of evolution by natural selection. Teachers mentioned that they do not know how to handle such problems in the classroom during teaching in a manner that would not criticise religious beliefs of other learners.

This study concluded that professional development of teachers in the form of workshops and in-service training should be an ongoing process within the Department of Education in order to help teachers with the ever-changing curriculum.

DECLARATION

I, Gugulethu Primrose Magubane, declare that

- The research reported in this dissertation, except where otherwise indicated, is my own original work.
- This dissertation has not been submitted for any degree or examination at any other university.
- This dissertation does not contain other person's data, graphs or other information, unless specifically acknowledged as being sourced from other persons.

Signed………………………………. **Date: ……………………………**

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AS	Assessment Standards
C2005	Curriculum 2005
DoE	Department of Education
FET	Further Education and Training
ICS	Interim Core Syllabus
LO	Learning Outcome
LPG	Learning Programme Guideline
NCS	National Curriculum Statement
NQF	National Qualification Framework

OBE	Outcomes-Based Education
RNCS	Revised National Curriculum Statement
TIMSS	Third International Mathematics and Science Study

CHAPTER ONE

1.1 Introduction

This introductory chapter outlines the purpose of the study, describes the rationale behind the study and provides the general background to the study. The chapter also introduces the conceptual framework and methodology which will underpin the study. Finally the research questions and overview of the study are provided.

1.2 Focus of the study

The theory of evolution is a relatively new topic in the field of teaching in South Africa. The introduction of the theory of evolution into the Life Sciences curriculum in 2008 was an attempt to provide explanatory principles for the phenomena in living world (Mayr, 1982). Evolution is defined as the gradual process by which the present diversity of plant and animal life arose from the earliest and most primitive organisms (Curtis,1989). Evolution results in change in the frequency of alleles within a gene pool from one generation to the next.…..Evolution of species is evidenced by studying changes in species over space (biogeography) and over time, by studying the fossils (paleontology) (Johnson, 2009).

The focus of this study was on grade 12 Life Sciences teachers. The purpose of the study was to examine the knowledge and understanding of the Life Sciences teachers regarding the theory of evolution. The study also aimed to investigate the challenges the Life Sciences teachers encounter during their teaching of the theory of evolution to the learners since this theory is a new topic in the curriculum in South Africa.

There is a distinct gap in the literature based on the studies of Life Sciences teachers in South Africa with regard to their knowledge of the theory of evolution as well as the classroom challenges these teachers encounter during teaching of the theory of evolution. While some articles have appeared, trying to explore the problem, there remains much to be investigated around introducing the theory of evolution into the South African school curriculum.

The research questions that drove this study were the following:

1. What content knowledge do the Life Sciences teachers possess regarding the theory of evolution?
2. What challenges besides content knowledge do the Life Sciences teachers encounter during the teaching of evolution?

In order to respond to these questions, we need to understand the conceptual framework which underpins my study on Life Sciences teachers' knowledge and understanding about the theory of evolution.

1.3 Conceptual Framework

This study was guided by the conceptual framework developed by Lee Shulman (1986; 1987) concerning teachers' areas of knowledge. Shulman (1986; 1987) describes a number of different types of knowledge that teachers need to have. He grouped these types of knowledge into three categories: Subject matter knowledge (SMK); Pedagogical knowledge (PK) and Pedagogical content knowledge (PCK). Shulman (1986) developed the construct of pedagogical content knowledge (PCK) in response to some problems encountered in teaching, especially in science teaching in the United States. According to Shulman (1987) subject matter knowledge involves the knowledge and understanding of facts, concepts and principles and the way in which they are organized as well as knowledge about the discipline (Shulman, 1986;1987). In order to answer the first research question, it was of paramount importance that I investigate teachers' SMK regarding the theory of evolution. Pedagogical knowledge on the other hand refers to aspects about pedagogy which empowers teachers with self-awareness of educational system as a whole together with an understanding of learners. This type of knowledge paves the way to build in pedagogical expertise as well as an understanding of curriculum materials. It allows the teachers to have a better understanding of their educational context (Shulman, 1987) .

1.4 Research Design and Methodology

My study was designed as a survey situated in the pragmatic paradigm, because it aimed to solve a problem (Creswell, 2003). The problem was to investigate the relationship between teachers' subject knowledge and their difficulties in teaching evolution. It was a case study of a group of Life Sciences teachers who attended teacher development workshops organised by the Department of Education. The study reports on both qualitative and quantitative data gathered from the teachers. My study involved Life Sciences teachers who taught Grade 12 in 2008. This sample was chosen because 2008 was the year in which the theory of evolution was first taught explicitly in the Life Sciences curriculum, and learners wrote their final examination at the end of 2008. The total number of teachers who participated in this research study was 84. Four teachers from this sample were also interviewed after they completed a questionnaire. The questionnaire consisted of 30 multiple choice questions. Teachers completed the questionnaire by putting a circle around the correct letter of their choice. The data were analysed using the computer programme called Statistical Package for Social Sciences (SPSS).

1.5 Motivation for the study

Several studies (Stears, 2011; Ngxola & Sanders, 2008; Abrie, 2010; Holtman,2010) have been conducted in South Africa regarding the teaching of evolution since its introduction into the school curriculum. This study aimed at contributing to the limited studies about the subject matter knowledge that the Life Sciences teachers possess and the challenges regarding the teaching of the theory of evolution. This study is a survey of Life Sciences teachers' understanding of evolution and exploring the challenges they face during the teaching of this theory.

I have been a Life Sciences teacher for 18 years. In February 2008 I attended a three-day workshop where the Life Sciences teachers from different schools received training on how to teach the theory of evolution, which was a new topic in Grade 12 in that year. In January 2009 we had an orientation workshop with the subject advisor for Life Sciences where we discussed the Grade 12 results for the previous year. The subject advisor pointed out that the learners' performance in questions on evolution was very low when compared to other questions in the question paper. My study aimed to ascertain whether the Life Sciences teachers do possess the knowledge of the theory of evolution. The study also wanted to find out about the challenges that the teachers encounter during the teaching of the theory of evolution.

My own interest in doing this study was because I have been involved in the marking of Grade 12 Life Sciences final examination since 2003. As a teacher who was involved in the marking of Paper 2 (which included questions on evolution) for Life Sciences in 2008, I became aware of the low performance of the learners in questions involving the theory of evolution. The questions on evolution were on the whole either very poorly answered or not even attempted. This resulted in poor performance of learners in paper two compared to paper one of Life Sciences. The analysis of learners' performance for 2008 results in Life Sciences paper two also indicated that learners scored very low marks in questions that were based on the theory of evolution (Provincial Report, 2009).

Table 1.1: Average score from lowest to highest marks (12% - 53%) in individual questions in Life Sciences Paper 2 of 2008. Adapted from: KZN Provincial Report (2009).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**	**Q**
2	**3.2**	**2.1**	**3.3**	**2.2**	**1.5**	**4.2**	**1.2**	**4.3**	**3.4**	**3.1**	**2.3**	**1.6**	**1.3**	**1.4**	**1.1**	**4.1**
3	12%	15%	21%	27%	30%	32%	34%	35%	38%	39%	41%	43%	50%	52%	53%	53%

Table 1.1 shows questions that were poorly performed. These questions were carefully selected from other questions in the question paper because they are based on the theory of evolution. The percentage under each sub-question indicates the average mark for learners in the district who got the answer correct for that particular question. In question 3.2, an average of 12% of the learners who wrote paper 2 in 2008 obtained the correct answer. Fifteen percent of leaners got the answer correct for question 2.1. This suggests that many educators and learners need intervention regarding the theory of evolution (Provincial Report, 2009).

Further investigation into this problem became the focus of this study. I became interested in finding out whether the Life Sciences teachers themselves know and understand what they teach in the theory of evolution. This is important because teachers' knowledge either supports or hinders students' learning and mastering of the subject matter (Veal & Kubasko, 2003). The problem therefore was to design a study that would investigate teachers' knowledge and understanding of the theory evolution.

1.6 Introduction of Biology into South African Schools

According to Le Grange (2008), Biology was introduced into South African education because of influences from overseas. Firstly Biology was taught in the Cape Province only prior to 1934 then later to the Transvaal Province for the first time in

1935 (Preller, 1953, as cited in Le Grange, 2008). Prior to its introduction, Botany was taught as a school subject in most schools (Preller, 1953, as cited in Le Grange 2008). Later the study of animal physiology and classification was included. From the time Biology was first introduced to all schools in South Africa, Biology focused mainly on plants and animal life. Later Biology was expanded to include molecular biology (Le Grange, 2008). During this period several criticisms were raised about the relevance of Biology to the lives of learners and South African citizens. Such critiques were aimed at questioning the dominance of a science of life approach to Biology education and argued for inclusion of elements of a science of living approach (Doidge, 1996, as cited in Le Grange, 2008).

1.7 Curriculum Reform in the New South Africa

Prior to 1994 education in South Africa has been a site for struggle between the two opponents, the ruling government at that time and the current democratic government. Curriculum reform followed immediately after the newly elected democratic government in 1994. Under the new democratic government, education was transformed and the curriculum was revised. The old curriculum was “cleansed”, i.e. the most offensive language was removed and the curriculum was “purged of their most controversial and out-dated content” (Jansen, 1999, p.57). Cleansing the curriculum was also done because the new government which was led by ANC wanted to iron out variations in the curriculum which was used by different education departments which existed in the past in South Africa.

After the 1994 democratic elections, the new government of South Africa was under pressure to bring about transformation in education. So the ministry and other stakeholders became involved in the national process of curriculum revision. The interim core syllabus was described by Jansen (1999, p. 62), as an act of “political symbolism”. This policy document consisted of a brief introduction with the objectives of the syllabus and some details about the examination at the end of the year. The content inside the document for Grades 10-12 was divided into Higher Grade and Standard Grade since at that time learners had to choose between the two.

Curriculum 2005 (DoE, 1997) arose out of a coalition process designed to ensure the integration of education and training through the National Qualification Framework (NQF). After the announcement of the introduction of the new curriculum in 1995 by the Minister of Education at that time, the implementation was scheduled for all grades by the year 2000. This was later rescheduled in 1997 and the revised time table stretched up to 2008 (in Grade 12). The new curriculum then became known as Curriculum 2005.

The master plan for C2005 was launched in March 1997, with the implementation in Grade 1 scheduled for 1998, and Grade 7 in 1999. It was thus to be phased in progressively so that it would cover all grades by year 2005. This curriculum had three design features as follows:

- Outcomes-based
- Integrated knowledge system
- Learner-centred pedagogy

Outcomes-Based Education (OBE) was implemented in South African schools from 1997. This kind of education was intended to enable the learners to achieve their full learning potential by the time they left school. The learning outcomes are specified for each learning area and they are the vehicles for teaching and learning in the classroom. Outcomes-Based Education encourages a learner-centred (constructivist) approach. The educator is expected to design the activities for learners to be engaged in during teaching, bearing in mind which learning outcomes are to be achieved at the end of the lesson. For each learning outcome there are assessment standards which describe what learners should know and be able to do at a certain grade. They demonstrate the kind of knowledge, skills and values that are required to achieve learning outcomes. The outcomes act as vehicles of the knowledge to be taught to learners.

1.8 Life Sciences Curriculum in South Africa

Before 1994, Biology and Physiology were taught as two different subjects at a high school level (Grades 10-12). The Interim Core Syllabus used from 1994 to 2005 was replaced by a National Curriculum Statement (NCS) for Grades 10-12 (DoE, 2003. The NCS was to be phased into the Further Education and Training band (Grades 10-12), beginning with Grade 10 in 2006. Outcomes-Based Education (OBE) continued to be the core of the National Curriculum Statement (Chisholm, 2002).

During the introduction of the National Curriculum Statement (DoE,2003) in South Africa, many subjects adopted new names. Life Sciences as a subject emerged from a combination of two subjects, i.e. Biology and Physiology (Dempster, 2007).

The National Curriculum Statement Policy document for Life Sciences stipulates three Learning Outcomes (LO) and three Assessment Standards (AS) to guide the teaching of the subject. These three LOs should not be covered in isolation but should be linked and integrated with the three ASs. The AS for each LO specify more complex, deeper and broader knowledge, skills, values and understanding to be achieved in each grade (DoE, 2007).The three LOs for the Life Sciences (Grades 10-12) are described in the National Curriculum Statement Grade 10-12 (General) Life Sciences, (DoE, 2003):

Learning Outcome 1

Scientific enquiry and problem-solving skills

The learner is able to confidently explore and investigate phenomena relevant to life sciences by using inquiry, problem solving, critical thinking and other skills.

Learning Outcome 2

Construction and Application of Life Sciences knowledge

The learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.

Learning Outcome 3

Life sciences, Technology, Environment and Society.

The learner is able to demonstrate an understanding of nature of science, the influence of ethics and biases in the Life Sciences, and the interrelationship of science, technology, indigenous knowledge, the environment and society.

For each leaning outcome above there are three assessment standards that need to be used when assessing the learners' knowledge. The assessment standards are as follows:

Assessment Standards for Learning Outcome 1

1. *Identifying and questioning phenomena and planning an investigation*
2. *Conducting an investigation by collecting and manipulating data*
3. *Analysing, synthesising, evaluating data and communicating findings.*

Assessment Standards for Learning Outcome 2

1. *Accessing knowledge*
2. *Interpreting and making meaning of knowledge in Life Sciences*
3. *Showing an understanding of the application of Life Sciences knowledge in everyday life.*

Assessment Standards for Learning Outcome 3

1. *Exploring and evaluating scientific ideas of past and present cultures*
2. *Comparing and evaluating the uses and development of resources and products and their impact on environment and society*
3. *Comparing the influence of different beliefs, attitudes and values on scientific knowledge.*

The following table is a summary of the three Learning Outcomes and their Assessment Standards in Life Sciences. The three LOs address the Critical and Developmental Outcomes. Assessment Standards are the vehicles through which the LOs can be achieved. The Assessment Standards for each Learning Outcome specify the progressively more complex, deeper and broader knowledge, skills, values and understanding to be achieved in each grade (DoE, 2003). The table below shows how the LOs for Life Sciences relate to the ASs. It also shows the progression of each AS per grade.

Table 1.2 Summary of the Life Sciences Learning Outcomes and Assessment Standards (DoE, 2003)

	A	B	C	D	E
			Grade 10	Grade 11	Grade 12
1	LO 1 Scientific Inquiry And Problem Solving Skills	AS1 Identifies and questions phenomena and plans investigation	1. Identifies and questions phenomena	1.Identifies phenomena involving one variable to be tested	1.Generates and test hypothesis based on identified phenomena for situations involving more than one variable
2		AS2 Conduct an investigation by collecting and manipulating data		Systematically and accurately collects data using selected instruments and techniques	4.Compares instruments and techniques to improve accuracy and reliability of data collection
3		AS3.Analyse, synthesizes and evaluate data and communicate findings	6.analyse, synthesizes, evaluates data and communicates findings	6. Compares data and constructs meaning to explain findings	7.Critically analyses, reflects on and evaluates findings
4		AS1.Access knowledge	1.Uses prescribed method to access information	1.Uses various methods and sources to access information	1. Uses various methods and sources to access relevant information from a variety of context
5	LO 2 Life Sciences knowledge	AS2 Interprets and makes meaning of knowledge in Life Sciences	2.Identifies concepts, principles, laws, theories and models of Life Sciences in the context of everyday life	2.Identifies, describe and explains concepts, principles, laws, theories and models by illustrating relationships	2. interprets, organises, analyses, compares and evaluates concepts, principles, laws, theories and models and their application in a variety of ways
6		AS3 Shows understanding of how life sciences knowledge is applied in everyday life	4.Organises, analyses and interprets concepts, principles, laws, theories and models of life sciences in the context of everyday life	4. Analyse and evaluates the costs and benefit of applied Life Sciences knowledge	3.Evaluates and presents an application of Life Sciences knowledge
7		AS1 Explores and evaluates the scientific ideas of past and present cultures	1.Identifies and investigates scientific ideas and indigenous knowledge of past and present cultures	1.Compares scientific ideas and indigenous knowledge of past and present culture	1.Critically evaluates scientific ideas and indigenous knowledge of past and present cultures

8	**LO 3 Life Sciences, technology, Environment and Society**	**AS2 compares and evaluated the uses and developments of resources and products and their impact on environment and society**	**2.Describes different ways in which resources are used and applied to the development of products, and report on their impact on the environment and society**	**2.Compares different ways in which resources are used in the development of biotechnological products, and analyse the impact on the environment**	**2.Analyse and evaluates different ways in which resources are used in the development of biotechnological products, and make informed decisions about their use and management in society for a healthy, sustainable environment**
9		**AS3 Compares the influence of different beliefs, attitudes and values on scientific knowledge**	**3.Analyses and describes the influence of different beliefs, attitudes and values on scientific knowledge and its application to society**	**3.Copmares scientific ideas and indigenous knowledge of past and present cultures**	**3.Critically evaluates and takes a justifiable position on beliefs, attitudes and values that influence developed scientific and technological knowledge and their application in society**

Table 1.2 above shows the progression of the assessment standards from Grade 10 to Grade 12. It also indicates what a learner should be able to do to show that he/she has achieved each learning outcome in each grade.

1.9 Introducing evolution into the Life Sciences curriculum

During the revision of the Interim Core Syllabus, one of the challenges that faced the Biology curriculum was the argument about the 'Creator Clause' which was present as one of the objectives of the science curriculum. The objective states that "the child becomes aware of the Majesty of creation through his acquaintance with the wonder and order of creation.........and in this way develops a sense of awe and reverence of the Creator" (Jansen, 1999, p.62). The argument was that the 'Creator clause' should be removed. It was felt that the 'Creator Clause' reflected the dominant ideology of Christian National Education and it was thought that it might interfere with the teaching of evolution. The clause was then removed.

A school Biology curriculum which fails to mention the word "evolution" as was the case with Interim Core Syllabus (ICS) under the Christian National Education has to be seen as being critically flawed and in need of revision (Johnson, 2009). Lever (2002, p.41) mentioned that the exclusion of Darwin's theory of evolution by natural selection from South African Biology curriculum served to reduce the syllabus content to a “tedious compendium of facts for children to regurgitate”. By omitting evolution, which is a concept regarded as biology’s highest integrating principle, the ICS presented the subject as being weak (Johnson, 2009).

Lever’s paper formed a point of departure for a meeting where different stakeholders in South Africa came together to discuss their views on the introduction of evolution into the school curriculum (James & Wilson, 2002). This meeting led to the inclusion of evolution in the Natural Science syllabus for the GET phase.

Similarly, Le Grange (2008) argues that topics such as evolution were not explicitly stated in the school curriculum (ICS) but only appeared under sections for enrichment. The reason he gives is that it was so because of the religious beliefs of the ruling government at that time.

1.10 The National Curriculum Statement (NCS) for Life Sciences

In constructing the National Curriculum Statement (DoE, 2003), debates which focused on the language of the curriculum and the selection of what was to be taught emerged. In the course of public comment on the draft of the Revised National Curriculum Statement grade R-9 (RNCS), a vocal campaign against the teaching of evolution was conducted by the Christian Right. The selection of what was to be taught, mainly in the Social Sciences curriculum but also in Natural Sciences, was contested (Chisholm, 2002). Not all Christians and other people of the religion felt the same way about the curriculum and its treatment of evolution (Chidester, 2002 as cited in Chisholm, 2005).

The National Curriculum Statement (DoE, 2003) Life Sciences policy was gazetted in 2003 and was first implemented in 2006 in Grade 10, the first year in which the subject names were changed. Learners in Grade 11 and 12 continued with the ICS. In 2007 National Curriculum Statement grade 10-12 was introduced in Grade 11 followed by its introduction in Grade 12 in 2008.

This National Curriculum Statement included new topics, such as social and environmental issues. 2008 was the first year that the theory of evolution was taught in South African schools. All the concepts of evolution were introduced and taught to learners for the first time when learners were in Grade 12. Learners had to write their final examination containing questions based on evolution in November 2008. The introduction of the theory of evolution in 2008 in Grade 12 content posed a tremendous challenge for South African teachers when one considers that during their teacher education programmes, many teachers who trained in the colleges of education or some universities pre-1994 were not taught about the theory of evolution. This was prohibited because of the ideology of the Christian National Education policy of the National Party government prior to 1994. Most Life Sciences teachers had very little subject matter knowledge to teach the theory of evolution. This is one of the reasons I became interested in conducting this study, which involves Life Sciences teachers and their understanding of evolution.

Reactions to National Curriculum Statement (DoE, 2003) for the Life Sciences were mixed. The inclusion of socially relevant content in the National Curriculum Statement (DoE, 2003) Life Sciences was welcomed by some researchers, such as Le Grange (2008). Le Grange (2008) argues that the new curriculum has marked a shift from a “science of life to a science of living” approach. Le Grange (2008) reports that school Biology (as it was so called before the subject name change) was focused mainly on plants and animals and later it expanded and included molecular biology, ecology and genetics. The order of presentation of topics in the National Curriculum Statement (DoE, 2003) changed from the Interim Core Syllabus, with some topics that were previously taught in Grade 12 being moved to either Grade 11 or Grade 10.

National Curriculum Statement (DoE, 2003) had a three-year lifespan. Dempster and Hugo (2006) criticised the lack of coherence and sequencing in NCS, particularly with regard to the teaching of evolution. This lack of coherence is mapped in detail by Johnson (2009). Dempster and Hugo (2006) showed that the foundations for understanding evolution were present in the Natural Science curriculum, but not carried through to Grade 10. They argued that effective teaching of evolution rests on foundational concepts that need to be established before presentation of the theory of evolution. They included awareness of deep time and the fossil record, awareness of the scope of diversity, but similarities within major taxonomic groups, and awareness of biogeography as foundational concepts that should be established before the theory of evolution is presented.

1.11 The New Content Framework for Life Sciences (NCS2)

As a result of critical comment on the content specification for NCS1, a revision of the content was conducted in 2006 and 2007. NCS1 was then replaced by NCS2 which was phased in from 2009 in Grade 10. NCS 2 also has a three-year life span, since it will be replaced by the Curriculum and Assessment Policy in 2012. It was examined for the first time in 2011 in Grade 12. Table 2.2 shows some content topics that changed grades in NCS2.

Table 1.3: **Topics in the Life Sciences syllabus that have moved from one Grade to another. (Grade 10-12) (Maintaining Standards Report. Part 2, 2008)**

	A	B	C	D
1	**Topic**	**ICS Grade:**	**NCS1 Grade:**	**NCS2 Grade**
2	Photosynthesis	12	10	10
3	Cellular Respiration	12	10	10
4	Nutrition	12	10	10
5	Gaseous exchange	12	10	10
6	DNA structure and function	11	12	12
7	Human reproduction	11	12	12
8	Excretion	12	11	11
9	Plant water relations	12	11	11
10	Evolution by natural selection		New in Grade 12	12
11	Environmental issues		New in Grade 12	11

Johnson's (2009) analysis of the changing curriculum for Biology and Life Sciences over the period 1994 – 2008 showed that the National Curriculum Statement 1 that was used from 2006-2009 contained more subject matter that was relevant to daily life than the Interim Core Syllabus, but that progression and coherence were lacking. The National Curriculum Statement 2 for Life Sciences had better progression and coherence, particularly in the strand "Diversity, Change and Continuity". Awareness of the long history of life on earth was established in Grade 10 and descent with modification and biogeography in Grade 11. The theory of evolution by natural selection was formally studied in Grade 12.

1.12 Curriculum and Assessment Policy for Grade 10-12 (2012)

In 2009 there was a review of the Revised National Curriculum Statement Grade R-9 and National Curriculum Statement for Grade 10-12. The two curriculum statements were amended in 2009 and a single curriculum and statement policy document was developed for each subject. This new curriculum (Curriculum and Assessment Policy Grade R-12) is a policy for teaching and learning in South Africa. It comprises of the following:

1. Curriculum and Assessment Policy Statement (CAPS).
2. Promotion requirements for Grades R-12.
3. National Protocol for Assessment Grades R-12.

CAPS has been implemented in Grade 10 as from January 2012 into South African schools.

1.13 Layout of the Dissertation

My study consists of five chapters. I use chapter one to clarify the focus of the study, to briefly describe the conceptual framework and research design to be used and to define the rationale of the study in a South African context. The key research questions that direct the study are also discussed.

In chapter two I review literature in the field of study. I examine the Life Sciences curriculum in South Africa. The background of the study in terms of Life Sciences curriculum changes in South Africa was also presented. I also review the need for science curriculum revision by describing the reshuffling of topics from grade to grade in the Life Sciences curriculum. I also review the literature about the teaching of evolution in South African contexts as well as in other countries. Finally I discuss the conceptual framework designed by Lee Shulman (1986) on teachers' pedagogical content knowledge. This literature will be used to synthesize the findings in chapter four.

The methodology chapter identifies the paradigm in which I place my research study. The process I used to capture and analyse data is also detailed in this chapter. The limitations of the study are also identified.

In chapter four I present my findings and I provide both quantitative and qualitative analysis of data. The quantitative data are presented in the form of tables and graphs whereas the qualitative data are presented in the form of discussion and text from the interviewees. The qualitative data are used to demonstrate a deep knowledge of the theory of evolution by the participants.

Chapter five presents the overall discussion on the findings from the quantitative and qualitative data as well as the conclusion and recommendations based on the findings of the study.

It is hoped that the results of my study would provide facilitators involved in the training and preparation of teachers with necessary insight into the needs and challenges of teachers. I also see this experience as part of my long journey in improving my teaching and learning practice.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This literature review aims at highlighting education reform in South Africa particularly the Life Sciences curriculum reform for the past few years. This is done in order to provide background for understanding the introduction of the theory of evolution in the school curriculum in the Further Education and Training (FET) (Grades 10- 12) Phase and the implications of the implementation process of this new curriculum in Grade 12 in 2008. Furthermore, previous studies are reviewed which have a relationship to this study. Most of these studies focus on the teaching of evolution, as well as attitudes, beliefs and misconceptions by students and teachers about the theory of evolution.

2.2 Curriculum Coherence in Science

Newman, Schmidt, Allensworth & Bryk (2001, p.301) define curriculum coherence as "sensible connections and co-ordination between the topics that students study in each subject within a grade and as they advance through grades." Schmidt, Wang and McKnight (2005) argue that the subject matter should progress from particular to deep knowledge structures which connect particular topics, and that this progression should occur both within and across the grades. They argue that curriculum coherence is vital for successful induction into a subject and that new topics should not be introduced before the pre-requisite knowledge has been covered. They further point out that progression should represent a continuing penetration of the discipline moving to a deeper structure.

Bybee (2003) argues that science teachers need to have an understanding of the science they teach in relation to other ideas or topics in science. If science teachers lack this understanding, the expectations of the new curriculum may never be reached and teachers will fail to assist students to understand science as a coherent subject (Bybee, 2003). Coherence in science is described by Bybee (2003) as a group of related ideas representing a coherent structure with unifying concepts such as diversity and evolution of living organisms. Curriculum materials in high-performing nations focus on fewer topics, but also communicate the expectation that those topics will be taught in a deeper and more profound way (Schmidt, McKnight, Valverde, Houang, Wang, Wiley, Cogan & Wolfe, 2001).

Coherence in science means making real choices about what to teach in science and how to teach it and articulate those choices in a consistent manner (Newman et al., 2001). Curriculum coherence in science is one of the keys to the learning and understanding of science. The teachers' responsibility is to help students to understand the science they teach and during teaching there should be connections among the ideas which will provide a coherent teaching experience for learners (Eberle, 1990).

2.3 Need for Science Curriculum Revision

The goals of science have been debated continuously since the inception of science as a school subject in the late 19^{th} century (Aikenhead, 2006). The goals of school science education are determined by numerous factors such as historical, political, economical and sociological context, the agents that are responsible for drawing up the curriculum. None of the above is static and because of that the science curriculum needs to be revised more often than other subjects (Roberts, 1988).

Donnelly (2006, p.623) argues that science as a school subject is "the most revised of established curriculum areas." He points out that science curriculum is revised to keep pace with advances in scientific knowledge. According to other researchers it is also revised in response to the concern on the part of the state, higher education institutions, teachers or public about the students' poor performance in the subject or in international comparative tests such as TIMSS (Adler, 2006; Valverde, 2005).

Science education has been researched and discussed by various authors such as Le Grange (2008); Rosenthal and Bybee (1987); Goodson (1993) and Atkin and Black (2003). Morais and Neves (2001) argue that science curricular revision may be due to the changes in socio-political landscape. A new socio-political context results in the revision of the science curriculum. The revision of the curriculum is determined by the goals of the agents that are responsible for drawing up the new curriculum. Some researchers argue that science should be meaningful to the students and relevant to life outside school (De Feiter & Ncube, 1999). The government, parent bodies and interest groups like religious organisations also play a role in shaping the science curriculum. These groups have a say in what should be/not be included in the school science curriculum, in particular with regard to socially controversial biological issues in the curriculum (Johnson, 2009). Science should also be revised because of socio-economic reasons. Science and technology should be part of every student's education so as to equip them with knowledge required for global economic competitiveness (De Feiter & Ncube, 1999).

2.4 The Impact of Curriculum Reform

Studies of policy implementation assume that those who will have to implement the new policies understand "the intended policy message" (McDermott, 2006, p.6). Failed implementation may mean that implementers honestly did not understand what policy makers intended them to do. The implementation process becomes ineffective if teachers have insufficient confidence and mastery of both subject content and basic teaching skills. Knowledge and understanding of content is considered to be the most important factor for a teacher to teach effectively (De Feiter, Vonk & Van der Akker, 1995, p. 46).

Research by Schneider and Krajcik (2002) has found that enacting reform-based curriculum is not easy. There are many challenges regarding the teaching of a reformed curriculum, such as teachers' knowledge of various techniques to promote learning and teachers' understanding of the new content. During the implementation of the new school curriculum, teachers become novices again (Schneider & Krajcik, 2002). Curriculum materials have been designed to support learners not to support teachers' learning. In order to support learning, Ball and Cohen (1996) suggest that curriculum materials should be designed in a manner that is educative for teachers.

Rogan (2007) examined how science teachers responded to C2005 when it was implemented in South African schools. He studied science teachers in one of the rural schools in Mpumalanga Province in South Africa. His study found that there was a gap between what was intended by the new curriculum (policy) and what the teachers were really doing (practice) in their classrooms. There were factors that hindered the implementation of C2005. Rogan (2007) argues that implementation strategies are effective when they take place ahead of the practice. In other words he states that curriculum implementation strategies should be "within the zone of feasible innovation" (Rogan, 2007, p.100). According to him there should be capacity to support that innovation before it is implemented. Teachers should be given time to understand C2005 and its intentions, and should be given enough time to shift their mind (paradigm shift) from the old (NATED 550) to the new (C2005) curriculum as to be able to enact the reformed curriculum.

2.5 Teachers and Introduction of Evolutionary Principles and Ideas into School Curriculum in South Africa

The introduction of the theory of evolution in 2008 in the Grade 12 curriculum posed many challenges for teachers. Some of the challenges were the complexity of the topic, the teachers' content knowledge about the curriculum and their attitude towards the proposed curriculum. This left some of the Life Science teachers not knowing how to deal with the topic in their classrooms. One of the reasons was that most of the teachers did not study evolution during their teacher training at tertiary level. This was mentioned by most of the teachers during the workshop in February 2008 prior to the teaching of this theory. Fullan (1991) argues that the success or failure of curriculum change depends on what teachers do and think of the new curriculum changes and how they respond to new developments. This is particularly true when the topic of evolution is introduced, as was the case with the NCS Life Sciences.

> “The theory of evolution states that the diversity of life on this planet is due to slow changes that happened over millions of years. Furthermore, all present-day life forms have descended from, and are related to, those that lived in the past” (Clitheroe, Dempster, Doige, Marsden, Mbambisa, Sinleton, & van Aarde, 2010).

According to Veal and Kubasko (2003) evolution is one of the unifying concepts in Biology. The theory of evolution states that life began after the earth was formed approximately 4.6 billion years ago. Evolutionary theory is supported by empirical, data-driven evidence and explanations. New evidence in evolutionary theory has altered the scientific understanding through time and will continue to do so as new discoveries and evidence are being added to existing knowledge base (National Academy of Science, 2008). Table 2.3 indicates how the theory of evolution was introduced in the Life Sciences curriculum from 2008.

Table 2.1: Roll-out of versions of the NCS 2006-2011, and evolution-related topics. (Adapted from: Dempster, 2010)**

National Curriculum Statement (NCS1)

National Curriculum Statement (NCS2)

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
1			**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
2	**Grade 10**	Curriculum	NCS1	NCS1	NCS1	NCS2	NCS2	NCS2
3		Evolution Topics	No Evolution			History of life		
4	**Grade 11**	Curriculum	ICS	NCS1	NCS1	NCS1	NCS2	NCS2
5		Evolution Topics	No Evolution				Descent with modification	
6	**Grade 12**	Curriculum	ICS	ICS	NCS1	NCS1	NCS1	NCS2
7		Evolution Topics	No evolution		Theory of evolution			Genetics

There are four knowledge areas for Life Sciences in the NCS:

* Tissues, cells and molecular studies

* Structure and control of processes in basic life system

* Environmental studies

* Diversity, change and continuity

Content related to evolution is located in the knowledge area Diversity, change and continuity. Topics within this knowledge area in Grade 12 in the NCS1 version of the Life Sciences curriculum are:

- Origin of species
- Evolution theories, mutation, natural selection, macro-evolution and speciation
- Fundamental aspects of fossil studies
- Cradle of humankind (South Africa)
- Biological evidence of the evolution of populations
- Popular theories of mass extinction (DoE, 2007).

The problem with NCS1 was that the curriculum lumps the entire topics relevant to evolution in Grade 12. NCS2 curriculum builds up the theory of evolution from Grade 10 to 12. In Grade 10, learners are taught:

* The history of life on Earth and fossil record

- The diversity of life, which can be grouped into six kingdoms.

In Grade 11, learners are taught:

- Descent with modification
- Biogeography
- Major phyla of plants and animals, and the relationships between the phyla.

In Grade 12 learners are taught:

- The theory of evolution by natural selection
- Genetics.

The spread out of the theory of evolution in the NCS2 makes it easier for learners to understand evolution by natural selection because the foundations are laid in Grades 10 and 11 (DoE,2007).

2.6 Teaching the Theory of Evolution in South African Schools

Ngxola and Saunders (2008) investigated how one of the institutions (an in-service training centre) may influence teachers’ knowledge about evolution and attitudes towards the teaching of evolution. Their study involved 125 South African secondary school teachers who were expected to teach evolution for the first time. Data was collected from four different groups of teachers who attended in-service workshops on the teaching of evolution. According to Ngxola and Saunders (2008), the introduction of evolution posed some challenges to Life Sciences teachers, since the majority of them were not well trained on how to teach the new curriculum in general, and particularly the topic of evolution (Ngxola & Saunders, 2008; Stears, 2006). The results showed that some teachers had knowledge gains in aspects of evolution and their attitudes changed positively, although some misconceptions were not changed by their visits to the centre (Ngxola & Saunders, 2008).

The introduction of the theory of evolution in South African school curriculum in 2008 has led to several studies being conducted by different scholars. Abrie (2010) investigated the attitudes of South African student teachers towards the theory of evolution and their willingness to teach it. The participants were first, second and third year students who were training to become Biology teachers at one university in South Africa. These student teachers had completed matric prior to 2008 and they had to interpret the new curriculum as secondary school Biology teachers with very little training about the theory of evolution. Results revealed that about 89% of the participants reject evolution giving the reason that they were religious. About 70% of the participants felt that they were adequately prepared to teach evolution but the data revealed that these teachers have a poor understanding of evolution and they had many misconceptions (Abrie, 2010). Of the participants, 76% agreed that it was important for Life Science teachers to understand the theory of evolution well enough to be able to make sense of the subject in general (Abrie, 2010).

Another study with students who were doing their final year in Biology education as part of a BEd degree in a university in South Africa was conducted recently by Stears (2011). This research study involved 24 final-year Biology students. The purpose of the study was to determine students' scientific understanding of evolution after they had completed the module in evolution as well as to explore the relationship between students' understanding of evolution and their understanding of the nature of science. Furthermore, the study wanted to find out how these students view the evolution/religion conflict and how this may influence their teaching of evolution (Stears, 2011).

The findings were that, at the end of the module, students showed some improvement in their content knowledge and a considerable improvement in their understanding of the NOS. With regard to their attitudes towards evolution; they showed a better understanding and altered their views of the conflict between science and religion. Stears (2011) suggests that teacher education programmes should focus on improving understanding of the NOS, and to give support to students on how to deal with conflict that may arise during teaching in their classrooms. She argues that teacher education should not only focus on conceptual understanding of evolution.

2.7 Teaching the Theory of Evolution in Other Countries

The topic of evolution in the science curriculum has been a persistently controversial issue in American education for decades (Veal & Kubasko, 2003). The debates that emerged in the United States of America regarding why and how evolution is taught have influenced the teaching of science curricula (Veal & Kubasko, 2003). Although evolution in the United States of America remains controversial for many people, its teaching is still required by the curriculum in most states (Veal & Kubasko,2003). Teachers need to be aware of the controversy surrounding evolution and must approach this topic with sensitivity and finesse.

The controversy about the teaching of evolution in schools is because for many people the ideas on the theory of evolution contradict their religious beliefs. The issue of science and religious beliefs likely will not subside and teachers who implement the curriculum will feel the impact of these divergent positions (Veal & Kubasko, 2003). But according to Branch (2009) learning and accepting evolution does not need to threaten personal religious beliefs. In his article, he mentions that teachers should consider the following factors as a pre-requisite to handle controversies:

Teachers should:

- Respect the views of others.
- Insist on testable ideas (sometimes learners would come with opposing ideas to evolution and they should ask whether the idea is testable or not).
- Acknowledge ignorance (if a teacher does not know the answer to a problem raised by a learner, he/she must acknowledge that, then search for it later).
- Distinguish the roles of science and religion in that science by definition is limited to the material world but does not provide moral guidance (e.g. a person cannot turn to science for life values but the Bible can provide these (Branch, 2009).

Some teachers ignore teaching evolution because they have not been trained in the subject; they fear controversy and do not know how to handle it (DoE,2009). Teachers should emphasise to their learners that evolution is a well-established fact which is supported by multiple lines of evidence (Branch, 2009). Without evolutionary theory, Biology is divested of the needed themes, coherence, understanding and interpretation of relationships (Cavallo & McCall, 2008). The National Academy of Science (National Academy of Sciences, 2008) as in Cavallo and McCall (2008) state that, evolution is a core concept in Biology based on the study of past life forms and the study of the relatedness and diversity of present-day organisms. The rapid advances now being made in the Life Sciences and in medicine rest on the principles derived from an understanding of evolution (National Academy of Sciences, 2008).

Evolution is an interesting subject. It is the unifying theme in Biology. Dobzhansky (1973) went so far as to say “Nothing in Biology make sense except in the light of evolution”. So it is important for students to understand the theory of evolution because it provides the foundation upon which other concepts can be built and it also provides a framework into which complex biological systems fit (Nieswandt & Bellomo, 2009). Scharmann (2005, p.13) points out that the theory of evolution is considered “as the most contemporary problem-solving tool at the disposal of biologists”. Its teaching is of crucial importance to pupils and essential to scientific literacy.

The teaching of evolution is also determined among other factors by the attitudes of teachers and their knowledge base. A study of the comparison between Korean and American teachers’ understanding of evolution and nature of science as well as their acceptance of evolution found that Korean science teachers showed moderate evolutionary acceptance levels when compared to American science teachers’ samples. Korean teachers’ understanding of the nature of science was related to their acceptance and understanding of evolution (Kim & Nehm, 2010).

Studies in the United State of America (Cavallo & McCall, 2008; Chuang, 2003; Veal & Kubasko, 2003) about the evolutionary knowledge among science teachers have revealed that there is a range of practices, beliefs, attitudes and competences and deliberate non-teaching of evolution. About half of the science teachers from New

York City, California and Indiana preferred that creationism or intelligent design be taught in public schools (Nehm & Schofold, 2007; Troost, 1966)

Research by Donnelly and Boome (2007) reveal that in some states in the United States of America, teachers allocate very little time to teaching evolution in their classrooms. Many teachers hesitate to teach evolution in a thorough manner because they do not fully understand the theory (Rutledge & Warden, 2000).Griffith & Brem (2004) argue in their study that many teachers face challenges from students and the local community when they do teach evolution. Some parents oppose the teaching of evolution to their children because of strong religious beliefs. It was also reported that a small number of teachers have faced criminal charges when they tried to teach evolution to their students (Griffith & Brem, 2004).

It has been established that in America as well, some science teachers do not want to teach evolution in their classroom (Aguillard, 1999; Eve & Dunn, 1990) because they do not feel adequately prepared to teach the topic (Griffith & Brem, 2004). It has also been discovered through research that science teachers' knowledge of evolution and the nature of science is often very low and some teachers possess naive scientific worldviews (Moore, 2008).

A survey of high school biology teachers in USA reveals that teachers' qualifications were a contributing factor to how to deal with the topic of evolution during teaching (Berkman, Pacheso & Plutzer, 2008). Teachers who completed all college credits in Biology and Life Sciences (highest qualification) were best prepared and devoted more class time to evolution than teachers with lower college credits. According to Miller, Scott & Okamoto, (2006) ambivalence or antipathy towards evolutionary knowledge is not only an American problem; many regions of the world, except Europe, are struggling with the issue of evolution education. Studies in Asia reveal that lower ability teachers find it more difficult to answer questions about evolution than about ecology. Out of 70 secondary schools and junior teachers in South Korea that were studied, a quarter felt that evolution was based on speculation (Kim & Nehm, 2010). What science teachers teach depends on their scientific understanding and skills.

Chuang (2003) studied the attitudes and strategies of educators in Utah universities regarding the teaching of evolution. The educators were requested to provide a statement as to how they handled students' challenges to evolution. A total of 78 teachers, representing teachers in eight different universities throughout Utah, replied to the survey. Among the challenges that emerged during their teaching are misconceptions about the theory of evolution. For instance teachers in their statements revealed that students believe that evolution is just a "theory". According to students the word "theory" is used loosely to mean a "guess". They do not understand that in science a theory is "firmly grounded in and is based on evidence" (National Science Teachers Association, 1997, p.187). Another misconception that emerged was that students think that "humans come from monkeys". This is based on incorrect description of scientific conclusions, which state that humans and other primates (including monkeys) share a common ancestor. This does not mean that humans descended directly from monkeys. In order to deal with these challenges, teachers stated that they emphasise to their students that evolutionary change does occur by showing them evidence for mechanisms of evolution such as antibiotic resistance (Chuang, 2003).

Prinou, Halkia and Skordoulis (2003) studied 111 teachers who teach Biology in secondary schools in Greece. They based their research on teachers' attitudes, views and difficulties during the teaching of evolution. Their study revealed that the majority of teachers had a positive attitude towards the teaching of evolution. However, the data revealed a lack of knowledge by a large part of the teachers in the study, particularly about natural selection (Prinou, Halkia & Skordoulis, 2003).

Very few research studies have been conducted locally around the issue of the theory of evolution and its teaching. The reason might be that the theory of evolution was never taught in South African schools prior to the National Curriculum Statement (2003). This research is trying to contribute towards the literature about knowledge of the Life Sciences teachers with regard to the theory of evolution and the teaching challenges in the South African context. While it may be tempting to assume that teachers who teach Life Sciences in Grade 12 exhibit a strong understanding of evolution, misconceptions that are not corrected may carry over to their learners. The goal of my study is to examine the degree of understanding of evolutionary processes among the Life Science teachers and to ascertain their challenges that they face while teaching the theory of evolution to their learners.

2.8 Conceptual and theoretical framework

2.8.1 Conceptual Framework

Teaching is a complex activity that requires teachers to understand content and pedagogy as they come together to support students' learning in the contest of their classrooms (Magnusson, Krajcik & Borko, 1999; Shulman, 1987). Shulman (1986) and later (1999, 2004) proposed a framework of knowledge areas that are necessary for science teaching to be successful. He classified these knowledge areas into:

- Subject matter (content) knowledge (SMK).
- Pedagogical knowledge (PK).
- Pedagogical content knowledge (PCK).

Shulman's framework proposes that teachers should master content of the subject they are expected to teach as well as knowledge of curricular development. Although Shulman (1987) has proposed the three knowledge areas that the teachers must display in their teaching, my study will only investigate one aspect i.e. **"Subject matter knowledge".** This aspect will provide a lens through which we can view and understand the topic of the research study.

Diagrammatically, we can represent Shulman's contribution to the scholarship of teacher knowledge by three circles which show the inter-relationship among the three knowledge areas.

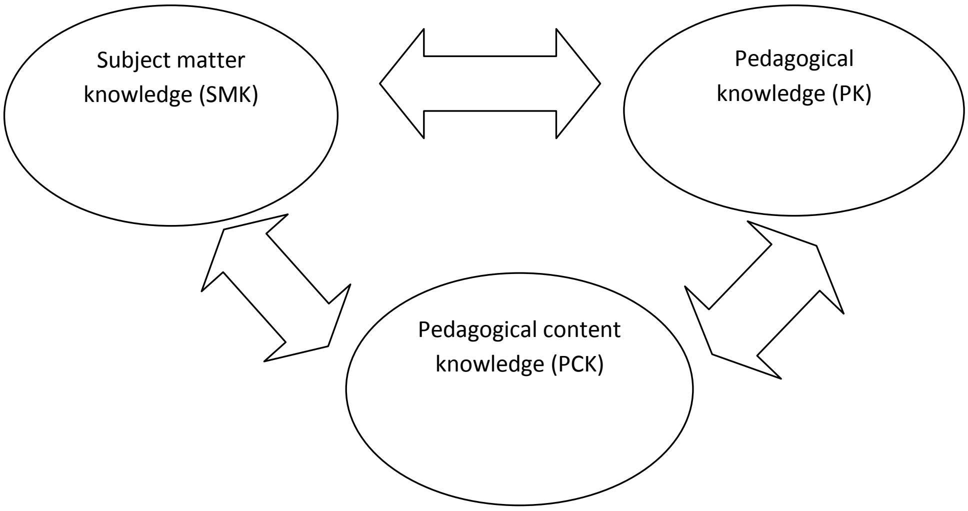

Figure 2.1 Shulman's knowledge areas (1987).

According to Shulman (1987):

Subject Matter Knowledge (SMK) can be described as the knowledge and understanding of central concepts of a discipline, factual information and organising principles of a specific discipline. It is argued that strong subject knowledge is a prerequisite for effective teaching, so the emphasis is placed on teachers having deep understanding of what they teach (Shulman, 1986; Grossman, 1990; Wilson & Shulman, 1989). Strong subject matter knowledge is essential for the development of PCK.

Pedagogical Knowledge (PK): This knowledge is defined by Shulman (2004, p.92) as "broad principles and strategies of classroom management and organisation that appear to transcend subject matter. It includes ways of maintaining discipline, efficient use of class time and ability to communicate instructions unambiguously." Shulman (1992) emphasises that teaching is intended to help students gain literacy, to make students more responsible, to empower students to discover and understand new information and prepare them to function as part of society. Furthermore, he stresses the need for teachers to also understand the educational purpose of teaching (Shulman, 1987; 1992). It is important to note that this research study is not about the knowledge of PK since it focuses only on teachers outside the classroom context.

Pedagogical Content Knowledge (PCK):

One of the unique characteristics of teachers that distinguish them from content specialists is their knowledge of teaching called pedagogical content knowledge (Shulman, 1986). The concept of PCK identifies what distinguishes a science teacher from a scientist. Shulman (1987, p.69) defines PCK as "the most useful forms of representation of ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations, the ways of representing and formulating the subject that make it comprehensible to others." PCK represents the blending of the content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and presented for instruction (Shulman, 1987). Shulman (1986) highlights the importance of pedagogical content knowledge, and he argues that the knowledge of only subject matter does not make one a teacher. According to Shulman (1986, p.9) "PCK goes beyond the knowledge of subject matter… to the dimensions of subject matter knowledge of teaching." In addition PCK represents content and pedagogy, addressing how teaching methods fit the content and how the components of the content can be arranged effectively for teaching, taking into account the diverse interest and abilities of the learners. According to Shulman (1992), in order to teach effectively, the teachers need to transform the content knowledge into "forms that are pedagogically powerful and yet adaptive to the variety of students' abilities and background".

2.8.2 Theoretical Framework

The study will also be supported by the theoretical framework developed by Rogan and Grayson (2003). According to Rogan and Grayson (2003), for new curriculum implementation to be successful, the strategies to be used to implement the new curriculum should be made known to teachers prior of implementation process. These strategies should be within "the Zone of Feasible Innovation" (ZFI) of the teachers. In order for the innovation process to be effective, teachers need to be knowledgeable about what they are expected to teach (SMK), they must be ready and prepared to implement the new curriculum. The ZFI has three constructs, which will serve as analytical framework in chapter five.

- Outside influences
- Profile of implementation
- Capacity to innovate.

The construct of "capacity to innovate" is appropriate to my study. Under this construct are several factors which can support or hinder the implementation of the reformed curriculum. According to Rogan and Grayson (2003), indicators of "capacity to innovate" fall into four categories:

- **Teacher factors:** professional development, teacher knowledge and understanding of content to be taught.
- **Physical factors:** include provision of physical resources such as textbooks, videos, slides and charts.
- **Learners factors:** How the learners understand the new topic taught to them.
- **School ethos and management:** the support given to teachers to implement the new curriculum. (Rogan and Grayson, 2003).

Only the "teacher factors" will be investigated in this study, since this research is about the knowledge of the Life Sciences teachers with regard to theory of evolution.

By using the framework, this study will be able to analyse the "Zone of Feasible Innovation" of the teachers during the discussion of the interviews in chapter five.

2.9 Importance of Professional Development of Teachers

Government officials focus only on curriculum development (Bower, 2002), try to adapt the existing curriculum to local context or scale up the curriculum reforms through the professional development of the teachers (Loucks-Horsely, Hewson, Love & Stile, 1998). They do not emphasise the importance of implementation and sustainability of the reformed curriculum (Loucks-Horsely et al., 1998). Furthermore Banilowe, Heck and Weiss (2007) argue that professional development which is content-based and takes into consideration the diverse contexts of the classroom will impact positively on students' learning.

Fullan (1991, p.127) emphasises the importance of professional development opportunities and in-service teacher education. He argues that implementing a newly introduced curriculum into teaching may be a very complex and difficult thing to achieve. So he suggests the following changes to be useful for successful implementation of curriculum reform (Fullan, 1991, p.130):

- New curriculum materials
- New knowledge and skills required by the teachers
- New values and attitudes concerning students' learning and
- New patterns of work in the classroom.

According to de Feiter, Vonk, and van den Akker, (1995), teaching materials to be used during the implementation of innovation should provide support for teachers. Enough opportunities should also be given to teachers to practise the new curriculum in a safe environment (Joyce & Showers, 1988) and support from school to try new changes should be provided.

The World Bank Report (1998) indicates that teacher quality and supportive school organization and management significantly influence school improvement and eventually pupil learning. Furthermore, the quality of a teacher is generally dependent on the quality of his or her education, training and the availability of in-service-training programmes (World Bank Report, 1998). Teacher performance and quality are affected by the educational qualifications of teachers, adequate teacher performance monitoring systems, the upgrading of teacher skills and growth oriented career structures.

Fullan (2001,p.142), on the other hand, argues that there are factors that affect the implementation of reformed curriculum, such as characteristics of the change itself, i.e. complexity of the change, practicability of the new programme, local factors such as teachers and principals themselves and how they accept the change and understand and implement the reformed curriculum, as well as external factors which include the community, technology and the teaching profession. In order for a change to be successful, there should be support from the district level, in providing the necessary resources and professional development for teachers (Datnow & Stringfield, 2000). However, the implementation of curriculum reform depends mostly on the understanding of subject matter by the teachers, the way they teach as well as teaching and learning (Powell & Anderson, 2002). Teachers' knowledge and beliefs about the nature of the new curriculum determine what actually happens in the classroom (Powell & Anderson, 2002).

In the South African context, the poor performance of learners in questions based on the theory of evolution in the 2008 external examination points to a breakdown in the curriculum implementation of this new topic. There could be many reasons for the breakdown. This study investigates one reason, which is teacher content knowledge.

2.10 Conclusion

I have highlighted the changes in the Life Sciences curriculum in South Africa and the introduction of the theory of evolution in Grades 10-12. I also considered the need for on-going science curriculum revision. I have also highlighted certain pivotal studies in the teaching of the theory evolution in South Africa as well as in international countries, and have also discussed the importance of professional development of teachers for successful reform.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter provides details of research design and methods used in this research. The chapter focuses attention on the methodological process I chose in order to generate and analyse data. Henning, van Rensburg & Smith, (2004) refer to methodology as a coherent group of methods that complement one another and that have goodness of fit to deliver data and findings that will reflect the research purpose. She continues to argue that if methods have been blended together well, they are able to render a thick description of the theme of the study and thick description of methodology itself. In this chapter, first the research focus is described, followed by the research paradigm. Thereafter design issues related to the data sources and procedure followed are described.

3.2 Research Focus

The study focuses on Life Sciences teachers and their knowledge and understanding of evolution. It also focuses on the challenges that emerge during the teaching of evolution. Personal experience and evidence from the performance of learners in paper two of Life Sciences in 2008, confirm that at that stage many learners did not understand the theory of evolution. They lacked adequate knowledge to answer the exam questions based on the theory of evolution. The problem I wish to investigate is whether teachers' content knowledge about evolution is a possible reason why learners performed so poorly in this section in Grade 12 examinations.

3.3 Research Approach

For this study I proposed to employ a mixed method design using multiple methods and mixed methodology as suggested by Saunders, 2003, Leedey & Okamoto, 2005; and De Vos, 2002. Saunders (2003, p.481) defines methods as “the tools and techniques used to obtain and analyse research data.” Leedy et al. (2005, p.12) defines methodology as “the general approach the researcher takes in carrying out the research project”. Babbie and Mouton (2001,p.74) describes a research design as a plan or a blueprint of how one intends conducting the research. The research design deals with the logical sequence that connects the questions to the collection and interpretation of data, analysis of findings and the interpretation and implications of findings (Babbie & Mouton, 2001).

This study uses questionnaires to collect quantitative data and semi-structured interviews to capture qualitative data. Different methods may be used for different purposes in a study and using different methods will, in turn, facilitate triangulation. The questionnaire used for this study consists of 30 multiple choice questions on topics which are in the curriculum and which relate to evolution. The questionnaire is thus a survey to ascertain teachers’ background knowledge about the theory of evolution. The interview questions were designed in such a way that they are open-ended and allow respondents to express themselves in terms of their attitude and acceptance of the theory of evolution as well as the challenges they encounter in the classroom during the teaching of the theory of evolution.

3.4 Research Paradigm

This study aims to answer questions about the nature of understanding of the theory of evolution by the Life Sciences teachers in one of the education circuits in Pietermaritzburg. It was the intention of this study to address the following research questions:

1. What content knowledge do the Life Sciences teachers possess regarding the theory of evolution?

2. What challenges besides content knowledge do the teachers encounter during the teaching of evolution?

3.4.1 Pragmatic Paradigm

Bryman (2006) defines a paradigm as a cluster of beliefs; it dictates to a scientist in a particular discipline what should be studied, how research should be done and how results should be analysed. In contrast Tashakkori and Teddie (1998) describe paradigms as opposing worldviews or belief systems that guide the decisions that the researchers make. The paradigms have traditionally fallen into two categories according to the scientists – for example Guba and Lincoln (1988) refer to the two paradigms as 'scientific and naturalistic' whereas Tashakkori and Teddie (1998) refer to them as 'positivist and constructivist'. So in the past a researcher will either use a 'positivist' paradigm or a 'constructivist' paradigm. The two research paradigms dominated research in the 1960s (Tashikkori & Teddie, 1998). But recently there has been a movement towards the mixed methods approach which indicates research designs that use the mixing of both qualitative and quantitative approaches during the data collection phase of the study.

The mixed methods and mixed models debate has led to the emergence of a third set of beliefs, the pragmatic paradigm (Tashikkori & Teddie, 2003). Using the mixed methods approaches as the pragmatic paradigm has become more firmly embedded in research. Pragmatists link the choice of approach directly to the purpose of and the nature of research questions posed (Cresswell, 2003). They use strategies that involve collecting data in a simultaneous or sequential manner using methods that are drawn from both quantitative and qualitative traditions in a fashion that best address the research questions. It is pluralistic, and based on rejection of the forced choice between post-positivism and constructivism.

The pragmatic paradigm implies that the overall approach to research is that of mixing data collection methods and data analysis procedures within the research process (Cresswell, 2003). Most of the research studies are multipurpose, so the pragmatic paradigm helps the researcher to address questions that do not sit comfortably within a wholly quantitative or qualitative research design and methodology (Cresswell, 2003).

3.5 Quantitative and Qualitative Research Approaches

A quantitative style of research is characterised by a number of factors such as the following:

- It measures objective facts
- It focuses on variables such as dependant, independent and controlled variables
- It is value free and focuses on reliability
- It enables statistical analysis.

Newman (1997) argues that quantitative data techniques reduce data in order to see a bigger picture in an objective manner. On the other hand, qualitative data enrich the data, enabling the researcher to see and understand the key aspects of the study in a clear manner. Newman (1997) further says that since each style of research has its own strengths and weaknesses, the best research often combines the features of both the qualitative and quantitative style. This study uses both styles so as to minimise the limitations of one style. The reason I have used two research styles is that they enrich my study as my first research question is best answered by the use of the one style, and the second by the use of the other. Quantitative data was used to provide information on how much knowledge the teachers have regarding the concepts of evolution, since the survey was conducted on quite a number of Life Sciences teachers when compared to the interviews. The qualitative data was used to investigate more deeply how teachers understand evolution, and what challenges emerge during teaching and how they deal with those challenges.

3.6 Population and Sample of Research

According to Morgan (1998), a population is a group of individual persons, objects or items from which samples are taken for measurement. The sample was taken from a population of Life Sciences teachers in the Pietermaritzburg region. Seventy two teachers completed the questionnaires and four of them were interviewed.

I chose to use a purposive sampling technique. The purposive sampling technique is described by MacMillan and Schumacher (1993) as selecting information-rich key informants, groups, places and events to study. Bailey (1987) on the other hand states that, in purposive sampling, the researcher picks only those who best meet the purpose of the study. Similarly Robson (1995, p.136) also contends that samples are chosen because they are likely to be knowledgeable about the phenomenon being investigated.

From my first engagement with the participants, I was careful to ensure that I proceeded in a highly ethical manner. The participants were aware of their rights as participants and I was careful to ensure their anonymity during data collection and data analysis process. They consented in writing to participating in the research, and were informed that they had the right to withdraw at any stage if they wished to.

3.7 Data Collection Techniques

A questionnaire is one of the many instruments that can be used to generate data for survey research. Questionnaires allow the researcher to gather a substantially large amount of data within a short space of time. For the purpose of this study I used structured questions. In designing the questionnaire I wanted to find out about the Life Sciences teachers' knowledge of the theory of evolution. A good questionnaire is designed with its primary focus being to address the research questions.

The questionnaire consisted of 30 multiple choice questions. These questions were divided into three categories. The first ten questions tested knowledge of fossils. The second category of ten questions tested knowledge of natural selection and the third category was made up of ten questions based on genetics and its relationship to evolution. I decided to include questions on genetics because some of the evidence for evolutionary theory comes from molecular biology and genetics. This evidence comes from DNA structure, the sequence of genes and proteins. All of these questions were based on the content in the Grade 12 syllabus. After the questionnaire was designed I discussed it with my supervisor (Dr E.R. Dempster) who is an expert in the field of education, particularly Life Sciences, in order to ensure content validity.

3.8 Reliability and validity

According to Robert, Priest & Traynor, (2006) "reliability and validity are ways of demonstrating and communicating the rigour of the research process and trustworthiness of the research findings" (p.41). Robert et.al. (2006) describe reliability as how far a test will produce similar results when tested or used in different circumstance. Validity is about how close we get to what we believe we are measuring to what we intend to measure (Robert, et al. 2006). The questionnaire used in this study was validated by doing a pilot study to a group of Life Sciences teachers.

3.9 Piloting the Questionnaire

Once the questionnaire is constructed, it is important that the questionnaire undergoes a pilot or pre-test before it is administered to the participants of the research. It is also of vital importance that the piloting of the questionnaire is conducted among the population that is similar to the sample.

In May 2009 the Natal Museum organised a workshop as part of their celebrations for the Darwin Bicentennial. These workshops were held on different days between April and May and were conducted by Dr Dempster, who is currently one of the Senior Lecturers at the University of KwaZulu-Natal at Pietermaritzburg campus. The aim of these workshops was to improve Life Sciences teachers' knowledge about evolution since it was a new topic in Grade 12 the previous year. Life Sciences teachers from different schools around Pietermaritzburg came to attend these workshops. I was granted permission by my supervisor to pilot my questionnaire using the first ten minutes of the workshop. I first introduced myself to the teachers and explained my research study to them. I told them that the success of the study depended on their participation because my study is about Life Sciences teachers and their understanding of the theory of evolution. I told them that participation was free and I gave them the consent form to complete and sign before I gave them the questionnaires. After the pilot study and discussion with my supervisor we agreed to continue using the same questionnaire without any alterations for the research study.

The questionnaire used in this study was a structured one, consisting of 30 multiple choice questions. It was structured because it consisted of closed questions only. I chose to use a questionnaire so as to obtain response from a large number of teachers.

The administration of questionnaires in phase two was done at a secondary school in October 2009, where Life Sciences teachers had gathered to moderate the Grade 12 learners' continuous assessment for the year (CASS). The teachers who attended this moderation workshop were from different high schools (from semi-rural and deep rural areas) that offer Life Sciences in the Vulindlela District. Initially the questionnaires were administered to 80 Grade 12 Life Sciences teachers. Not all the questionnaires were returned. After checking all the questionnaires that I collected from the participants, I discovered that some of them were spoiled. In some of the questionnaires, very few questions were answered. Other teachers chose two letters for a single question instead of one. My final sample of questionnaires for analysis was 70 questionnaires that were almost completed. Under the fossil sub-test, 70 teachers answered all the questions. Under the natural selection sub-test, 70 teachers answered all the questions. In the genetics sub-test, 70 teachers answered all the questions.

3.10 INTERVIEWS

Interviews with four selected educators were conducted at the Natal Museum during the July holidays in 2010. These educators were chosen based on the fact that they are Life Sciences teachers who were involved in the teaching of the theory of evolution when it was first introduced in grade 12 Life Sciences curriculum in 2008. I chose to use the Natal Museum as a venue, because it is centrally situated in town and the teachers were able to come from their different homes. All the interview questions were open-ended, allowing the participants to express their views. I was fully aware of the limitations inherent in using this kind of data collection method, for example, subjectivity and bias could be a problem. In order to overcome this, I decided to use semi-structured interviews which then focused the interview process. Four participants from different geographic areas were interviewed separately. The interviews were conducted in English but some respondents chose to use both English and their mother tongue to answer the questions. A tape recorder and audio tapes were used to record the interviews so as to be able to probe their responses. It enabled me to be engaged fully with the interviewees because I did not have to write everything down.

LeCompte, Schensul and Schensul (1999) argue that in semi-structured interviews, questions are pre-formulated, but answers to those questions are open-ended. They can be fully expanded at the discretion of the interviewer and interviewee and can be enhanced by probes. Similarly De Jager (2005) points out that those interviews provide an opportunity for both interviewer and interviewee to discuss a topic in more details. She mentions that the researcher is free to modify the sequence of questions, change wording, explain them or add to them.

Likewise Bogdan and Biklen,(1992 ,p. 94); Burges (1984, p.185); and Eisner,(1991, p. 104) see good interviews as those where participants can freely express their views and the researcher listens carefully to interviewees, and asks questions for clarification.

Questions in the interview schedule were divided into three sub-categories. The first part of the questions was about each teacher's biography, the second part was based on the concepts used in evolution and the third part was about teachers' challenges during the teaching of evolution in their respective classrooms.

Open-ended interviews were perceived as the most appropriate for this research study. It was hoped that they would capture a detailed comprehensive picture of how Life Sciences teachers understand the theory of evolution.

3.11 Limitations of the Study

This research study is about Life Sciences teachers teaching Grade 12 in one of the districts in Pietermaritzburg. The findings may not be generalizable for the rest of the Life Sciences teachers and their understanding of the theory of evolution.

Due to the fact that some of the participants were known to me, they could have responded in the way they thought I wanted them to respond.

Some teachers refused to complete the questionnaires, stating clearly that they have insufficient knowledge of the theory of evolution since it was new to them and they did not want to expose themselves. My knowledge of the subject could also have influenced the way I interpreted the results from the respondents.

3.12 Conclusion

In this chapter I detailed the methodology and research design employed in the study. The sampling of the participants from a large population was described. Finally the limitations of the study were presented to indicate the methodology hurdles faced by the study. In the next chapter I present the findings of my research.

CHAPTER FOUR

PRESENTATION OF FINDINGS

4.1 Introduction

This chapter focuses on the presentation of data and key findings from my research. What I was looking for in the data was empirical evidence of how the Life Sciences teachers understand the theory of evolution. The themes and findings presented emerged from the data collected through survey questionnaires as well as through individual interviews. The research findings are presented in three stages. The first stage is supported by the data from the questionnaires. This section intends to answer the first research question which is:

What content knowledge do the teachers possess regarding the theory of evolution?

The second stage is supported by the data collected through interviews, particularly data from the first part of the questions in the interview schedule. This section also tries to answer the first research question above. The third stage reveals common themes that emerged from the participants and aims to answer the second research question which is:

What challenges besides content knowledge do the teachers encounter during the teaching of evolution?

The following figures represent the data that was collected in the form of questionnaires from 70 participants. The first graph represents the summary of scores that were obtained by the teachers in all three sections of the questionnaire. The second graph represents the scores that were obtained by the participants with regard to the knowledge of fossils. The third graph represents the scores that were obtained by the participants regarding the topic of natural selection. The fourth graph is the scores obtained under the sub-test on genetics.

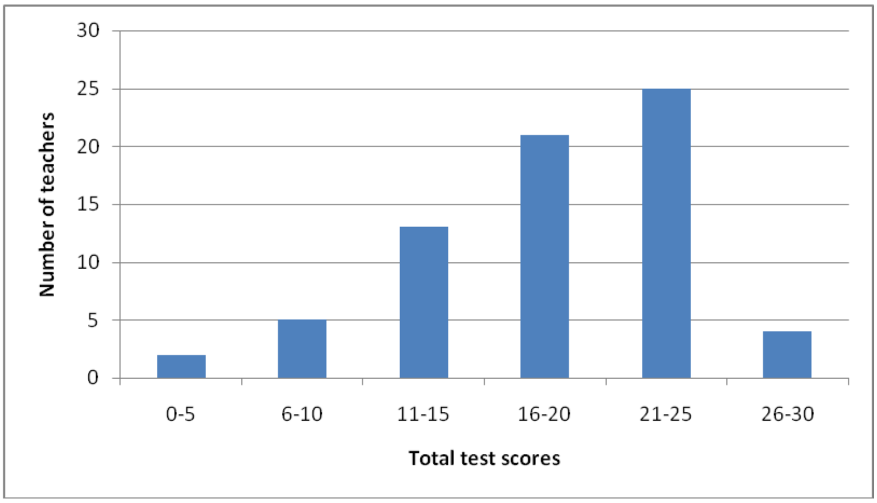

Figure 4.1: Frequency distribution of total scores obtained by teachers. (N=70)

Figure 4.1 above shows the distribution of scores obtained by teachers who completed the questionnaire. From the data, one can see that most teachers scored above 50% of the total score. Few teachers scored below 16%.The modal score was 21 (70%). The average score was 19 (63%).

Table 4.1: Summary Statistics for the Scores on each sub-test (N=70 for each sub-test)

	A	B	C	D	E	F
1		**n**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
2	**Fossils sub-test**	70	0	10	5.8	1.99
3	**Natural selection sub-test**	70	2	10	6.0	2.08
4	**Genetics sub-test**	70	1	10	7.0	2.42

Teachers performed better on the genetics sub-test than on the fossils or the natural selection sub-test. The Standard Deviations are quite high relative to the Mean Score. This indicates that the participants varied considerably in their knowledge base.

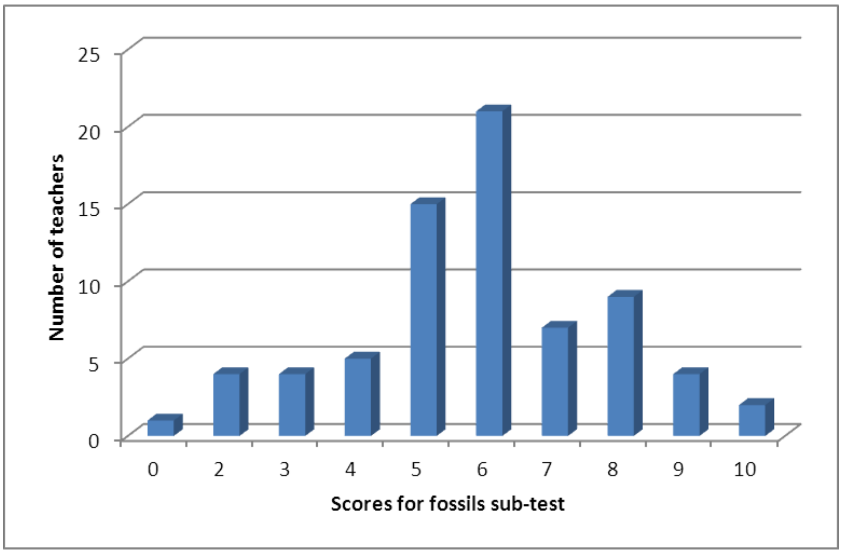

Figure 4.2: **Frequency distribution of score on the fossils sub-test (N=70)**

There were 10 questions in this subtest. Figure 4.2 shows that the majority of teachers scored between five and 10 answers correct. Very few teachers (14) got less than five answers correct. Two of the teachers got all 10 questions correct. The modal score was 6. The mean score was 5.8.

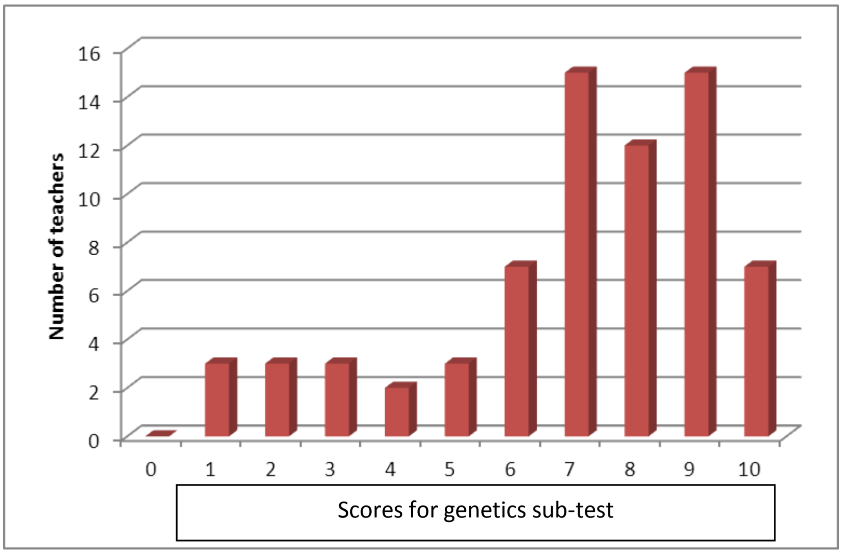

Figure 4.3: **Frequency distribution of scores in genetics sub-test scores N=70)**

Figure 4.3 shows that seven teachers got all the questions correct. From a total of 70 teachers who wrote this test, 59 teachers scored above five out of 10 which is above 50%. Only 11 teachers scored below five. The mean score was seven. The data show that most teachers performed well on this test.

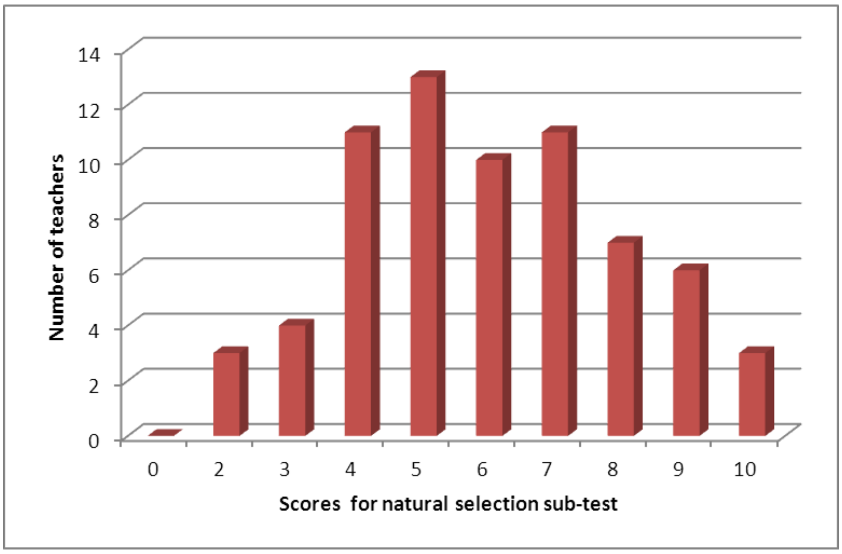

Figure 4.4: Frequency distribution of scores in the natural selection sub-test. (N=70).

Figure 4.4 indicates that the teachers' performance was moderate. 18 teachers obtained less than four answers correct. 51 scored above five (50%).The modal score is five, and the mean score is six.

4.2 Findings from the Questionnaires

The questions that seemed to be difficult for teachers were identified and selected for analysis. The selected questions were grouped under the following topics: Fossils; Natural Selection and Genetics.

4.2.1 Knowledge about Fossils

In this section samples of three questions were selected and analysed for any possible misconception and errors made by teachers.

QUESTION 6

The earliest forms of life on earth were………?

A. Viruses
B. Humans
C. Plants
D. Bacteria

The correct answer is **D**.

Table 4.2: Number of teachers selecting each possible answer for Question 6

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	C	*** D**	
3	Number of teachers	16	7	13	34	70

Out of a sample of 70 teachers who completed the questionnaires, a total of 36 chose the wrong answer. A large number of teachers (16) chose A (viruses) as their answer, while another 13 teachers chose C (plants).

QUESTION 8

A Dinosaur is /was…………

A. A mammal-like reptile
B. A bipedal reptile that became extinct 65 million year ago
C. A reptile that evolved into tortoises

D. The ancestor of the crocodiles

The correct answer is **B.**

Table 4.3: Number of teachers selecting possible answers for Question 8

	A	B	C	D	E	F
1		Teacher's response				Total
2	Answers	A	***B**	C	D	
3	Number of teachers	31	30	3	6	70

The total number of teachers who chose the wrong answer is 40, with 31 of them choosing (A) as the correct answer.

QUESTION 9

A mass extinction means that…………

A. Thousands of species become extinct over a few thousand years
B. Thousands of species become extinct over a few days
C. Thousands of species become extinct over a few years
D. All life on Earth becomes extinct

The correct answer is **A**.

Table 4.4: Number of teachers selecting possible answers for Question 9

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	***A**	B	C	D	
3	Number of Teachers	37	7	20	6	70

A total of 33 participants chose wrong options, with C being the second most popular answer after A.

QUESTION 10

"A living fossil" is………..

A. The remains of animals and plants which have been preserved by natural causes in Earth's crust
B. The material remains of human beings
C. An impression cast or tracks of any living organism on Earth
D. A living organism that belongs to a group of mostly extinct species

The correct answer is **D**.

Table 4.5: Number of teachers selecting possible answers for Question 10

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	C	***D**	
3	Number of teachers	31	3	9	27	70

A large number of teachers chose option A as the correct answer. Teachers do have an idea that fossils are the ancient remains of animals and plants that have been preserved in rocks They did not understand the concept of a "living fossil".

4.2.2 Knowledge of Natural Selection

The following sample of questions was selected from those that were based on natural selection in the questionnaire. Four questions were selected and analysed because they seemed to be difficult for most teachers.

QUESTION 14

Evidence for "descent with modification" is….

A. Different bones in the forelimbs of vertebrates
B. The same genes in all the vertebrates
C. **I**dentical bones in the forelimbs of vertebrates
D. Similar bones in the forelimbs of all vertebrates

The correct answer is **D**.

Table 4.6: Number of teachers selecting possible answers for Question 14.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	C	***D**	
3	Number of teachers	10	11	26	23	70

Out of 70 respondents, 47 chose the wrong answer. Twenty six of teachers chose option 'C', indicating an inability to differentiate between "identical" and "similar".

QUESTION 17

Species that exist in present time are called………..?

A. Extinct
B. Dominant
C. Selective
D. Extant

The correct answer is **D**.

Table 4.7: Number of teachers selecting possible answers for Question 17.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	C	*** D**	
3	Number of teachers	3	28	12	27	70

A total of 43 teachers chose the wrong answer. Only 27 teachers out of a total of 70 chose the correct answer D. It is also interesting to find that a total of 28 teachers chose option B.

QUESTION 19

The theory of natural selection requires that……

A. Variation exists within a population of organisms
B. A population must pass through difficult environmental conditions to evolve
C. A population must be separated from other populations in order to evolve
D. Species must compete with each other to evolve

The correct answer is **A**.

Table 4.8: Number of teachers selecting possible answers for Question 19

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	***A**	B	C	D	
3	Number of teachers	28	12	12	18	70

A total of 42 out of 70 respondents chose the wrong answer. Although the correct answer A was the most popular answer, many teachers also chose B, C or D.

4.2.3 Knowledge of Genetics

QUESTION 20

Artificial selection shows that…….

A. Farmers can create new species by selective breeding
B. Biotechnology can be used to create new species artificially
C. Humans can change the characteristics of a plant or animal by selective breeding
D. By isolating animals artificially in game parks, we cause inbreeding

The correct answer is **C**.

Table 4.9: Number of teachers selecting possible answers for Question 20.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	*** C**	D	
3	Number of teachers	10	29	30	1	70

A total of 40 teachers chose the wrong answer. The most popular incorrect answer was 'B'. Biotechnology has been a new topic in the curriculum since 2006, and proved to be a strong distracter in this question.

QUESTION 22

Choose the correct statement.

A. Mendel worked together with Darwin
B. Mendel worked before Darwin
C. Darwin and Mendel never met
D. Darwin formulated the theory of artificial selection

The correct answer is C.

Table 4.10: Number of teachers selecting possible answers for Question 22.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	*** C**	D	
3	Number of teachers	7	26	23	14	70

Of 70 subjects, 47 chose the wrong options. The most popular answer was B. The data show that some teachers do not know whether the two scientists worked together or not and whether they lived during the same period.

4.3 Questions that were Easy for Teachers

The questions that seemed to be easy for teachers were also identified and presented. I have chosen a sample of nine questions from those that were correctly answered by the teachers.

4.3.1 Knowledge of Fossils

Question 2

Fossils are………

A. Models made by scientists
B. Only made by bones
C. Very rare and broken into small pieces
D. The remains of living organisms preserved in rocks

Table 4.11: Number of teachers selecting possible answers for Question 2

	A	B	C	D	E	F
1		Teacher's responses				Total 70
2	Answers	A	B	C	***D**	
3	Number of teachers	1	1	4	64	

From a total of 70 teachers, 64 chose the correct answer which is option D.

Question 3

What do fossils tell us?

A. About life in the past
B. Those scientists are good at making fossils
C. Fossils are only connected with fuels
D. God made other forms of life

Table 4.12: Number of teachers selecting possible answers for question 3.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	***A**	B	C	D	
3	Number of teachers	65	1	4	0	70

Sixty five teachers chose the correct answer, option A. It shows that the teachers know that fossils that are being discovered on earth tell us about the living organisms that lived long time ago.

4.3.2 Knowledge of Natural Selection

Question 13

Charles Darwin formulated the theory of ……..

A. Artificial selection
B. Catastrophism
C. Evolution by natural selection
D. Natural theology

Table 4.13: Number of teachers selecting possible answers for Question 13

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	*** C**	D	
3	Number of teachers	3	1	65	1	70

A total of 65 teachers chose the correct answer. This was one of the easiest questions for teachers.

Question 15

The theory of acquired characteristics states that…

A. Organisms acquire characteristics to help them fit in with their environment
B. Organisms that do not fit in with their environment die
C. Organisms tend to become more complex over time
D. Organisms pass detrimental characteristics to their offspring

Table 4.14: Number of teachers selecting possible answers for Question 15.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	***A**	B	C	D	
3	Number of teachers	53	6	4	7	70

Fifty three teachers chose the correct answer, option A. However, the wording of answer A may have influenced teachers to choose this answer, since the question uses the words “acquired characteristics” and answer A contains “acquire characteristics”. It is not clear from this question whether teachers really did know what the theory of acquired characteristics states. Teachers who chose other options are still not clear that acquired characteristics cannot be inherited.

Question 16

The study of distribution of plants and animals around the world is called….

A. Anthropology
B. Biogeography
C. Palaeontology
D. Anatomy

Table 4.15: Number of teachers selecting possible answers for Question 16.

	A	B	C	D	E	F
1		Teacher’s responses				Total
2	Answers	A	***B**	C	D	
3	Number of teachers	7	50	12	1	70

The correct answer is option B, and 50 teachers chose this answer. It is interesting to see that 12 teachers chose palaeontology as the correct answer. One can see that some of the teachers are still confusing the terminology used in teaching evolution.

4.3.3 Questions on genetics

Question 21

Who is regarded as the father of genetics?

A. Charles Darwin
B. Gregor Mendel
C. Louis Pasteur
D. Jean Lamarck

Table 4.16: Number of teachers selecting possible answers for Question 21

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	***B**	C	D	
3	Number of teachers	14	52	4	0	70

Fifty two teachers chose the correct answer. It is also interesting to find out that 14 teachers chose answer A, and none chose answer D

Question 23

What are the factors that control inheritance called?

A. Phenotype
B. Genotype
C. Locus
D. Genes

Table 4.17: Number of teachers selecting possible answers for Question 23

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	C	***D**	
3	Number of teachers	1	10	2	57	70

The correct answer is D. Fifty seven teachers chose this answer. For teachers who have taught genetics for many years this was easy to answer. Nevertheless, 10 teachers chose a closely-related answer, which is B.

Question 26

The process of forming messenger RNA is called…….

A. Translation
B. Replication
C. Transcription
D. Dehydration

Table 4.18: Number of teachers selecting possible answers for Question 26.

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	***C**	D	
3	Number of teachers	8	7	55	0	70

The correct answer is C. The majority of teachers chose this answer. The few teachers who chose A are still confusing the terms transcription and translation.

Question 30

If the sequence of bases in DNA is TAGC, then the sequence in RNA will be….

A. ATCG
B. TAGC
C. GTCA
D. AUCG

Table 4.19: Number of teachers selecting possible answers for Question 30

	A	B	C	D	E	F
1		Teacher's responses				Total
2	Answers	A	B	C	***D**	
3	Number of teachers	18	5	2	45	70

The correct answer is D. Forty five teachers chose the correct answer. It is interesting to see that 18 teachers chose A.

STAGE TWO

4.4 Findings from the Interviews

Table 4.20 is a brief profile of the four teachers that were interviewed.

Table 4.20 Teachers' profile

Teacher	A	B	C	D
Qualifications	Bachelor of Science	Bachelor of Arts.	Senior Primary Teachers' Diploma	Senior Teachers' Diploma
Teaching experience	22 years	18 years	2 years	20 years
Grade taught	11 and 12	10, 11 and 12	12	10, 11 and 12
Gender	Female	Female	Male	Female
School type	Ex-model C	Township	Rural	Township

The purpose of these introductory questions was to reveal how variables such as qualifications and experience influence the teaching of a particular subject. Three of the teachers teach in Vulindlela District and only one came from outside Vulindlela District. These teachers were interviewed separately but using the same interview schedule. Teacher A was interviewed at her school. The other three teachers were interviewed on different days at the venue provided by the Natal Museum for convenience, during the holidays in 2009.

4.4.1 Teachers' perceptions of their own understanding of concepts related to evolution.

After a careful analysis of the interviews, some interesting findings emerged in terms of how much content knowledge the teachers possess regarding the theory of evolution. However, it is important to note that the teachers were implementing the NCS Life Sciences curriculum in 2008.When the respondents were asked “what do they know about fossils”. Their responses were like this:

Teacher A,

> “*Not a lot, I am learning… that is an area that definitely feels I could improve on, I do feel that my background is lacking…”*

She pointed out that she did not study evolution but was forced by the circumstances to read different books about the topic in order to be able to understand it better.

From the responses of other participants, it was found that teachers do know what fossils are although they could not go beyond than what is written in the textbooks. They were unable to show a deep understanding of fossils and not able to supply examples.

The response from **teacher B**

> **“***Remains of creatures that use to live… I mean exist long time ago, they can be embedded in rocks, ice, in water, ya…”*

Teacher C responded like this*“*

> *“Fossils are remains of dead organisms and became fossilised in rocks or inside the soil… you see when they dig through developments then these fossils come out”.* This teacher has a limited understanding of fossils.

This is how **teacher D** responded to the above question:

> “*Fossils are the remains of dead plants and animals”.*

Question: “Did you study fossils at college or university?”

This is how the teachers responded to this question:

Teacher A

"*No, I studied at UKZN a while ago in 1984. I do feel that my background is lacking".*

Teacher B

"Yes we did in Zoology".

Teacher C

"Unfortunately not, I have only seen the pictures from TV and newspapers".

Teacher D

"*Oh no, no".*

Question: "What do you know about comparative anatomy and what it tells us about evolution?"

Teacher A

"As far as I know, that homologous and analogous structures were ehm… used… for example like the bat wing and… They are structurally different but both used for flight".

Her reply indicates that she was referring to analogous structures only.

This is how teacher B responded to the above question:

"It looks at different organisms within a group, like vertebrates, because there are many vertebrates then if we look at different vertebrates, looking their embryos, looking to their anatomy, there would be like common features which show that they are also coming from a common ancestor".

Mh…. Comparative anatomy….I can say that bones of other animals are the same but the structure is not the same even if the function which is done by those animals is not the same".

This answer indicates that the teacher has a fair idea of comparative anatomy and its significance in evolution.

Teacher C responded like this:

> *"Eh… What I know is that fins of dolphins… if you look at their structure, they show some relationship with our upper limbs although the two do not perform the same function but the origin is the same."*

This teacher was able to cite an example of homologous structures, and to link it to the concept of a common ancestor.

Teacher D:

> "*Mh…..ya….. comparative anatomy, I can say bones of animals are the same but the structure is not the same even the function is not the same."*

This teacher has some idea of homologous structures, but not the link with descent from a common ancestor.

Question: "What do you know about comparative embryology and what does it tells us about evolution?"

Teacher B responded like this:

> *"It showing that life use to originate from eh… common ancestor because the embryo themselves if they show certain features which are common but differ as the organisms grow then that showed they* evolved *from a common ancestor."*

This teacher has a reasonably good idea of the contribution of comparative embryology as evidence of evolution.

Teacher C responded like this:

> *"If you look at the embryo of a fish and compare it with that of a human, you can see that from its early stage of development, you can see that they look the same. That simple mean one thing, common descent".*

This teacher was able to link similarities in embryos with the theory of common descent.

Teacher D

> *"Mh… (long silence)… embryos of organisms are not the same eh…"*

This teacher did not understand comparative embryology.

Question: Tell me what you know about the theory of natural selection and who developed it?

This is how the teachers responded:

Teacher A

> *"What I know about it basically involves survival of the fittest, so Darwin suggested that ehm… in a group of population, organisms have genetic variety because of their genetic makeup, they might be better at doing something or eating something… those organisms can go on to reproduce because they have that genetic advantage ehm… the others will die out, they become less and less. Over a long time those organisms that have the competitive advantage become the dominant population, so as I understand that is natural selection."*

Teacher A had a good understanding of natural selection. She ignored the second part of the question "Who developed it". Teacher B also showed understanding of this concept, but did not mention the genetic link. This is how she responded:

> "*Mh… is that certain features in organisms will tend to disappear due to the influence of the environment. If the environment is not favouring them, then they tend to disappear. Those that can cope well within the environment will then last and continue that kind of generation of organisms".*

Teacher C

> *"What I understand is that… Amongst the organisms of similar species eh… they can be genetically unlike. Some can be well adapted to the changing environment others cannot. So those who cannot adapt… they get eliminated. Those that have characteristics that enable them to adapt to the*

environment survive and continue to reproduce. This theory was developed by Charles Darwin".

The response from this teacher shows that he really understands what natural selection is, and makes the link with genetics.

The following response from teacher D revealed that some of the Life Sciences teachers may find it difficult to understand the evolutionary concept:

> *"Natural selection… I think it is when you use an animal which is stronger than the other, may be if you mix for example different species of cows, and the young one will look like one of the parents not the other."* This teacher was unsure of what natural selection is. Teachers C and D are not clear about the concept of a species.

This is how the teachers responded when they were asked what they know about the concept biogeography and how it relates to the theory of evolution.

Teacher A

> *"There I think biogeography also relate to the fact that we find similar sorts of animals in very diverse parts of the world. For example an African hunting dogs… and wild dogs in Australia. Similar animals are found in very diverse part of the world as a result of continental drift."*

In response to the relationship of this concept and the theory of evolution she stated

> *"originally the continents were together and there was possibility of animals to reproduce from different areas. They then got separated as a result of continental drift and ehm… those animals were then reproductively isolated and developed in their own specific way, but there was a common origin."*

Formatted: Font: Not Italic

Teacher B responded:

> *"Eh… I would say is looking into the earth as such eh… which use to be like one block of mass which then due to certain earthquakes then pieces of the big mass started drifting apart. We now live on different locations because of the environment we live in but we are from the same ancestor. For example the people who live up in the arctic have different colour of the skin when*

compared to those that live in the tropics, but if you find traces of fossils found in Africa they show that these areas were part of one big block of land."

Teacher C responded:

"Eh... Biogeography… (What is it?)…….(laughing)… I think…(pause) it refers to the earth as a crust and then it drifted apart… I'm not sure about this."

Teacher D responded:

"Mh… it is based on life as well as on soil."

Teachers C and D clearly had no idea about the concept of biogeography.

4.5 Interviews about the Challenges

The next part of Chapter 4 reports the findings of the empirical investigation into the challenges facing Life Sciences teachers when teaching the theory of evolution in their classrooms in 2008. Several themes emerged from the interviews regarding these challenges. I must stress at this point that these themes are my own interpretation of what was revealed and important for my study. I will further use the related literature in my discussion of the findings from the data. I tried to ensure trustworthiness by using quotations from the interview data within the following discussion.

The following are the themes that emerged from the collected data:

- Lack of self-confidence by teachers
- Science versus creationism in the classrooms
- Lack of content knowledge and understanding of the theory of evolution
- Lack of support by the school and DoE
- The need for in-service training workshops

Theme 1: Lack of self-confidence to teach evolution

Did you experience any difficulties when you first taught evolution?

The most common challenges identified amongst the respondents were: lack of adequate knowledge, lack of acceptance of the topic, and lack of skills and different strategies to teach the topics to the learners.

One of the respondents (**Teacher A)** mentioned that she feels she has gaps in her knowledge of evolution. She did acknowledge that the seminars she attended about the theory of evolution helped her a lot. She further pointed out that her Grade 12 learners in 2009 were very receptive when compared to those of 2008 and the reason could be that she decided to approach the topic differently from the previous year Although the learners were without any resistance to the teaching of evolution, the respondent argued that the concept of evolution seem to be difficult for learners to understand.

The effect of teaching evolution was experienced differently by different teachers. **Teacher B** responded like this to the above question:

> "*Definitely yes… I have long forgotten evolution and it is not an interesting topic to me, even at the university, it uses things that are imaginary, so it is difficult to relay such information to the learners."*

***Teacher C** response was*

> *" ya! I did encounter difficulties, especially my religion as a Christian….. was the first thing that made it difficult to accept that we are related to chimpanzees, it was very difficult as a teacher to tell such a thing to learners. But later I was convinced that this is true according to evolution but I am still holding my principles as a Christian."*

This kind of a response indicates clearly that some of the Life Sciences teachers were faced with difficulties when teaching evolution regarding their own religious beliefs, so it was not easy for them to teach this topic.

Teacher D states:

> *"yes… learners were coming with all sorts of questions and ideas. Some of them were saying evolution is just 'a fairy tale' there is no truth in it. Others did not want to believe in it saying it contradict with their faith according to the bible."*

The sudden introduction of the theory of evolution in the Grade 12 syllabus in 2008,brought insecurities in most teachers in a way that their confidence in teaching Life Sciences diminished due to their lack of knowledge of this topic.

How did you deal with the challenges?

Teacher A:

> **"I** *spoke to the learners that were not happy about teaching evolution, I explained to them that it was not my job to convert them into believing evolution but to teach them the theory and present evidence as it is and they can then make their own choices at the end."*

In order to deal with challenges**, teacher B** mentions that she had to read different books and prepare documents for learners if possible. She also said that she had to bring newspaper cuttings for learners in order to show them that evolution is still in existence today.

Teacher C on the other hand tells his learners that they must be patient and read their books, look for evidence before they can reject the theory.

What is the attitude of learners towards the theory of evolution and how do you respond to them?

The teachers that were interviewed mentioned that the attitude demonstrated by the learners regarding the theory of evolution was mostly negative.

Teacher A:

> "*For me I said to them if you are not happy with this section, you must at least understand that this theory is a huge theory in Biology and you are required to understand it in order to answer questions during the examination."*

This is how some of the Life Sciences teachers deal with attitudes of the learners during the teaching of the theory of evolution.

Teacher B:

> "*The attitude is negative, so as I am also showing that… it's not good. I allow opposition, because I do understand that we are not supposed to change learners' convictions although it is difficult for me to bring evidence of creationism*."

Teacher B also mentioned that she allow debates amongst the learners around the topic, although sometimes the debates goes out of hand and need to be controlled.

Teacher C said

> *"Mh….half of them accepts it but half of them don't. I remember last year (meaning in 2008) they ended up not believing that the evolution of living organisms happened long time ago and is still happening today."*

This is how **teacher D** responded:

> "*Attitude of learners is very bad, because of my beliefs, I consult my HoD. To assist me in this regard and sometimes I ask my colleagues from other schools on how do they deal with learners' response to evolution, and then I will come and apply what is relevant to my class."*

From the above response, it shows that the attitude of the teacher can hinder the teaching of the theory of evolution.

Theme 2: Science versus Creationism in the classroom

It was not a surprise to find out that even teachers themselves are struggling to deal with their attitudes and beliefs regarding the teaching of evolution. Different studies on teaching evolution have also found that teachers have come to the teaching profession ill prepared emotionally and conceptually to teach evolutionary concepts (Veal & Kubasko, 2003).

The responses of the following question confirmed the above:

Have you ever felt pressure to include creationism when you teach evolution in your classroom? If the answer is yes, explain.

Teacher A response:

> "*I do talk about creationism ehm… In a sense that I explained to the learners that creationism is a concept they are absolutely free to believe in, but that there is no evidence as such or that the evidence is not a scientific one. The theory is based as far as I know on faith. So what I teach in evolution is a scientific theory that has evidence*."

This teacher shows that she is able to deal with classroom challenges during the teaching of evolution.

This is how teacher B responded to the above question:

> "*Learners know from their homestead that we were created by GOD……..but then evolution counteracts that, it become difficult for me to bring in backing evidence of evolution into creationism*."

Unlike the first respondent, teacher B does not have strategies to deal with this challenge.

Teacher C's response was

> *"In fact, I try to accommodate them (learners)…….I can't ignore them or chase them out (meaning the learners)."*

The teachers need to cater for different beliefs that prompt out during the lessons on the theory of evolution.

Teacher D on the other hand emphasise that

> "*As a Christian, I always tell myself that GOD is the master of everything. I even tell learners that evolution is guided by God for it to happen the way it does."*

Theme 3: Lack of content knowledge regarding evolution

Three of the four respondents admitted that the topic was difficult for them. They argued that they did not have previous knowledge concerning the theory of evolution gained from their teacher training at colleges or universities; it was something new to them.

Question: Do you feel that you have adequate knowledge to teach evolution? This is how they responded to the question:

Teacher A

> "Yes *I do……..but I think it requires effort on the part of a teacher. For me the theory of evolution has taught me that I should read a little bit and expand my knowledge about it."*

The response from this teacher indicates the importance of self development on the part of teachers. They must not wait for the Department of Education to organise workshops for them.

Teacher B responded like this

> *"Not exactly…. I still need to be developed."*

Teacher B's response differs from teacher A's in that teacher B is expecting someone to develop her.

Teacher C:

> **"***Not yet…. Not yet because even the textbook that I used last year (2008) was not rich in information as the one I am using now (2009)."*

He did not explain how he dealt with the deficiencies of the textbook.

Teacher D's

Response was

> "No*… because I am still learning, I'm still struggling to get more information to know about this concept."*

Theme 4: Lack of support

Question: Do you think the Department of Education has done enough to prepare Life Sciences teachers about this new topic?

One respondent argues that the teachers need to read a lot in order to equip themselves with knowledge about the theory of evolution. Other respondents claimed that they did not receive any kind of support from the department. There was no follow up during the year (2008) to find out how the teachers were coping with the teaching of this new topic. This is how one of the respondents (Teacher C) confirmed the above statement

> *"No… we usually have one information session at the beginning of the year where I think we were enlightened on evolution but it been only two days. We were only showed slides of the fossils that have been found such as Taung child, Mrs Ples, etc. There was no explanation about how to teach the theory to the learners."*

Similarly, **teacher C** felt that he did not benefit anything from the three-day workshop he attended at the beginning of 2008. This is how he responded

> *"The Department did not even make an effort; it should give us more time to interact with the experts of evolution. Another thing is about the content, you*

can learn something and understand it but it is different when you have to teach someone, you teach it the way you have understood it which is sometimes not correct."

Theme 5: The need for proper training of teachers

Question: What do you think the Department should do in order to assist Life Sciences teacher on this topic?

There was only one respondent **(Teacher A)** who felt that it was not the duty of the Department to empower teachers. But the other three respondents argued:

Teacher B

"*The Department needs to give us more teaching aids because we cannot always afford to visit site that are mentioned in the textbooks concerning discovery of fossils."* **Teacher C** also confirmed that "*the Department should give us more time not only three days, so that teachers could be trained and know the theory properly."*

Formatted: Font: Italic

Furthermore **teacher D** stated that more workshops are needed, and teaching materials such as slides, DVDs should be provided by the department so that learners can understand the theory better.

4.6 Conclusion

This chapter depicted the knowledge possessed by the participants who took part in answering questionnaires as well as those that were interviewed. The study revealed that teachers have considerable knowledge of evolution but there are some gaps. The data also revealed that the Life Sciences teachers face many challenges during the teaching of evolution. The next chapter summarise these findings and links them to the previous studies discussed in chapter two.

CHAPTER FIVE

DISCUSSION OF FINDINGS AND RECOMMENDATIONS

5.1 Introduction

Previous studies have focused on Life Sciences student teachers and their attitudes towards teaching evolution in South Africa (Abrie, 2010; Stears, 2011). However, little is known about the knowledge and understanding of the theory of evolution by practising Life Sciences teachers in South Africa.

. This study sought to answer the following questions:

1. What content knowledge do the Life Sciences teachers possess regarding the theory of evolution?

2. What challenges besides content knowledge do Life Sciences teachers encounter during the teaching of evolution?

This study was initiated a year after the theory of evolution was introduced into the Grade 12 Life Sciences curriculum in 2008. Most of the participants completed their school education as well as tertiary education with no or very little training in the theory of evolution. The National Senior Certificate examinations in 2008 showed that learners performed very poorly in questions related to evolution. This observation raised questions about teachers' content knowledge and competence to teach evolution. Although this was a small study conducted in one of the districts in KwaZulu-Natal and the questionnaire only covered a small section of evolution, the data reveals that Life Sciences teachers do possess some knowledge of evolution, but significant gaps exist.

Having presented the data collected from both questionnaires and the interviews in the previous chapter, in this chapter I present an interpretation of the data. However, rather than making interpretations of the two data sets separately, as the data shows some overlap in the responses by the teachers, I organise the information thematically and also use the frameworks of Shulman (1987) on the principles of subject matter knowledge as discussed in chapter two, and Rogan and Grayson on the Zone of Feasible Innovation. . Furthermore I link my data to the previous studies about the teaching of evolution and its challenges presented in chapter two.

5.2 Discussion

As discussed in chapter two, subject matter knowledge refers to deep understanding of the subject matter. The data reveal that some teachers from the study lack sufficient content knowledge required from them in order to be able to teach evolution effectively. Sound SMK is crucial, however SMK in itself is powerless if the teacher lacks expertise in creating a teaching-learning environment that optimises the learning process (Ruthven, 1993). PCK, as defined by Shulman (1986) depends on SMK. Shulman (1986) and later Ruthven (1993) argue that the knowledge of only the subject matter does not make one a teacher. He further argues that the teachers should have pedagogical content knowledge. They should be able to arrange the components of the topic for effective teaching. Teachers should also take into account the diverse interest and abilities of learners (Shulman, 1986).

In many cases a deficient SMK could have a direct impact on learners' academic performance (Young, 2006). The findings from the data collected by means of questionnaires reveal that some of the Life Sciences teachers were not ready in 2008 to teach the topic but the Department of Education was expecting them to produce good results at the end of the year. A number of problems that were mentioned in the previous chapter could be the reason why the learners performed poorly in questions that were based on evolution during the final examination in 2008. Three teacher respondents drew attention to the need for on-going professional development in order to address the demands of the new curriculum.

Although this was a small study conducted in one of the districts, the data reveals that knowledge and understanding of the theory of evolution in this group of teachers is moderate to good in some sections, but poor in others. It is possible that the data was biased as questionnaires were filled in anonymously, and some teachers refused to fill in questionnaires. Perhaps those who were supportive of evolution were more likely to participate. Based on the findings that emerged even form this sample of 70 teachers, it is clear that understanding of the theory of evolution by Life Sciences teachers should be investigated further. The lack of knowledge of certain concepts regarding the theory of evolution is likely to have an impact on their teaching and consequently on the learners.

It is not known to what extent the acceptance and understanding of evolution by the teachers will influence the quality of teaching this theory. Three out of four teachers who were interviewed hold strong religious views that conflict with the theory of evolution, beliefs that are likely to interfere with successful teaching. The debates that are reported in the literature regarding the teaching of evolution in the United States of America (Veal & Kubasko, 2003) did not emerge in South Africa. Although there was a minority group from the Christian view who tried to oppose the introduction of evolution in South African schools, they did not get much support from other bodies in the community.

The data also reveal that teachers tend to increase their knowledge and levels of understanding of science concepts as they teach these concepts year after year. This was evident from the scores of the teachers under the section of genetics. They scored high marks in this section because genetics was introduced into the Biology curriculum more than twenty years ago. Fossils, biogeography and comparative anatomy were introduced in 2008, and teachers had considerably less knowledge about these topics than about genetics.

Evolution has been identified as a unifying principle within which many diverse biological facts are integrated and explained. It is a unifying principle for understanding the relationships among living organisms and the history of life on earth (American Association for the Achievement of Science, 1990). For South African teachers, this is a tremendous challenge when one considers that during teacher training at colleges and university, teachers were not necessarily taught about evolution prior to 1994.

During the interviews, three teachers reported a lack of support from the Department. They pointed out that there was only a once-off workshop which was organised for them at the beginning of 2008. One respondent mentioned that it was not the responsibility of the Department to develop teachers but teachers themselves. Most teachers do not attend the workshops even if they are organised for them. I am saying this because when they were invited to a workshop regarding the teaching of evolution which was organised by the Natal Museum in 2009, the attendance was very poor.

Shulman (1986), and Grossman, Wilson & Shulman (1989) point out that content knowledge is the knowledge and understanding of central concepts and topics of a subject. Furthermore, they emphasise the need for teachers to understand what they teach. The data reveals that teachers demonstrated different levels of understanding of the theory of evolution. Knowing the subject matter of a science subject entails knowing concepts and principles that the students are supposed to know about particular topics in the school science curriculum (Deng, 2007). According to Deng (2007) science teachers should understand that science as a subject is never fixed and unchanging as it appears to be. They should know that changes are occurring in the economy and social context and science as a school subject need to be responsive to these changes through content modification or renewal.

Shulman (2004) argues that teachers must possess deep subject matter knowledge and understanding thereof. Teachers need to understand the central concepts of a discipline and understand how best to present and communicate specific concepts and topics (Shulman, 1986; Grossman, Wilson & Shulman, 1989). Similarly, in his discussion (Freire, 1989, as cited in Howard & Aleman, 2008) points out the need for teachers "to be knowledgeable in their field and to apply challenging curriculum." The data captured in this research study shows that most of the teachers displayed some knowledge of the theory of evolution although there were some gaps.

A study by Griffiths and Brem (2004) found that many teachers face challenges from their students when they teach evolution. This is similar to my study in that the participants are faced with many challenges such as when students raise questions about evolution and creationism. This is especially so in the light that the majority of the learners come from homes where the parents emphasise the point that everything was created by God. Edwards (2001) warns the teachers that they need to be aware of this controversy and must approach this topic with sensitivity and finesse. Meadows,Doster and Jackson (2006) argue that teachers of evolution should respect both the teaching of evolution and the religious beliefs of learners. Students should be given a chance to express their concern about evolution and teachers should listen to their concerns (Meadows & Jackson, 2006).

The data revealed that even the teachers find it difficult to teach the theory of evolution because of their own religious beliefs. But according to Branch (2009) learning and accepting evolution does not need to threaten personal beliefs. Stenhouse (1975) argues that the teachers must know his/her own subject and must be secure enough to rejoice when he/she is beaten in argument or even overtaken by his/her pupils.

There was a variation in the levels of SMK revealed in the findings. Some teachers were concerned about their own understanding of the content. In the areas of fossils, comparative anatomy, comparative embryology, natural selection and biogeography, some teachers were more proficient than others but struggled to supply enough and relevant information regarding the concepts.

5.3 Discussion of the Interviews

Grossman, Wilson & Shulman (1989) argue that strong subject knowledge is a pre-requisite for effective teaching. On the other hand Griffith and Brem (2004) found in their study of Biology teachers in Arizona that they lack confidence in their knowledge of evolutionary theory. Their study revealed that lack of knowledge can cause concern for teaching and some embarrassment and this could also result in spending little time on this topic. In 2008 in South Africa, the theory of evolution was first taught in Grade 12 curriculum. It was being taught by many teachers who did not study it at their tertiary education level. There was insufficient training of the Life Sciences teachers prior to the introduction of this theory in 2008. The majority of teachers were faced with the problem of teaching this theory and did not know how to handle any challenges they may encounter during teaching of evolution. Rogan and Grayson (2003) argue that the implementation of a curriculum innovation should occur in manageable steps. They refer to it as "Zone of feasible innovation" (ZFI), which according to them is likely to occur when it proceeds just ahead of existing practice. The degree of "ZFI" for the participants was low since all the teachers expressed dissatisfaction about the way the theory of evolution was infused in the grade twelve curriculum without any prior professional development. They argued that it would be better if the topic was introduced slowly from grade ten. There was no capacity to support innovation, teachers were supposed to be developed on the topic of the theory of evolution.

My own opinion as a researcher as well as an insider is that the introduction of the theory of evolution in 2008 was not properly thought through by the curriculum planners. I base my assertion on the fact that there was a lot of new content to be taught to Grade 12 learners without any background or foundations from Grades 10 and 11. Furthermore Rogan and Grayson (2003) propose that for a new curriculum to be effective, the implementation strategies need to take into account both current level of curriculum and classroom practice and the current capacity to support innovation. The participants in this research study pointed out that there was limited support from the district and Department of Education. They argue that the only training they received was at the beginning of 2008 and it only lasted three days. There was no discussion of the concepts such as natural selection, biogeography, descent with modification etc. There was nothing provided for them to assist during teaching of the theory. Teaching of evolution was left to an individual teacher with little support from the advisors. The teachers relied on textbooks and study guides that they bought for themselves because the Department did not supply them with the relevant resources regarding the new topic. There was no provision of physical resources such as textbooks, charts to refer to and slides based on the theory of evolution to show the learners so as to help them to understand the theory better. Some schools did not even have textbooks for learners, so the teachers had to write notes for them. Fullan (2001) writes that in order for a change to be successful there should be support from the district level in providing the necessary resources and professional development for teachers.

Three teachers that were interviewed expressed dissatisfaction with the in-service training they received. The findings reveal that some of the participants were able to show fair knowledge of the theory of evolution and were able to handle the challenges of the content while others showed much gaps in their knowledge which needs to be addressed.

Some teachers don't think it is their professional duty to develop themselves. They expect the Department of education to do things for them.

Out of four interviewees, only one showed a deep understanding of evolution, although she mentioned that she feels that she needs to read more about the theory to equip her.

5.4 Conclusion and Comments

Prinou, Halkia and Skordoulis (2003) based their research on teachers' attitudes, views and difficulties during the teaching of evolution. Their study revealed a lack of knowledge by a large part of teachers that were studied particularly natural selection. However the results of this study cannot be directly compared with those of Prinou et al (2003) because a different questionnaire was used. South African teachers found some questions easy, since most chose the correct answer, and some difficult, where less than half chose the correct answer. Shulman (1987) strongly believes that subject matter knowledge is a prerequisite for science teaching. I also agree that it is of crucial importance that Life Sciences teachers have deep knowledge and understanding of what they are expected to teach.

Abrie (2010) points out that it is not known to what extent the knowledge of evolution by Life Sciences teachers will influence the quality of teaching of this theory to their learners. The poor performance of Senior Certificate learners in questions about evolution in 2008 raised some concerns. It is not known whether there was a relationship between the content knowledge of evolution by the teachers and the poor performance of learners during that year. Stears (2011) also found that teachers in the South African context have no formal training in the principles of evolution. They feel inadequate as they never had to teach evolution (Holtman, 2010) It is worth noting that although the introduction of evolution into the school curriculum appears to have impacted on teachers' content preparedness, the scores of the teachers who participated in this research indicates substantial room for further improvement.

The findings of my study regarding challenges of teaching evolution reveal that some teachers have a negative attitude towards the theory of evolution. Similarly Stears (2011) found that the student teachers in one of the universities in South Africa came with negative views about the theory of evolution when they first started their degree which will allow them to be Life Sciences teachers. Stears (2011) wanted to find out their scientific understanding of evolution after completion of a module including evolution. A deeper understanding of students' views of evolution with regard to possible conflict between their acceptance of evolution and their religious beliefs was obtained through interviews (Stears, 2011).

The findings revealed that after the completion of the module regarding evolution, there was improvement in content knowledge of these student teachers, but they scored poorly in a significant number of questions pertaining evolution, finding many concepts difficult. Although they seemed to question the origin of life as it is described by Charles Darwin in his book, most of these student teachers believed that their scientific understanding and religious beliefs could co-exist (Stears, 2011). On the other hand Abrie (2010) found that the student teachers who participated in her study rejected evolution, giving the reasons that they were religious.

Another key finding of my study is that teachers do not know how to handle learners who oppose evolution. They do not have strategies for how to deal with such learners especially if they interrupt the lesson trying to infuse creationism. This problem can lead to learners becoming confused and finding it difficult to understand the scientific view point about the origin of species on earth and about evolution by natural selection.

Fullan (1991) cited in de Feiter & Ncube (1999) argues that it is very important for teachers to receive professional development opportunities especially when they are expected to implement the newly formed curriculum. Findings from this study indicate a great need for professional development by these Life Sciences teachers. It is also crucial for teachers to be engaged in professional development training in an attempt to bridge the gaps in pedagogical content knowledge. It is of paramount importance that the Department of Education trains the subject specialists, so that they could assist the teachers in the subject they teach. Their knowledge of the subject must be in line with the new content they are supposed to teach.

New Life Sciences teachers are being recruited every year into the teaching profession. It is possible that if these new teachers were not trained in teaching evolution, they might encounter some challenges during the teaching of this theory. Successful implementation of reform curriculum depends mostly on understanding the subject matter by the teachers (Powell & Anderson, 2002). Professional development in the form of in-service training should be an on-going process so as to equip teachers with the necessary information regarding the science curriculum which is continuously being revised.

5.5 Recommendations

* Subject specialists should be offered specialised training when there is new content in their subject. In this way they will train the subject teachers with confidence.

.* Life Sciences teachers who have not been exposed to the theory of evolution during their previous teacher training should be offered opportunities for retraining.

* Detailed instructional materials should be made available to all teachers. These instructional materials should also provide teachers with information they need to deal with the conflicts that arise in the classroom during the teaching of evolution.

* Teachers should take responsibility for their own professional development by attending courses offered by museums and other organisations, reading books on the subject, or watching TV programmes on evolution.

5.6 Suggestions for Further Studies

* A more in-depth study involving a larger sample of teachers throughout the province to investigate how are they coping with the teaching of the theory of evolution.

* **I** would like to extend this study to include investigation of Life Sciences teachers at the classroom level to see how evolution is taught and learned.

* A study of attitudes and beliefs of the teachers with regard to the theory of evolution is also required in a South African context.

REFERENCES

Abrie, A.L. (2010). Student teachers' attitude towards and willingness to teach evolution in changing South African environment. *Journal of Biological Education, 44*(3), 102-107.

Adler, R. (2006). Doing it for the kids. *New Scientist,192*(2574), 24.

Aguillard, D. (1999). Evolution education in Louisiana public schools: A decade following Edwards v Aguillard. *The American Biology Teacher, 61*(3), 182-188.

Aikenhead, G.S. (2006). *Science education for everyday life*. New York: Teacher College Press.

American Association for the Achievement of Science (1990). *Science for all Americans*: New York: Oxford University Press.

Atkin, J.M., & Black, P. (2003). *Inside science education reform: A history of curricular and policy change.* New York: Teachers College Press.

Babbie, E., & Mouton, J. (2001).*The practice of social research*. Cape Town: Oxford University Press.

Bailey, K.D. (1987). *Methods of social research* (3rd ed.). London: Macmillan.

Ball, D.L., & Cohen, D.K. (1996). Reform by the book: What is – or might be – the role of curriculum materials in teacher learning instructional reform. *Educational Researcher, 25*(9), 6-8.

Banilowe, E.R., Heck, D.J., & Weiss, I.R. (2007). Can professional development make the vision of the standard a reality? The impact of the National Science Foundation's local systemic change through teacher enhancement initiatives. *Journal of Research in Science Teaching, 44*(3), 375-395.

Berkman, M.B., Pacheso, J.S. & Plutzer, E. (2008). Evolution and creationism in America's classrooms*: A National Portrait. PLoS Biology, 6(5)*, 920-924.

Bogdan, R., & Biklen, S. (1992*). Qualitative research for education*. Boston: Allyn and Bacon.

Bower, J.M. (2002). *Scientists and science education reform: myths, methods and madness.* Washington DC: National Academy.

Branch, G. (2009). Teaching and learning about evolution: Part 2*. Quest, 5*(3), 42-47.

Burges, R. (1994). In the field: An introduction to the field of research. London: Rutledge.

Bybee, R. (2003). *Evolution in perspective: The science teacher's compendium*. Arlington, VA: NSTA Press.

Cavallo, A.M.L. & McCall, D. (2008). Seeing may not mean believing: Examining Students' Understanding & Beliefs in Evolution. *American Biology Teacher, 70(9),* 522-530.

Chen, S. (2006). Development of an instrument to assess views on nature of science and attitudes towards teaching science. *Science Education, 90 (5),* 803-819.

Chisholm, L. (2002). *A South African curriculum for the twenty first century. Report of the Review Committee 2005*. Pretoria: Department of Education.

Chisholm, L. (2005). The making of South Africa's National Curriculum Statement. *Journal of Curriculum Studies, 37(2),* 193-208.

Chuang, H.C. (2003). Teaching evolution; attitudes & strategies of educators in Utah.*The American Biology Teacher, 65(3),* 669-674.

Cresswell, J.W. (2003). *Research design: Quantitative,Qualitative, and Mixed Method Approaches.* SAGE: Thousands Oaks,USA.

Datnow, A., & Stringfield, S. (2000). Working together for reliable school reform. *Journal of Education for Students Placed at Risk, 5*,183-204.

De Feiter, L., Vonk, H., & Van der Akker, J. (1995). *Towards more effective science teacher development in Southern Africa.* Amsterdam: University Press.

De Feiter, L.P., & Ncube, K. (1999). Towards a comprehensive strategy for science curriculum reform and teacher development in Southern Africa. In S. Ware (Ed), *Science and environment education: Views from developing countries* (pp.177-197).Washington D.C.: World Bank.

De Jager, P. (2005). The response of principals to the FET reform process in South Africa: case studies of three schools in New Castle. [s.n]

Dempster, E.R. & Hugo, W. (2006). Introducing the concept of evolution into South African schools. *South African Journal of Science, 102*,106-111.

Deng, Z. (2007). Knowing the subject matter of a secondary-school science subject. *Journal of Curriculum Studies, 39 (5),* 503- 535.

Department of Education. (2003). *National Curriculum Statement Grade 10-12 (General). Life Sciences*. Pretoria: Government Printers.

Department of Education. (2007). *A new content framework for the subject life sciences as listed in the National Curriculum Statements Grade 10-12 (General)*. Pretoria: Department of Education.

Dobzhansky, T. (1973). Nothing in Biology makes sense except in the light of evolution. *The American Biology Teacher, 35(30)*, 125-129.

Donnelly, L.A., & Boome, W. J. (2007). Biology teachers' attitudes toward and use of Indiana's evolution standards*. Journal of Research in Science Teaching, 44(2),* 236-257.

Donnelly, J. (2006). The intellectual positioning of science in the curriculum and its relationship to reform. *Journal of Curriculum Studies, 38(6)*, 623-640.

Eberle, F. (2008). Investigation of the relationship between middle school science teacher's knowledge and beliefs regarding the coherence and connections among science concept and their classroom practice. Lesley University: Cambridge.

Eisner, E. (1991). The enlightened eye: Qualitative inquiry and the enhancement of educational practice. New York: Macmillan.

Eve, R.A., & Dunn, D. (1990). Psychic powers, astrology & creationism in the classroom? *American Biology Teacher,* 52, 10-20.

Fullan, M. (2001). Leading in a Culture of Change. San Francisco, CA: Jossey-Bass.

Fullan, M.G. (1991). The new meaning of educational change. New York: Teacher College Press.

Gay, L.R., & Airasian, P. W. (2003). Educational research: Competencies for analysis and applications (7th ed.). Upper Saddle River, N.J.: Merrill.

Gess-Newsome, J. (1999). Secondary teachers' knowledge and beliefs about subject matter and their impact on instruction. In J. Gess-Newsome & L.M. Lederman (Eds),*Pedagogical content knowledge and science education* (pp. 51-94). Boston: Kluwer.

Goodson, I. (1993). *School subjects and curriculum change: Case studies in curriculum history.* London: Croom Helm.

Griffith, J., & Brem, S. (2004). Teaching evolutionary biology: Pressure, stress, and coping. *Journal of Research in Science Teaching, 41*, 701-809.

Grossman, P.L. (1990). *The making of a teacher: Teacher knowledge and teacher education.* New York: Teacher College Press.

Grossman, P.L., Wilson, S.M., & Shulman, L. (1989). Teachers of substance: subject matter knowledge for teaching. In M.C. Reynolds (Ed). Knowledge base for the beginning teacher (pp.23-36). Oxford: Pergamon Press.

Guba, E.G., & Lincoln, Y. (1988). Do inquiry paradigms imply methodologies? In D.M. Fetlermore (Ed), *Qualitative approaches to evaluation in education* (pp.89-115). New York: Praeger.

Henning, E. van Rensburg, W., & Smith, B. (2004*). Finding your way in qualitative research.* Pretoria: Van Schaik.

Holtman, A.L. (2010). The teaching of evolution in South African schools: challenges and opportunities. *Biology International, 47*, 102-108.

Howard, T. C., & Aleman, G.R. (2008). Teacher capacity for diverse learners: What do teachers need to know? In M. Cochran-Smith, S. Feimen, M. Nemser, D.J.

Mcintyre, & K. E. Demers (eds.), *Handbook of Research on Teacher Education: Enduring questions in changing contexts* (pp. 157-174). Florence, KY: Taylor & Francis Group.

Jansen, J.D. (1999). Grove Primary: Power, privilege and the law in South African education*. Journal of Education, 23(1)*, 5-30.

Johnson, K. (2009). *Biology and its contextualisation in the school curriculum: A comparative analysis of post-apartheid South African Life Sciences curriculum.* Unpublished thesis submitted for the degree of Masters of Education, University of KwaZulu-Natal, Pietermaritzburg.

Joyce, B., & Showers, B. (1988).*Student achievement through staff development.* New York: Longman.

Kim, S. Y., & Nehm, R.H. (2010). A cross-cultural comparison of Korean and American science teachers' views of evolution and nature of science. *International Journal of Science Education, 1*, 1-31.

Le Grange, L. (2008). The history of biology as a school subject and developments in the subject in contemporary South Africa. *Southern African Review of Education 14(3)*, 89-105.

Leedy, P.D. & Ormorod, C.J.E. (2005). *Practical research, planning and design* (8^{th} ed.). New Jersey, NJ: Pearson Merrill Prentice Hall.

Lever, J. (2002). *Science, evolution and schooling in South Africa.* In W. James & L. Wilson (Eds.), *The architect and scaffold: evolution and education in South Africa* (pp10-44). Cape Town: HSRC Press.

Loucks-Horsely, S., Hewson, P., Love, N., & Stiles, K. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Magnusson, S., Krajcik, J. S., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In N.G. Lederman (ed.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). Netherlands: Kluwer Academic Publishers.

McDermott, K. A. (2006). Education reform, writ large and small. *Journal of Curriculum Studies, 38(6),* 737-747.

McMillan, J.H., & Schumacher, S. (1993). *Research in education*. New York: Harper Collins.

Meadows, L., Doster, D., & Jackson, D. F.(2000). Managing the conflict between evolution and religion*. American Biology Teacher, 62(2)*, 102-107.

Miller, J.D., Scott, E.C., & Okamoto, S. (2006). Public acceptance of evolution. *Science, 3(3),* 765-766.

Moore, R. (2008). Creationism in the biology classroom: What do teachers teach and how do they teach it? *American Biology Teacher, 70*(2), 79-84.

Morais, A., & Neves, I. (2001). Pedagogic social context: Studies for a sociology of learning. In A. Morais, I. Neves, B. Davis, & H. Daniels (Eds), *Towards a sociology of pedagogy: The contribution of Basil Bernstein to research.* New York: Peter Lang.

Morgan, D.L., (1998). Practical strategies for combining qualitative and quantitative methods: Applications to health research. *Qualitative Health Research, 8,* 362-376.

National Academy of Sciences. (2008). *Science, evolution and creationism.* Washington, D.C.: The National Academies Press.

National Science Teachers Association. (1997). An NSTA position statement on the teaching of evolution. *Science –Scope,2,* 26-27.

Nehm, R. H., & Schonfeld, I.S. (2007). Does increasing biology teacher knowledge of evolution and nature of science lead to greater preference for teaching of evolution in schools? *Journal of Science Teacher Education, 18*(5), 699-723.

Neuman, F. M., Smith, B. Allensworth, E., & Bryk, A.S. (2001). Instructional programme coherence: What it is and why it should guide school improvement policy. *Educational Evaluation and Policy Analysis, 23*(4), 297-321.

Newman, W. L. (1997). *Social research methods: Qualitative and quantitative approaches* (3rd ed.). Boston: Allyn and Bacon.

Ngxola, N., & Saunders, M. (2008). *Teaching evolution in the new curriculum: Life sciences teachers' concerns.* Paper presented at the 16th annual conference of the Southern African Association for Research in Mathematics, Science and Technology Education, 14-18 January, in Maseru, Lesotho.

Nieswandt, M., & Bellomo, K. (2009). Written extended questions as classroom assessment tools for meaningful understanding of evolutionary time. *Journal of Research in Science Teaching, 46,* 333-356.

Powell, J., & Anderson, R.D. (2002). Changing teachers' practices: Curriculum materials and science education reform in the U.S.A. *Studies in Science Education, 37,* 107-135.

Prinou, L., Halkia, L., & Skordoulis, C. (2003).*Teaching the theory of evolution: Secondary teachers' attitudes, views and difficulties.* Athens, Greece: University of Athens.

Roberts, D. A. (1988). What counts as science education? In P. Fenshan (Ed). *Development and dilemmas in science education* (pp. 27-54). London: Falmer Press.

Roberts, P., Priest, H. & Traynor, M. (2006). Reliability and validity in research. *Nursing Standard*, *20(44)*, 43-45.

Robson, C. (1995). Real world research. Blackwell: Oxford.

Rogan, J. M. (2007). An uncertain harvest: a case study of implementation of innovation. *Journal of Curriculum Studies, 39*(1), 97-121.

Rogan, J.M., & Grayson, D. J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education, 25(10),* 1171-1204.

Rosenthal, D. B., & Bybee, R. W. (1987). Emergence of biology curriculum: A science of life or science of living. In T. Popkewitz (Ed), *The formation of school subjects: The struggle for creating an American Institution* (pp.123-144). London: Falmer Press.

Ruthven, K. (1993). Pedagogical knowledge and the training of mathematics teachers. Mathematics and Education Review. Retrieved 21 March, 2007, from

Rutledge, M.L. & Warden, M.A. (2000). Science and high school Biology teachers: Critical relationships. *American Biology Teacher, 62,* 23-31.

Saunders, M. (2003). *Research methods for business students* (3rd ed.). Harlow, UK: Pearson Education.

Scharmann, L.C. (2005). A proactive strategy for teaching evolution. The American *Biology Teacher, 67,* 12-16.

Schmidt, W. H., McKnight, c. C., Valverde, G. A., Houang, R. T., Wiley, D. E., Cogan, L.S., & Wolfe, R.G. (2001*). Why schools matter: A cross- national comparison of curriculum and learning.* San Franciso, CA: Jossey-Bass.

Schneider, R.M., & Krajcik, J. (2002). Supporting science teacher learning: The role of educative curriculum materials. *Journal of Science Teacher Education, 13(3),* 221-245.

Shulman L.S. (1999). Taking learning seriously. *Change 31(4),* 10-17.

Shulman, L.S. (1992). Ways of seeing, ways of knowing, ways of teaching, ways of learning about teaching. *Journal of curriculum Studies, 28*, 393-396.

Shulman, S.L. (1986). Those who understand: Knowledge growth in teaching. *Educational Research, 15(2),* 4-14.

Shulman, S.L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57(1),* 1-22.

Shulman,L.S. (2004). *The wisdom of practice: essays on teaching, learning and learning to teach.* San Francisco, CA: Jossey Bass.

Stears, M. (2011). Exploring biology education students' responses to a course of evolution at a South African university: Implications for their roles as future teachers. *Journal of Biological Education*, Stenhouse, L. (1975). *Introduction to curriculum research and development*. London: Heinemann.

Strauss, A.L., & Carbin, J. M. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage.

Tashakkori, A., &Teddie, C. (1998*). Mixed methodology: Combining qualitative and quantitative approach.* London: Sage.

Troost, C.J. (1966). *An analysis of factors influencing the teaching of evolution in the secondary schools of Indiana.* Unpublished doctoral dissertation, Indiana University, Bloomington, IN

Umalusi. (2009). *From NATED 550 to the new National Curriculum: Maintaining standards in 2008. An Umalusi curriculum evaluation repor*t. Pretoria: Umalusi.

Valverde, G. A. (2005). Curriculum policy seen through high-stakes examinations: Mathematics and Biology in a selection of school leaving examinations from the Middle East and North Africa*. Journal of Education, 80(1).*29-55.

Veal, R.W., & Makinsten, J. (1999). Pedagogical content knowledge taxonomies. *Journal of Science Education,* Retrieved , from www.unr.edu/home page/crowther/ejse/vealmark.html.

Veal, W. R., & Kubasko, D. S. (2003). Biology and geology teachers' domain-specific pedagogical content knowledge of evolution. *Journal of Curriculum and Supervision, 18(4),* 334-352**.**

Wilson, S., & Shulman, L. (1989). 150 different ways of knowing: Representation of knowledge in teaching. In J. Calderhead (Ed.), exploring teacher thinking. Sussex: Holt, Reinhart & Wilson.

World Bank. (1998). *Education in Sub-Saharan Africa World Bank Policy Study*. Washington D.C.: The World Bank.

Young, V.M. (2006). Teachers' use of data: Loose coupling agenda setting and team norms*. American Journal of Education, 112(4),* 521-548.

UNIVERSITY OF
KWAZULU-NATAL

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

30 SEPTEMBER 2009

MS. GP BUTHELEZI (200402301)
EDUCATION

Dear Ms. Buthelezi

ETHICAL CLEARANCE APPROVAL NUMBER: HSS/0654/09M

I wish to inform you that your application for ethical clearance has been granted full approval for the following project:

"A survey of Life Sciences Teachers' Understanding of the Theory of Evolution"

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

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

PROFESSOR STEVEN COLLINGS (CHAIR)
HUMANITIES & SOCIAL SCIENCES ETHICS COMMITTEE

cc. Supervisor (Dr. E Dempster)
cc. Ms. R Govender

APPENDIX A

QUESTIONNAIRE

PLEASE INDICATE THE CORRECT ANSWER BY PLACING THE CIRCLE AROUND THE CORRECT LETTER. THE CORRECT ANSWER IS INDICATED AS BOLD.

1. How old is the Earth?
   A. 530 million years.
   B. 6000 years.
   C. 4 500 million years
   D. 2 billion years.

2. Fossils are…………
   A. Models made by scientist.
   B. Only made by bones.
   C. Very rare and broken into small pieces.
   D. The remains of living organisms preserved in rocks.

3. What do fossils tells us?
   A. About life in the past.
   B. That the scientists are good at making models.
   C. Fossils are only connected with fuels.
   D. God made other forms of life.

4. Gondwana is/was………….
   A. A fossil plant that occurs in South America, Africa and Australia.
   B. A mammal-like reptile.
   C. An ancient land mass in Southern Hemisphere.
   D. An ocean between the Northern Hemisphere and Southern Hemisphere.

5. Methods of dating fossils are………….
   A. Usually reliable.
   B. Very unreliable.
   C. Biased.
   D. Inaccurate.

6. The earliest forms of life on Earth were……..
   A. Viruses.
   B. Humans.
   C. Plants.
   D. Bacteria.

7. Humans have been on the Earth for………..
   A. 2000 years.
   B. **100 000 years**.
   C. 4000 years.
   D. 20 000 years.

8. A Dinosaur is/was…….
   A. A mammal-like reptile.
   B. A bipedal reptile that became extinct 65 million years ago.
   C. A reptile that evolved into tortoises.
   D. The ancestor of the crocodiles.
9. A mass extinction means that…….
   A. Thousands of species become extinct over a few thousand years.
   B. Thousands of species become extinct over a few days.
   C. Thousands of species become extinct over a few years.
   D. All life on Earth becomes extinct.

10. "A living fossil" is………
    A. The remains of animals and plants which have been preserved by natural causes in Earth's crust.
    B. The material remains of human beings.
    C. An impression cast or tracks of any living organism on earth.
    D. A living organism that belongs to a group of mostly extinct species.

11. What provides strong evidence of evolution?
    A. Fossils.
    B. Humans.
    C. Artefacts.
    D. Peppered moths.

12. Which is the place of origin of Hominids?
    A. Israel.
    B. Eurasia.
    C. Gondwana.
    D. Africa.

13. Charles Darwin formulated the theory of…
    A. Artificial selection.
    B. Catastrophism.
    C. Evolution by natural selection.
    D. Natural theology.

14. Evidence for "descent with modification" is…
    A. Different bones in the forelimbs of vertebrates.
    B. The same genes in all vertebrates.

C. Identical bones in the forelimbs of vertebrates.
D. Similar bones in the forelimbs of all vertebrates.

15. The theory of acquired characteristics states that
    A. Organisms acquire characteristics to help them fit in with their environment.
    B. Organisms that don't fit in with their environment die.
    C. Organisms tend to become more complex over time.
    D. Organisms pass detrimental characteristics to their offspring.

16. The study of distribution of plants and animals around the world is called…
    A. Anthropology
    B. Biogeography
    C. Palaeontology.
    D. Anatomy.

17. Species that exist at the present time are called…
    A. Extinct.
    B. Dominant.
    C. Selective.
    D. Extant.

18. The theory of natural selection was most strongly influenced by…
    A. Darwin's observations in South Africa.
    B. Darwin's collection of beetles.
    C. Darwin's reading of an essay by Thomas Malthus.
    D. Darwin's visit to the Galapagos.

19. The theory of natural selection requires that….
    A. Variation exists within a population of organisms.
    B. A population must pass through difficult environmental conditions to evolve.
    C. Populations must be separated from other populations to evolve.
    D. Species must compete with each other to evolve.

20. Artificial selection shows that…
    A. Farmers can create new species by selective breeding.
    B. Biotechnology can be used to create new species artificially.
    C. Humans can change the characteristics of a plant or animal by selective breeding.
    D. By isolating animals artificially in game parks, we cause inbreeding.

21. Who is regarded as the father of genetics?
    A. Charles Darwin.
    B. Gregor Mandel.
    C. Louis Pasteur

D. Jean Lamarck.

22. Choose the correct statement (s)
    A. Mendel worked together with Darwin.
    B. Mendel worked before Darwin.
    C. **Darwin and Mendel never met**.
    D. Darwin formulated the theory of natural selection.

23. What are the factors that control inheritance called?
    A. Phenotype.
    B. Genotype.
    C. Locus.
    D. Genes.

24. Which of the following are the monomers of DNA?
    A. Nucleotides.
    B. Nucleic acids.
    C. Amino acids.
    D. Nucleons.

25. What is the natural shape of DNA?
    A. Single stranded.
    B. Double stranded.
    C. Ladder-like.
    D. Hexagonal.

26. The process of forming messenger RNA is called….
    A. Translation.
    B. Replication.
    C. Transcription.
    D. Dehydration.

27. Where does protein synthesis take place?
    A. Mitochondria.
    B. Nucleus.
    C. Endoplasmic reticulum
    D. Ribosomes.

28. RNA differs from DNA because…
    A. RNA contains deoxyribose.
    B. **RNA has uracil instead of thymine**.
    C. RNA is double stranded.
    D. RNA has thymine instead of uracil.

29. Which type of RNA transfers the amino acids to the ribosomes?
    A. mRNA.
    B. rRNA.
    C. tRNA.
    D. Both A and C.

30. If the sequence of bases in DNA is TAGC, then the sequence in RNA will be…
    A. ATCG.
    B. TAGC.
    C. GTCA.
    D. AUCG.

APPENDIX B

INTERVIEW SCHEDULE

INTRODUCTORY QUESTIONS

1. How long have you been teaching Life Sciences?
2. Which grades are you teaching?
3. What is your highest qualification in Life Sciences?
4. Do you enjoy teaching Life Sciences?

CONTENT QUESTIONS

FOSSSILS

1. What do you know about fossils?
2. Did you study fossils at college or university?
3. How do the fossils support the concept of common descent?

COMPARATIVE ANATOMY

1. What do you know about comparative anatomy?
2. What does it tells us about evolution?

COMPARATIVE EMBRYOLOGY

1. What do you know about comparative embryology?
2. How does this support the concept of common descent?

NATURAL SELECTION

1. Tell me what you know about the theory of natural selection?
2. Who developed this theory?

BIOGEOGRAPHY

1. What do you know about the concept biogeography?
2. How does biogeography relates to the theory of evolution?

QUESTIONS ABOUT CHALLENGES

1. Did you experience any difficulties when you first taught evolution?

2. If the answer to the above question is yes, what kind of challenges did you experience?
3. How did you deal with these challenges?
4. What is the attitude of learners towards the theory of evolution?
5. How do you respond to learners' responses that oppose evolution?
6. Have you ever felt pressure to include creationism to evolution in your classroom? If the answer is yes, tell me about that incident.
7. Do you feel that you have adequate knowledge to teach evolution>
8. Do you think that the department of education has done enough to prepare Life Sciences teachers about this new topic?
9. What do you think the department should do in order to assist Life Sciences teachers on this topic?