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The influence of the beliefs of teachers and learners on the teaching and learning of evolution

by

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DEDICATION

This work is dedicated to my parents, Ntate Tau le ‘M’e ‘Matseka Kali and to my beloved brother, Tseka. Ke u hopola kamehla Mokoena.

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'Mamotena Mpeta

ABSTRACT

The influence of the beliefs of teachers and learners in the teaching and learning of evolution

Key words: beliefs, culture, evolution, evolution education, Life Sciences, multiple research methods, nature of science, religion, science education, worldview

This study explores and describes the beliefs of teachers and learners with regards to the concept of biological evolution and how those beliefs affect the teaching and the learning of the concept. Multiple research methods were used to collect and analyze qualitative and quantitative data from Grade 12 Life Sciences learners and teachers from five secondary schools in the Vhembe District of the Limpopo Province. Quantitative data included biographical information. The Measure of Acceptance of the Theory of Evolution (MATE) was used to assess acceptance of evolution by learners. Qualitative data included opinions of teachers and learners about evolution and how it was taught and learned. The results showed that the background of the participants, such as religion and from whom they had first heard of evolution, had a strong influence on their beliefs about evolution. Most of the learners and the five teachers in the study held Christian beliefs and some of them perceived evolution to be in conflict with those beliefs. There was moderate acceptance of evolution by learners. In teaching evolution, all the teachers engaged learners in discussions and debates about evolution, and encouraged them to separate their beliefs from evolution in order to avoid 'the conflict'. Despite their Christian beliefs and the dissonance between them and evolution, learners were motivated to learn evolution. They felt that evolution was responding to some of the questions they had about themselves, and therefore wanted to understand it more. There was a perception from both teachers and learners that there was not enough evidence in support of evolution, and this is what brings the doubt about its validity. The research encourages further exploration of learners' and teachers' beliefs, and assistance of teachers in the nature of science, better understanding of the concept of evolution. In addition, the research advocates assistance for teachers on how to deal with Life Sciences topics perceived to be controversial.

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LIST OF ACRONYMS

Acronym	Description
AAAS	American Association for the Advancement of Science
ABET	Adult Basic Education and Training
AC	Advanced Certificate
ACE	Advanced Certificate in Education
AD	Advanced Diploma
ADE	Advanced Diploma in Educaion
ATR	African Traditional Religions
BEd	Bachelor of Education
CAPS	Curriculum and Assessment Policy Statement
CDE	Centre for Development and Enterprise
CNE	Christian National Education
CPTD	Continuing Professional Teacher Development
C2005	Curriculum 2005
DHET	Department of Higher Education and Training
DoBE	Department of Basic Education
DoE	Department of Education
DRC	Dutch Reformed Churches
EC	Elementary Certificate
FC	Further Certificate
FET	Further Education and Training
GC	General Certificate
GET	General Education and Training
GFET	General and Further Education and Training
GFETG	General and Further Education and Training Qualifications
HET	Higher Education and Training
HEQ	Higher Education Qualification
IC	Intermediate Certificate
ID	Intelligent Design
IKS	Indigenous Knowledge Systems
IPET	Initial Professional Education of Teachers
MATE	Measure of Acceptance of the Theory of Evolution
MCTE	Ministerial Committee on Teacher Education
NC	National Certificate
NCS	National Curriculum Statement
NOMA	Non-overlaping Magisteria
NOS	Nature of Science
NPDE	National Professional Diploma in Education

NPF	National Policy Framework
NQF	National Qualifications Framework
NRC	National Research Council
NSC	National Senior Certificate
OBE	Outcomes Based Education
PCK	Pedagogical Content Knowledge
PGCE	Post-graduate Certificate in Education
RNCS	Revised National Curriculum Statement
RSA	Republic of South Africa
SA	South Africa
SAQA	South African Qualifications Authority
SAARMSTE	Southern African Association for Research in Mathematics, Science and Technology Education
SETA	Sector Education and Training Authority
SKA	Square Kilometre Array
UK	United Kingdom
UN	United Nations
USA	United States of America
YEC	Young Earth Creationism

LIST OF APPENDICES

OUTLINE OF THE THESIS

This thesis consists of seven chapters. Each chapter is presented in several sections some of which are divided into sub-sections. The chapters are followed by the list of references. The thesis concludes with appendices which include instruments, letters of permission from different people for conducting the research and extracts showing examples of data and data analyses.

The chapters are presented in the following manner:

Chapter 1: Introduction
Chapter 2: Schooling system in South Africa
Chapter 3: Trends in science and evolution education; beliefs and worldview theory
Chapter 4: Research design and methodology
Chapter 5: Results of the quantitative application of the study
Chapter 6: Results of the qualitative application of the study
Chapter 7: Discussion, conclusions and recommendations

The thesis commences with an 'Introduction' in Chapter 1. This chapter gives the background of the study, stating the problem, as well as the questions for the study. Also included in this chapter is a brief discussion of research design, quality assurance measures applied as well as the ethical considerations for the study.

Chapter 2, 'Schooling system in South Africa', presents the context under which the study was conducted. This looks at the past and present of the schooling system in South Africa, teacher education and the Life Sciences curriculum for the secondary schools and more closely at evolution education.

Chapter 3 is on 'Trends in science and evolution education, beliefs and worldview theory'. This chapter presents the literature review which covers a brief outline of the history and developments in science education and in evolution both internationally and locally. Also discussed are the beliefs of teachers and learners and the impact they have on classroom practice and teaching and learning in general. Following is the theoretical framework that has guided the study, which includes the worldview theory and others that describe the formation of beliefs and the impact of beliefs on people's actions and behaviour, particularly in the teaching and learning of science with a focus on evolution.

Chapter 4, 'Research design and methodology' presents, as the title states, the design and methodology employed in the study. This covers the data collection and analysis techniques, and the rationale behind their selection as well as the quality measures applied.

The research findings from the quantitative applications are presented in Chapter 5, and include findings from learners' questionnaires, teachers' biographical data and those from classroom observations.

Findings from the qualitative applications are presented in Chapter 6, 'Results of the qualitative applications of the study'. They include findings from learners' and teachers' interviews as well as from school visits. The latter covers data from the field notes classroom and observations.

The final chapter, Chapter 7, is titled 'Discussion, conclusion and recommendations'. This chapter discusses the findings in relation to the research questions, highlights the limitations of the study, gives recommendations including future research, and concludes the study.

USE OF TERMS

Biology and **Life Sciences** are used equivalently in this text. Biology is used worldwide and appears in documents from South Africa and other countries. Life Sciences has replaced Biology in the school curriculum in South Africa since the educational developments of the recent past, and will therefore be used in the South African context in this report.

Learners and **students**: 'Learners' is a term used currently in South Africa for primary and secondary school pupils while 'students' refers to those in tertiary institutions. In other countries 'students' applies to pupils in schools as well as in tertiary institutions. In this report, 'learners' will be used for South African school pupils but students will be used to describe those in tertiary education as well as school pupils in other countries.

Teacher and **educator**: 'Teacher' has been replaced by 'educator' in the South African education system, and is applicable in primary and secondary schools. However, in this study, 'teacher' has been used to refer the individual teaching and facilitating learning in the classroom.

CHAPTER 1
INTRODUCTION TO THE STUDY

"At a time when educational renewal is a strong current in our own society, the opportunity to make scientific knowledge both accessible and exciting is there for the grasping" (Lever, 2002, p. 44).

1.1 CHAPTER OVERVIEW

In this chapter, the study is introduced by describing its background, and stating the problem as well as the research questions. A brief discussion of the design of the research, quality assurance measures and ethical considerations for the research is also provided.

1.2 BACKGROUND OF THE STUDY

South Africa has been in the world limelight for some interesting scientific, political and socio-economic developments and events. Abolishing apartheid and establishing democratic rule in 1994 was politically significant, not only for the country, but also for other national and global developments. World sporting events such as the prestigious Soccer World Cup in 2010 for the first time found their way into the country and into the whole of Africa. Scientific and technological events such as the discovery of the hominids *Australopithecus africanus* by Raymond Dart in 1924, and *Australopithecus sediba* by Professor Berger in 2008 and named in 2010, the hosting of the 17th Climate Change World Conference in November, 2011, and more recently the renowned Square Kilometre Array (SKA) project, have all featured the country in the global stage.

These important events in South Africa are undoubtedly a result of the level of participation of the country's citizens. They also highlight political, scientific, socio-economic and sustainability issues which demand informed debates and conversations. Of necessity for people to participate and contribute meaningfully in such debates, is the acquisition of a literacy that will enable them to make informed decisions. A country, therefore, has to be abreast of developments locally and globally in order to provide an education that will respond to such demands.

In order for people to acquire the necessary literacy, educational developments in most countries take place with the intention of improving the system of education in order to

respond efficiently to the need for skilled, literate and creative citizenry in the country (Abd-El-Khalick, 2001). Philosophies and principles are usually espoused in an attempt to define a country's aspirations and inform the design and implementation of the curricula. Science curricula reforms, in particular, envisage learners who will emerge as citizens who are scientifically literate and who can contribute meaningfully to socio-economic and technological developments, in order for their countries to be able to provide for their people in a sustainable way, as well as participate meaningfully in global events. The realization of these aspirations depends to an extent on educational reform being systemic: from policy pronouncements to teaching, assessing and evaluating the learning effects. Setting up the infrastructure that will support implementation, selection of content to be learned, and provision of resources are usually guided by policy ideals and determined on the basis of the learning outcomes expected.

One of the latest developments in the curriculum of South African secondary schools has been the addition of evolution to the Life Sciences subject. Although related sub-concepts are covered in Grade 10, the bulk of evolutionary theory is dealt with in Grade 12 (final year of secondary school education). The Life Sciences curriculum for Grade 10-12, as reflected in the National Curriculum Statement (NCS), has organized the scientific knowledge around content areas which include 'Diversity, Change and Continuity'. In Grade 12, this content area consists only of Evolution concepts. Evolution has been included in examinations since 2008. As stated in learning outcome 2 (LO2), learners in Grade 12 are expected to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences related to: origin of species, evolution theories, mutation, natural selection, macro-evolution and speciation, etc. (DoE, 2003a, p. 40). They are also expected, as stated in learning outcome 3 (LO3), to be able to "demonstrate an understanding of … the influence of ethics and biases in the Life Sciences, and the interrelationships between science, … indigenous knowledge, the environment and society in relation to: historical developments, indigenous knowledge systems, … social behaviour and ethics; adaptation and survival; beliefs about creation and evolution; changes of knowledge through contested nature and diverse perceptions of evolution" (*ibid*., p. 40). While awareness about evolution is part of the outcomes, awareness of beliefs about evolution is also included, as well as construction and interpretation of concepts. To deal with those, teachers and learners are likely to tap on their own belief systems, particularly if what they believe in is perceived to be contradictory to evolution.

As also indicated in the NCS, learners are to learn "beliefs about creation and evolution" as well as "changes of knowledge through the contested nature and diverse perceptions of evolution" (DoE, 2003a, p. 40). Perhaps this is a way of catering to the different worldviews and exposing learners to them, irrespective of their own philosophical or religious positions. Ogunniyi (1988) recognizes that some people operate from both scientific and religious or cultural views, and that, for these people, science should take care of the body while religion should take care of the soul. Reiss (2008) supports the idea of including religion in the teaching of science, with the notion that it will be respectful to students. He gives evolution as an example of a topic that can be used for this purpose as it will give secondary school learners an opportunity to exercise their reason. Also, Lategan has stated that by promoting the teaching of evolution and not of creation, or vice versa, one is adopting a paradigm of the 'either/or', or exclusivist (Lategan, 2002, p. 69), an indication that, one and not the other, is the true representation of reality. Considering the diversity of people and their beliefs in South Africa, such an approach would be detrimental to evolution education as some people having deeply-entrenched religious beliefs might feel left out. As it is, therefore, teaching about evolution and bringing in awareness of creation is bound to bring science and religion and/or culture together in the classrooms.

As stated by Aikenhead and Jegede (1999), learners have their own life-worlds where indigenous knowledge mostly operates, whereas at school learners operate within the culture of science. While this should provide an opportunity for learners to debate the interactions between the different worldviews (Le Grange, 2007, p. 581) when in science classrooms, it is not easy for most learners to "move between their everyday life-world and the world of science" (Aikenhead & Jegede, 1999, p. 269), sometimes experiencing cognitive conflicts or dissonance arising from the differences in the two worlds (Jegede, 1995). Lever (2002, p. 17) writes "that the majority of children" in South Africa "find 'science' boring and incomprehensible", and "avoid it like the plague". Furthermore, the 'nature of science' (NOS) has been linked with the understanding and, to some certain extent, acceptance of evolution. When learners understand the NOS, they tend to understand evolution better and then accept it (Nadelson, 2009; Smith, 2010a, 2010b). But to reach the level of understanding of NOS, learners have to cross over from their own culture to the culture of science.

Teaching science should help learners to recognize different epistemologies and evolution is an example of a topic that can assist teachers in achieving that. The inclusion of indigenous

knowledge in the curriculum, and beliefs about creation and evolution in Grade 12 may well facilitate the awareness among learners of different ways of knowing and worldviews. With the failure to do that, a conflict created as "different ways of knowing become lumped together" (Martin-Hansen, 2008, p. 323) surfaces in college and school science classrooms. Moreover, the interaction between the modern scientific and African or other worldviews in the classroom can complicate the learning process (Le Grange, 2007, p. 581) and alienate learners who have divergent worldviews. The critical question, however, is whether the relevant stakeholders will be willing to implement and sustain an alternative approach (Lategan, 2002, p. 72).

One of the challenges that South Africa faces is the realization of curricular expectations through the provision of appropriate instruction. It has been noted that, contrary to expectation, policy intentions and suggestions are not necessarily reflected in science instruction (Fullan, 2001). Further, as stated by Lever (2002), educational renewal should offer an opportunity to make curricula more accessible and exciting. This can be achieved by identifying factors that obstruct the accessibility to exciting knowledge. Studies on factors that affect the teaching of science in South Africa have been done (e.g. Howie, 2002) but more investigation into the teaching and learning of specific content areas is required.

Research has been done elsewhere on the state of education of evolution in secondary schools and tertiary institutions, but this kind of research is fairly new in South Africa (see Abrie, 2010; Chinsamy & Plaganyi, 2007; Molefe & Sanders, 2009; Sanders, 2010; Sanders & Ngxola, 2009). Now that evolution is being taught in the schools, it becomes essential to understand the situation in relation to its teaching and learning and find out how teachers and learners deal with it. The fundamental concern is the extent to which teachers can assist learners in understanding evolution, and about the quality of evolution education itself in South Africa. This study aims at exploring how people's beliefs, particularly the beliefs of teachers and learners in South Africa, influence the teaching and learning of evolution in Life Sciences.

1.3 THE RESEARCH PROBLEM

There have been concerns that South African teachers may avoid teaching evolution (Abrie, 2010; Bower, 2006 as cited in Le Grange, 2008b), indicating uncertainty about the readiness of Life Sciences teachers to implement evolution teaching. My classroom experience with

student teachers, information from teachers of Life Sciences, studies done internationally, particularly in the United States, and those done locally (see Abrie, 2010; Sanders, 2010; Sanders & Ngxola, 2009) indicate that the teaching of evolution is problematic for teachers, leaving them frustrated and not knowing how to cope.

Because evolution is new in the curriculum, practising Life Sciences teachers who were educated in South Africa did not learn evolution formally in schools, but only came across the concept formally for the first time at university. These teachers, therefore, do not have classroom experience in the learning of evolution. Exposure (or lack of exposure) to the concept of evolution during secondary education has been found to be one of the determinants of subsequent views of learners about evolution and its acceptance (Moore & Cotner, 2009). Lack of that exposure at school level, therefore, could imply that such views develop mainly in homes, and may remain entrenched influencing learning and teaching later. Exposure in an environment where misinformation about evolution prevails could lead to the development of misconceptions and affect later beliefs about evolution. For instance, Abrie (2010) found that many of the student teachers who participated in her survey subscribed to some of the common misconceptions regarding the theory of evolution. If teachers hold misconceptions about evolution, they are likely, therefore, to teach those misconceptions. This can also lead to non-acceptance of evolution (*ibid*, 2010), which can lead to poor instruction characterized by insufficient teaching or avoidance.

Other findings relating to teachers' knowledge about evolution have shown that teachers do not understand the concepts underlying evolution well enough to teach it (Chinsamy & Plaganyi, 2007), an observation made elsewhere as well (see Smith, 2010b). Similarly, findings by Sanders and Ngxola (2009) indicate the commonest concern of teachers was related to the possession of inadequate knowledge. This concern could therefore affect teachers' confidence when it comes to teaching evolution, leading to fears. Fear of opposition and potential conflict in classrooms affects teachers (Sanders & Ngxola, 2009) and student teachers (Abrie, 2010), especially if they do not know what to expect from learners and how to deal with any conflicts that may arise. But, as found by Sanders (2010) teachers feared evolution even before teaching it, but most realized that their fears were unfounded as they taught it. One of the possible reasons for this undeniable fear could be rooted in the teachers' prior knowledge or past experiences with evolution, either as a student or as a teacher.

Regarding learners, it has been found in some contexts that they already know a remarkable amount about evolution even before receiving formal school instruction (Kagan & Sanders, 2012). This study, done in a Jewish school, found that some of the knowledge is erroneous even though for this school, the finding was that the extent of these erroneous ideas is far less than that reported in other studies (*ibid.*). However, Lawrence and Sanders's (2012) study on students' misconceptions showed that there were many erroneous ideas held by the students in one public school in South Africa, and that the misconceptions seemed to persist across grades (years of schooling). Perhaps the misconceptions persist even beyond secondary school to higher levels, as was found in studies at those levels (see Abrie, 2010).

Furthermore, it has been stated from studies by Abrie (2010), Chinsamy and Plaganyi (2007), Sanders (2010), Sanders and Ngxola (2009) that some of the teachers and learners who have deeply entrenched religious beliefs find it hard to accept evolution. Some teachers remain sceptical about evolution and somehow communicate this to learners (Sanders, 2010), which could result in learners not wanting to learn about evolution. Moreover, the biology student teachers who participated in a survey by Abrie (2010, p. 104) "did not support the idea that evolution should be taught in South African schools", which could imply that when they become teachers, they might not teach evolution properly. In addition, teachers have concerns regarding how to deal with their own beliefs about evolution as well as those of learners. Some of them may choose to avoid teaching evolution or some parts of it as has been observed in the United States (Moore & Kraemer, 2005; Rutledge & Mitchell, 2002; Trani, 2004). Learners also have their own beliefs, and if they are not sufficiently and appropriately taught about evolution, the likely results are increased lack of knowledge, disbelief in evolution's validity as a scientific model, and lack of acceptance of evolution itself.

Furthermore, as shall be discussed in Chapter 2, the South African National Curriculum Statement (NCS) (DoE, 2003a) mentions 'origin of species' and 'evolution theories', as well as 'beliefs about creation and evolution'. Bringing awareness of such beliefs is likely to bring science and religion together in the classroom. As cautioned by Reiss (2008), the issue of science and religion in education poses pedagogical challenges for teachers. Furthermore, there is a danger that teachers having a religious bias may "introduce divine creationism as a respectable, scientific alternative to evolution" (Abrie, 2010, p. 106). With no proper guidelines in the curriculum, and perhaps insufficient preparation as well, teachers may lack proper content or pedagogical content knowledge for the teaching of evolution. In addition,

teachers need strategies to manage any conflicts arising from evolution and creation debates in classrooms, while promoting and maintaining quality instruction.

It has been found that some teachers use methods that are not appropriate for dealing with the controversy and complexity of the concept of evolution Sanders (2010). For instance, they do not use learner-centred methods where learners' views would be incorporated and discussions which could avert any potential conflict with learners are not entertained. This unintended dogmatism results in teachers' lack of accommodation of differences of opinion in class (Sanders, 2010). Learning in this kind of atmosphere may prejudice learners against the concept of evolution, with learners having a distorted view of evolution, not recognizing its unifying status in Life Sciences, and rejecting it outright.

In summary, therefore, it can be said that some Life Sciences teachers in South Africa have concerns about teaching evolution. Also, classrooms dealing with evolution are faced with tensions evoked by the nature of the content covering evolution, teachers' and learners' beliefs about evolution and teachers' dilemmas about how to teach it. This tension is further compounded by teachers' lack of content knowledge and pedagogical content knowledge appropriate for the teaching of evolution. Teachers' own beliefs seem to be posing problems resulting in lack of understanding and lack of acceptance of evolution, fear of conflict in classrooms in case their own and learners' beliefs clash with what is being taught, and use of inappropriate strategies to cope with or avert the conflicts. Learners also come to schools with some knowledge about evolution, part of which is erroneous. They also have views and beliefs which might clash with those of the teachers. But, even if teachers' and learners' beliefs do not clash, there could be discord between those beliefs and the content of evolution, leading to cognitive dissonance and lack of effective learning about evolution.

1.4 AIM OF THE RESEARCH

As implied from the discussion above, the aim of this study was to determine how the beliefs about evolution by teachers and learners influence evolution education in South Africa. The research focused on secondary schools around the Vhembe District of Limpopo Province (see Figure 2.2) in South Africa. The intention was to explore the beliefs about evolution held by teachers and learners, and to understand how those beliefs influence the instruction of biological evolution. Exploring the teaching strategies used would add to this understanding and identify any gaps that may exist in the teaching of evolution. Teachers' and learners'

experiences were explored to determine the factors that influence formation of their beliefs and add to an understanding of the characteristics of such beliefs and how they relate to beliefs about evolution. Through this exploration, the researcher also sought to understand if instruction about evolution in the schools reflected the curriculum ideals applicable to Life Sciences.

It was hoped that this study would (i) provide new insights into people's worldviews and their impact on learning that can facilitate discussions within the South African context; (ii) facilitate generation of teacher profiles and increase knowledge of teachers' actual needs, (iii) illuminate and help to understand the gaps existing in the implementation of evolution education, and (iv) identify areas where appropriate interventions could be instituted.

1.5 OBJECTIVES OF THE RESEARCH

The following objectives were addressed in the study:

1.5.1 To describe the beliefs teachers hold about the theory of evolution and how these beliefs influence the way teachers teach evolution and related concepts.

1.5.2 To describe the beliefs learners hold about the theory of evolution and how these beliefs influence the way learners learn about evolution and related concepts.

1.5.3 To describe the factors which influence the formation of teachers' and learners' beliefs about evolution.

1.5.4 To describe the strategies used by teachers and learners to negotiate the tension between their beliefs about evolution and the requirements of the curriculum during the teaching of evolution.

1.6 RESEARCH QUESTIONS

The following main question and sub-questions were critical to understanding the situation concerning evolution education and how it is affected by teachers' and learners' beliefs.

Main question

How do the beliefs of teachers and learners influence evolution education in secondary schools in the Vhembe district of Limpopo Province, South Africa?

Sub-questions

1. What do teachers in Vhembe district believe about evolution, and what influence do their beliefs have on their teaching of evolution?

2. What do their learners believe about evolution, and how do their beliefs influence their learning of evolution?

3. What factors influence the establishment of beliefs about evolution held by these teachers and learners?

4. How do these teachers and learners negotiate potential tensions between their beliefs and the requirements of the curriculum when teaching and learning evolution in the Life Sciences classrooms?

1.7 RATIONALE AND SIGNIFICANCE OF THE STUDY

This study has been motivated, firstly, by the recent addition of the theory of evolution in the Life Sciences curriculum in South African secondary schools. Evolution accounts for about 25% of the content in Grade 12 Life Sciences curriculum, a percentage high enough to influence performance in Life Sciences examination. It has been examined since 2008, and reports of examiners indicate poor performance in it, which should be a matter of concern to Life Sciences educators. The poor performance by learners in evolution may be attributed to a number of factors, including the way the activities and assessment are aligned to each other and to the expected curriculum outcomes. The aim of this study was not to investigate performance but to look at how teaching and learning took place, which might indicate how the curriculum was perceived and enacted by the teachers and learners.

In addition, the design of the current curriculum in South Africa is underpinned within constructivism, a theory that posits the recognition of prior ideas in teaching and learning. Prior ideas include any knowledge and beliefs that learners bring to the classroom which could reflect learners' belief systems. Some of the knowledge might be erroneous or clouded in misconceptions. Regarding the influence of social context on teachers' beliefs and practices, most of the research on beliefs, particularly of science and religion, has been done mainly in Western culture. However, studies done in other cultures (Dzama & Osborne, 1999; Liu & Lederman, 2007; Mansour, 2008a, 2008b; Mansour, 2010) have shown that teachers and learners from foreign cultures have difficulty coming to terms with Western (modern) scientific knowledge. Generally, the results indicated that students often bring alternative conceptions into science classes, and these conceptions may or may not be in agreement with the scientific conceptions being taught.

It is argued, in this study, as has been expressed elsewhere by Nadelson (2009, p. 492), that "how teachers are taught, the way that they teach, what they teach, and the misconceptions

that they hold" all influence and are in turn influenced by others. Furthermore, the social context that teachers operate within, from when they are learners themselves to the point when they are teachers, influences what and how they learn, as well as what and how they teach. In addition to this, learners' views are also pertinent to the learning setup. In a discourse that recognizes the importance of learners' prior conceptions and ideas, teaching is affected because teachers cater for those in shaping their instruction. Some studies done locally have focussed on the perceptions of teachers (Sanders & Ngxola, 2009), and the understanding of evolution by preservice teachers (Chinsamy & Plaganyi, 2007). Recently, more studies have looked at the misconceptions held by high (secondary) school students (Kagan & Sanders, 2012; Lawrence & Sanders, 2012). Studies that have examined the beliefs of teachers and learners in Limpopo and how they interact during actual classroom discourse, or investigated the teaching and learning strategies used in instruction about evolution were not found. Hence, what goes on at school level regarding the teaching and learning of evolution in Limpopo was not fully known. Furthermore, the extent to which teachers identify learners' misconceptions prior to giving instruction is not known. This study was therefore an attempt to understand that situation, so as to inform future curricular and pedagogical decisions regarding science and the theory of evolution in South African schools.

As discussed in coming sections, beliefs held by the general public as well as by teachers can shape the teaching and learning of evolution (Mansour, 2008a; Moore & Kraemer, 2005). A recent study by Ogunniyi (2012) found that all teachers in the sample, including the survey cohort, held dualistic and amalgamated worldviews, even though the influence of those worldviews awaited further investigation. Therefore, more specifically, this study looked at the views of teachers about evolution and about teaching it, and how such views influenced the classroom discourse. In other words, "understanding how teachers' social and cultural values influence their ways of viewing the disciplines in which they have been involved … [might] provide science educators with valuable information about how to design curricula suitable to the needs of the culture and society" (Liu & Lederman, 2007, pp. 1282-1283).

Given that literature has pointed to the centrality of teacher beliefs in the decisions teachers make about what they teach and how they teach (Bandura, 1997, 2001; Pajares, 1992), and that the evolution controversy is at the heart of the belief systems of many teachers, this study explored how teachers' beliefs in evolution influenced the teaching of evolution. As stated by Bandura (1997, 2001), among the mechanisms of personal agency, none is more central or

pervasive than people's beliefs in their capability to exercise some measure of control over their own functioning and over environmental events. Some teachers and student teachers in South Africa have raised concerns (see Abrie, 2010; De Villiers, 2011; Sanders & Ngxola, 2009) in relation to evolution education. This could indicate dissatisfaction or discomfort by some teachers in preparatory programmes and those in the service already about teaching evolution. Thus, when examining the influence of beliefs on the teaching and learning, it is imperative to also examine the teachers' and learners' perspectives of pedagogy and, in the context being considered here, their misconceptions about evolution.

Taking into account the controversy surrounding the concept of evolution elsewhere, and the cultural and religious backgrounds of South African teachers and learners, there is a need to understand the situation in South Africa. This study investigates what teachers teach about evolution, how they teach it and how they manage the classroom discourse. It also aimed at drawing attention to the experiences of teachers and learners in some secondary schools when teaching and learning concepts that may be in conflict with their beliefs. In the case of challenges, this study provided an insight into how teachers manage teaching and learning in conflict situations. Furthermore, the study was meant to illuminate the intricacies of teacher practice as influenced by teachers' and learners' belief systems when teaching scientific topics deemed controversial. As Speer (2005, p. 364) states, "understanding [teachers'] decisions requires understanding of what knowledge [and beliefs] they possess, as well as how they decide what knowledge to invoke, when and how".

This study was the first conducted in the Limpopo Province since the commencement of teaching evolution at senior secondary level in schools in 2008. The expectation was that at the time of the study, teachers would have had sufficient classroom experience with evolution to reflect upon and provide valuable insights for the study. It was conducted on the premise that teachers' and learners' beliefs are vital in determining classroom action and outcomes and that the culmination of teachers' decisions is reflected in classroom activity and learning outcomes. The main assumption underlying this study, therefore, was that teachers' beliefs have an influence on the decisions teachers make about what content to teach and how to teach it. Thus, teachers' beliefs about evolution are likely to influence their pedagogical beliefs, which in turn determine their decisions about what evolution content to teach and the relevant teaching strategies to use during instruction. Similarly, learners' beliefs are assumed to have an influence on the way they respond to teachers' choices of content and instructional

strategies during the teaching of evolution, which would therefore have an effect on how and what they learn. Therefore, comprehending the intersection between beliefs and the understanding of science, particularly of evolution, can provide an insight into areas that need attention when assisting teachers to deal with their concerns, and inform effective approaches to curricular and pedagogical decisions regarding evolution education.

2.2.1 Vhembe District in Limpopo Province

South Africa attained its democratic fulfilment in 1994. Before then, the country had four provinces: Cape and Natal – which were formerly British colonies − and the Orange Free State and Transvaal which were formely Afrikarner colonies. Under the policy of apartheid, also known as 'separate development', the Black people of South Africa were forced to live and obtain citizenship in ten officially tribally-based 'homelands' scattered about the country. In the north eastern part of the country were found three of these homelands, one of which was Venda, the homeland for the people whose home language is TshiVenda. Upon the attainment of democracy and regime change, the homelands were dissolved and reincorporated into the Republic of South Africa. Under the new dispensation South Africa was divided into nine provinces, each with its own government, with a provincial legislature and provincial premier. Under this new provincial set-up, the former Venda homeland is now in the Vhembe District of the Limpopo Province.

The map in Figure 2.2 represents Limpopo Province. This province is in the far northern part of the country, with an area of 125 755 km^2, having been part of the former Transvaal. In the 2011 census the population of Limpopo was estimated to be 5 404 868 (Statistics SA, 2012). This province shares borders with Zimbabwe to its north, Mozambique to the east, and Botswana to the west. Limpopo Province, like the others, has been broken down into districts. The five districts are Capricon, Mopani, Sekhukhune, Vhembe and Waterberg. Figure 2.3 shows a map of Vhembe District in the northern part of the Province.

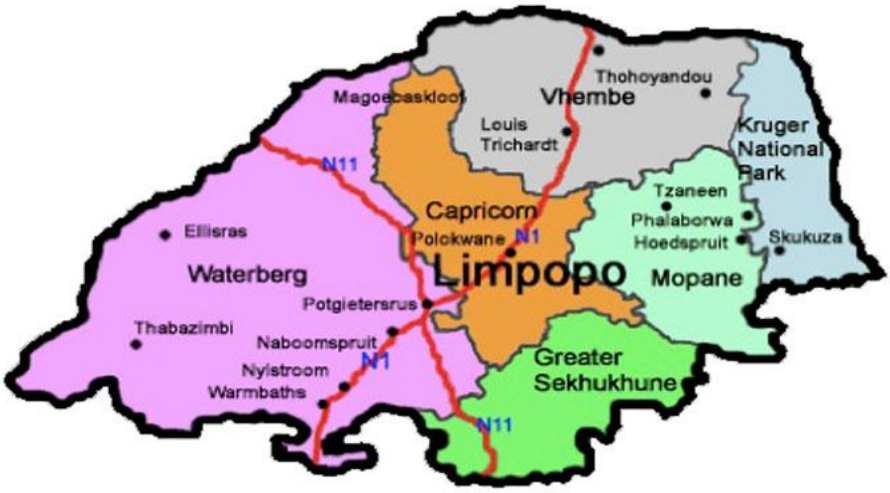

Figure 2.2: Map showing the districts of Limpopo Province [Source: Municipal Dermacation Board (2006a)]

The research for this dissertation was conducted in Vhembe District, which includes the former Venda homeland. Vhembe District is further divided into four municipalities, namely, Makhado (previously Louis Trichardt), Musina, Mutale and Thulamela. Figure 2.3 is a map showing the Vhembe district with its municipalities.

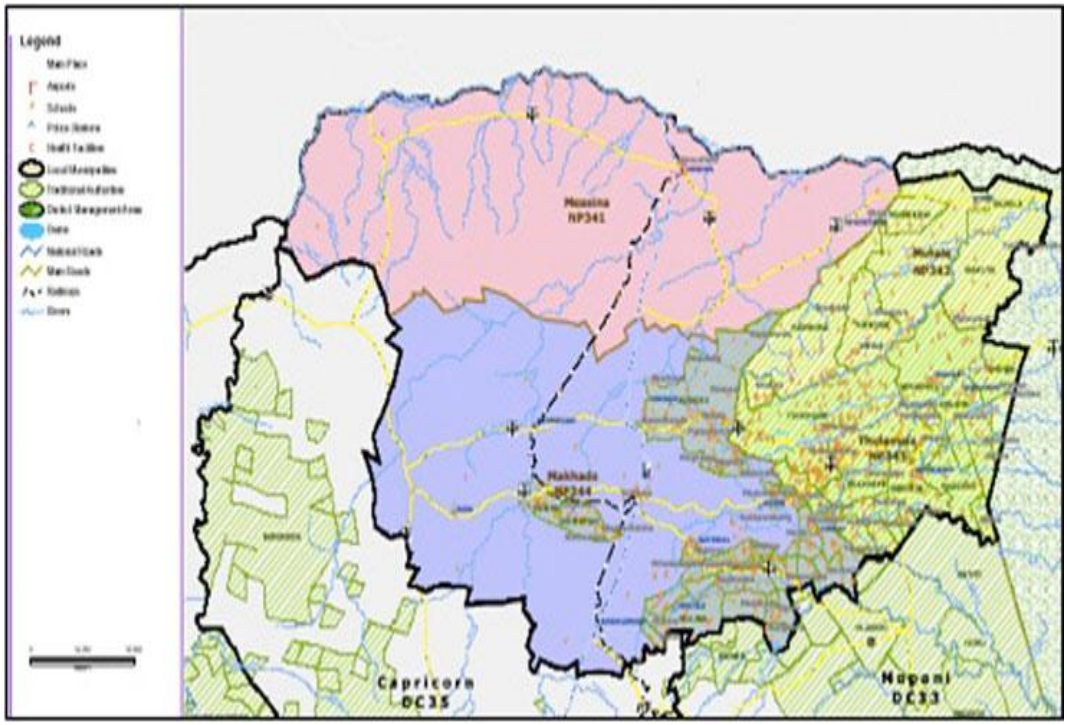

Figure 2.3: Map showing the divisions of Vhembe District in the Limpopo Province [Source: Municipal Dermacation Board (2006b)]

1.8 DESIGN OF THE STUDY

This study was conducted in the Vhembe District of the Limpopo Province in South Africa. A multiple-model design was used wherein qualitative and quantitative approaches were used throughout the stages of the research process (Johnson & Onwuegbuzie, 2004, p. 20). Multiple data sources were used to answer the questions of the study and "to uncover numerous perspectives while elaborating on the complex realities of each participant with respect to" the situations they face (Griffith & Brem, 2004). The study recognized that teachers and learners were "direct sources of data" (Bradley, 1993); therefore data collection involved talking to them and observing them in action, as well as obtaining written responses from the learners. There were altogether 480 Grade 12 learners studying Life Sciences in the five schools. Table 1.1 and Figure 1.1 present the information about the sources of data as well as the methods used to collect the data from these five schools.

Table 1.1: Sources of data and methods of data collection for the study

Method of data collection	Sources			
	Learners		Teachers	
	Number of participants	Returns (% of total sample)	Number of participants	% of total sample
Questionnaires	348	72.50	-	-
Interviews	33	6.88	5	100.00
Classroom observations	342	71.25	5	100.00

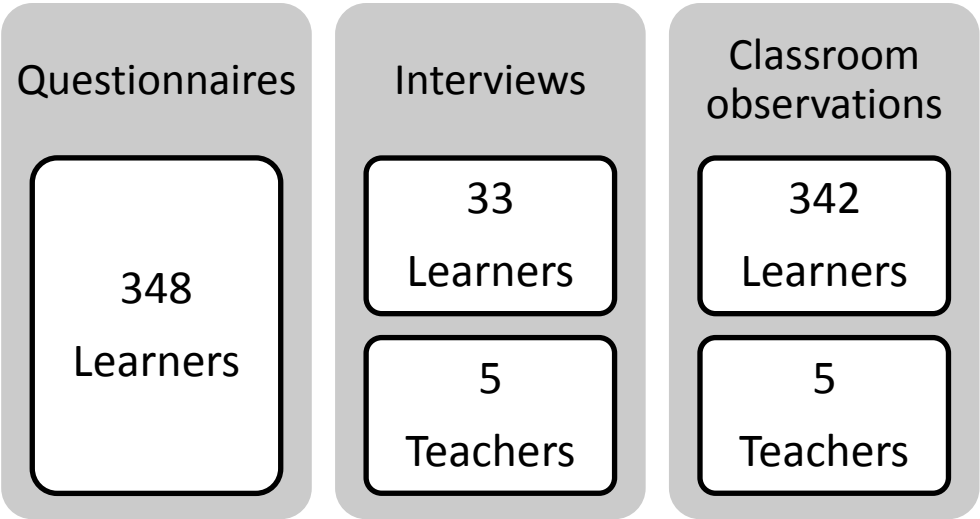

Figure 1.1: Sources of data and data collection instruments

Data were collected quantitatively using questionnaires which covered biographical data of the participants and their perceptions about evolution. To allow for measurement and analysis of the associations between variables regarding the beliefs and perceptions of learners, a questionnaire was administered to all the learners who participated. The use of questionnaire enabled a larger sample of learners to participate. The questionnaire also investigated their acceptance of the theory of evolution, their beliefs about evolution and attitudes towards learning it.

As discussed in Chapter 3, acceptance of evolution is affected by certain variables including the background of people. Associations were measured between different characteristic variables and learners' acceptance of evolution. The null hypothesis (H_o) being tested was that there was no association between the variables, suggesting that a change in one variable would not have an effect on the other variable. The alternative hypothesis (H_A) was that there was association between a variable being tested and evolution acceptance.

Data were collected qualitatively by interviewing five teachers, one from each school, and a total of thirty-three learners from the five schools, as well as observing some lessons which covered evolution. Teachers' interviews covered their knowledge of evolution and of pedagogical practices suitable for teaching it. The interviews were also meant to elicit their views regarding evolution and how those beliefs influenced their teaching of evolution in Grade 12 Life Sciences classrooms. Learners' interviews sought in-depth information regarding their beliefs and attitudes towards education about evolution. Classrooms were visited to observe the teaching and learning strategies used during the teaching of evolution. The behaviour, actions and comments of teachers and learners were noted as well as the ways in which they interacted with each other and with the content of the lessons. Such observations also enabled the researcher to observe the strategies that both teachers and learners use to cope with any tension. The intention was to explore any tensions existing between the beliefs of teachers and learners about evolution and the curriculum requirements of teaching and learning.

1.9 ETHICAL CONSIDERATIONS

This study was about beliefs held by people. For this reason it was essential to consider ethics when soliciting people's personal information and reporting that in a study. Of utmost

importance was maintaining confidentiality and privacy, and obtaining informed consent (Esterberg, 2002). To ensure confidentiality and privacy the following measures were taken:

- Permission was requested from the Limpopo Provincial Education Department and from the District Education office in Vhembe to visit schools, observe classroom activities and interview teachers and learners in the schools. Permission was also sought from the principals of the schools where the study was to be conducted, Life Sciences teachers who were to participate in the research, the parents and guardians of learners, and the learners.

- According to Fontana and Frey (1998, p. 70), right to privacy involves protecting the identity of the subject, while informed consent is received after the subject has been carefully and truthfully informed about the research. Prospective participating teachers and learners were informed of the intentions behind the study and were assured that confidentiality and right to privacy would be maintained by means of not exposing their identity. They were also assured that there would be no harm to them as individuals and there would be no damage done to the school setting as a result of their participation in the research.

- Teachers were informed that participation in the study was voluntary and that they were free to opt out if they wanted to. Upon agreeing to participate in the study, the teachers were requested to fill in forms to indicate their willingness. A letter informing the parents and guardians of the learners about the research accompanied a consent form that parents were requested to complete if they approved of their children taking part in the study. Only those learners whose parents or guardians approved and who themselves gave consent responded to the questionnaire and took part in interviews.

1.10 CONCLUSION

The chapter has outlined the background behind this study, the problem being investigated and the rationale behind the investigation. Literature to support the problem of the study and to rationalize this study has been cited. In addition, a brief outline of the study design and an account of ethical considerations that guided the study have been presented. The next chapter discusses the schooling system in South Africa so as to describe the context in which the study was conducted.

CHAPTER 2

THE SCHOOLING SYSTEM IN SOUTH AFRICA

*"I share much of his [*Feyerabend*] concern about the role of science as an ideology because of how it dominates our world-views and how, as an ideology, science provides frameworks for action"* (Volmink, 1998, p. 63).

2.1 CHAPTER OVERVIEW

This chapter describes the context of the conduct of this research. First, South Africa is described looking briefly at history and political developments up to the time the research was conducted. The history of this country has had a profound effect in the livelihoods of its people, their views about life and about what to believe. Next, the education system, and the development thereof, is looked at more closely. Of more relevance to this study are the specific developments in Life Sciences (Biology), particularly evolution education. People's beliefs are central to this research. For this reason, culture and religion in the country are also briefly discussed, especially because cultural and religious beliefs are usually at the heart of debates pertaining to evolution education.

2.2 THE REPUBLIC OF SOUTH AFRICA (RSA)

With an area of 1 230 088 square kilometers, South Africa, otherwise known as the Republic of South Africa (RSA), is found at the southern tip of the African continent with a coastline of 2 798 kilometers with the Atlantic and Indian oceans. It shares boundaries to its north with Zimbabwe, Botswana, Namibia and to the east with Mozambique and Swaziland. Lesotho is bordered on all its sides by South Africa. A map showing South Africa and the surrounding countries, South Africa's provinces, provinces boundaries and capitals, as well as the major cities is given in Figure 2.1. According to Statistics South Africa's mid-2011 estimates, the population of South Africa stood at around 50.59 million (Statistics SA, 2012) in 2011.

Figure 2.1: Map of South Africa showing current provinces [based on a United Nations (UN) map. Source: UN Cartographic Section]

The political history of South Africa has been one of the most interesting in the world. Often and affectionately referred to as the Rainbow Nation, South Africa is one of the most culturally diverse nations in the world. The early people recorded as living in this county are known as 'the Khoisan' who lived in the southern part of the continent. The Bantu-speaking people, who seem to have moved out from the centre of Africa, came later and settled mainly in the north-eastern and eastern parts of present-day South Africa.

The arrival of the Dutch in 1652 began the settlement by Europeans and a documented history of South Africa. The Europeans occupied farm land and brought slaves from East Asia and north Africa to work on those farms. Those people who came from the East brought their religions, such as Islam and Hinduism, with them. The settlement by the Europeans had all the characteristics of colonisation, the colonialists in this case being mainly Dutch, British, German, and French (Huguenots). The descendents of the Dutch, Germans and French later became known as 'Afrikaners', their language being related to Dutch. When the British took over the Cape, and later Natal, many of them moved out into what became the Transvaal and Orange Free State, forming countries independent of Britain. When precious minerals were later discovered in these territories, and the British wanted possession, the Afrikaners fought

with thte British in what was called the Anglo-Boer War over the rule of the land, particularly with the development of the gold mines.

Although the British eventually won the war, the Union of South Africa was formed in 1910, and power fell into the hands of Afrikaners under the South African Party. This was followed by the passing of legislation, which included the 1913 Land Act and the pass laws, meant to entrench white supremacy. A corollary of this self-awarded domination was determined resistance from the Blacks together with the Indians and various people of mixed descent. The term 'Black' in South Africa is used mostly to denote those people speaking one of the several Bantu languages, but often includes those of mixed descent whose language is mainly Afrikaans, but who were never regarded as Afrikaners, but often also known as 'Coloureds'. By contrast, the term 'White' is used mostly to denote anyone of European descent, including Afrikaners and the British.

Further political moves on the part of the Afrikaners led to the formation of the Nationalist Party, which became home to extremist Afrikaners. Under the Nationalist Party, laws were passed to segregate Blacks and Whites and to thwart Black urbanisation. Further entrenchment of the Nationalist party led to the passing of more segregation laws, such as the Group Areas Act and the Population Registration Act, both of 1950, also the Separate Amenities Act and the Bantu Education Act, both of 1953. Under these laws Blacks were restricted from moving in certain designated places in the country.

2.3 THE PEOPLE OF SOUTH AFRICA

South Africa is characterized by the immense diversity of its people, formerly and for official purposes still categorized into four main population groups: Black (of African ancestry); Coloured (mixed ancestry which includes European, Indian, African as well as Khoisan); Asian (Asian ancestry); and White (European ancestry). The population distribution in 2011 divided proportionately into: 79.2% Black; 8.9% Coloured; 8.9% White; 2.5% Asian, and 0.5% for other groups (Statistics SA, 2012, p. 17) for the whole country, although the percentages differed from province to province. Compared to the other provinces, the Limpopo Province had the highest Black population at 96.7% and the lowest of the other populations: 0.3% for each of Coloured and Asian populations, and 2.6% White.

The diversity of the South African people also manifests itself in the many languages spoken, of which eleven are officially recognized in the Constitution. Tsi-Venda is one of these officially recognized languages in South Africa.

Diversity is also manifested in the many religions that people follow and practise. These include the traditional African religion(s) and those that have come from other parts of the world, particularly from Europe in the West and Asia in the East. Of the total population, 85% belong to some religion, with 80% of these professing to Christianity. According to the Statistics SA (2012), the predominant form of Christianity among Black South Africans is that of the indigenous and independent Zion Christian Church, with about 24% following it nationally, whereas of the White and Coloured South Africans, 86% are Christians of different denominations. Among the Indian and/or Asian population group, Hinduism is most common at 47.3%, followed by Islam at 24.7% and Christianity at 24.2% (Statistics SA, 2012).

In the Limpopo Province, where the research for this dissertation was conducted, Statistics SA (2012) estimates a population of 5.5 million, of which 69% profess to being Christian (Statistics SA, 2012). The 2011 census revealed that more than a third, about 42.5% of the Limpopo Province's Christian population, stated that they belonged to one of the independent churches. The independent churches include the Zionist churches, iBandla lamaNazaretha and Ethiopian-type churches (*ibid.*). The mainline churches − which include reformed churches, considered to be Anglican, Methodist, Presbyterian, Lutheran, Roman Catholic, Orthodox and the United Church of South Africa − had a following of about 13.1% in 2001. Of the rest, the Pentecostal Charismatic Churches accounted for 8.3%, other Christian denominations 4.8%, and Eastern or other faiths and Islam, 1.7% and 0.2% respectively. Other religions make up just 2% with the African Traditional beliefs accounting for 1.4%. In 2001, 28.5% of the people in Limpopo Province indicated that they do not belong to any religious grouping, compared to 27.1% in the 1996 census.

The Christian denominations follow the teachings of the Bible although some, such as the indigenous and independent churches, also diverge to other forms of worship such as devotion to ancestors. Islam uses the Qur'an as its holy book. In addition, all the faiths believe in the creation by God or the Supreme Being of the earth and all that is in it, including humans. Some Eastern religions, such as Hinduism, also believe in reincarnation, by which, when a person dies, his or her soul lives on and can be born again in a different body.

2.4 THE SOUTH AFRICAN EDUCATION SYSTEM

Although previously under one ministry, in 2009 the National Department of Education was split into two ministries, namely the Department of Basic Education (DoBE) and the Department of Higher Education and Training (DHET). As the names imply, each of the two ministries serves specific levels of education across the country. The Ministry of Basic Education is responsible for primary and secondary education, as well as Adult Basic Education and Training (ABET). The Ministry of Higher Education and Training deals with tertiary education, technical and vocational training, as well as the Sector Education and Training Authorities (SETAs). The nine provinces have their own departments of education, and their operations are informed by the National Policy Framework (NPF). The provinces are responsible for administration and administrative issues. In each province there are District Offices which are responsible for organizing the work that filters to the schools through the Circuit Offices.

With the attainment of democracy in 1994, the government planned to provide equal opportunities for all the people of South Africa and to redress the imbalances created by apartheid. The diversity and complexity thereof have been aknowledged in many forums, as in the report of the Centre for Development and Enterprise (CDE) workshop held in 2011:

> The South African education system is large and complex, comprising more than 12 million learners, more than 350 000 educators, and about 30 000 schools in more than 70 disctricts in nine provinces. It is also very diverse, with huge differences within and among provinces, districts and schools. Any reform attempts are complicated by South Africa's legacy of apartheid and past and current issues of race and politics (CDE, 2011, p. 2).

This report, written in September 2011, makes this statement seventeen years after the change to democracy. It indicates that, while there had been successes in some areas of the education system, there was still a lot that the country had yet to accomplish. The report further acknowledges that South Africa has unique problems, and while lessons may be learned from other places, what is important is to forge ahead and not to concentrate on the past. For instance, the distribution of resources in schools remains unequal, which could impede access to quality education by some learners.

The 1996 Constitution of South Africa, which is the supreme law of the country, contains a range of legislation, among which is the Bill of Rights. The latter stipulates that everyone in the country has a right to basic education, including adult basic education and futher

education, and that the State has an obligation, through reasonable measures, progressively to make education available and accessible. The Bill of Rights also stipulates that everyone is equal before the law, and that everyone has the right to freedom of conscience, religion, belief, thought and opinion.

With this realisation, the government embarked on policy formulation designed to restructure education in South Africa. This process was articulated in the White Paper on Education and Training, Notice 196 of 1995. As stated in the report of the Ministerial Committee on Teacher Education (MCTE): "[A]t the heart of these policies stands the view that what a democratic society requires is a range of complementary authorities to avoid the domination of the education system by any single authority" (MCTE, 2005, p. 2).

The government has also launched a Plan of Action aimed at: "Improving access to free and quality basic education for all" (DoE, 2003b). The plan includes strategic pointers to ensure that the government's resources are used effectively to accomplish the mission of providing quality education for all learners (DoE, 2003b, p. 2).

In line with the provision of quality education, and keeping up with fast-moving technological and economic developments, South Africa, through the Department of Education, came up with several other strategies, including working with other groups and through committees. For instance, the Task Team of 1992 set up eight working groups charged with the development of a national training strategy, a process which culminated in the draft of the National Qualifications Framework Bill, passed as the South African Qualifications Authority (SAQA) Act, No. 58 of 1995. This Act included among its goals an integrated approach to education and training (DoE, 1995).

2.4.1 Basic Education in South Africa

The South African basic education system is divided into 'bands' which are further categorised into 'learning phases'. School life takes about 13 years, beginning with Grade R or the reception year and going up to Grade 12, when learners graduate from the school system. Basic education, or the General Education and Training Band (GET), goes up to Grade 9. GET is sub-divided into three phases of schooling, namely Foundation Phase (Grades R-3), Intermediate Phase (Grades 4-6), and Senior Phase (Grades 7-9). In most public schools, Grade 1 is preceded by Grade R, which is offered as a pre-primary year which serves as a preparatory period for schooling. The senior phase starts in the last year of

primary schooling and covers the first two years of secondary education. Education is therefore compulsory up to Grade 9.

The last three years of secondary school (Grades 10-12) form the Senior Secondary phase, or the Further Education and Training (FET) band where learners are prepared for tertiary or higher education. This level ends with a National Senior Certificate (NSC) which is a discipline-based qualification at exit level for schooling and for FET colleges (RSA, 2013).

The curriculum is organized into 'learning areas' at General Education and Training (GET) level and subjects at Further Education and Training (FET) level. The National Qualifications Framework (NQF) is organized as a series of achievements in learning. Table 2.1 shows two NQF Levels labelled as 'old' and 'new'. The old NQF, which ranges from Level 1 to the highest 8, is actually being phased out and being replaced by the new framework, which came into effect with the repeal of South African Qualifications Authority Act, 1995 (Act No. 58 of 1995) and the passing of the National Qualifications Framework Act, No. 67 of 2008, by the President of the country. This new structure is represented by three qualification sub-frameworks for (1) General and Further Education and Training, (2) Higher Education, and (3) Trades and Occupations.

Among other features, the General and Further Education and Training Qualifications Framework "is designed to be sufficiently flexible to accommodate different types of general and further education needs and to enable a variety of public and private institutions to pursue their teaching and learning obligations responsibly" (Umalusi, 2011, p. 20). This would enable articulation of programmes and the transfer of students between programmes of higher education institutions. The revision therefore affects the levels pertaining to the higher education sector. These revised qualifications and sub-frameworks collectively have levels running from 1 to the highest 10. Table 2.1 is an adaptation of the representations for the General and Further Education and Training (GFET) and the Higher Education and Training (HET) qualifications sub-frameworks as shown in the Government Gazette Vol. 558 No. 34883 of 2001.

The curriculum process which led to the inclusion of the topic of evolution was under the former Department of Education. This study was conducted at Grade 12 which is at NQF level 4 in both the new and old frameworks. At the end of this level, learners sit national examinations which provide them with a national certificate. These are high stakes

examinations which qualify them for entry into tertiary education level or into the world of work. Performance in these examinations is thus important to learners.

Table 2.1: National education system in South Africa showing the old and new NQF levels for HEQ and GFETQ sub-frameworks[1]

Band	Phase	School grade	Old NQF Levels		New NQF Levels	
			NQF Level	Qualifications	NQF Level	Qualifications
HIGHER EDUCATION AND TRAINING			8	Doctoral degrees Masters degrees	10	Doctoral Post-doctoral research
					9	Masters
			7	Professional Qualifications Honours degrees	8	Bachelor Honours degree Postgraduate diploma Bachelor's degree
			6	National first degrees Higher diplomas	7	Bachelor's degree Advanced Diploma (AD)
			5	National diplomas National certificates	6	Diploma Advanced certificate (AC)
					5	Further Certificate (FC)
FURTHER EDUCATION AND TRAINING (FET)	Senior secondary education	10-12	4	National certificates	4	National Certificate (NC)
			3		3	Intermediate Certificate (IC)
			2		2	Elementary Certificate (EC)
GENERAL EDUCATION AND TRAINING (GET)	Senior phase	7-9	1	Adult basic education (ABET) Level 4 National certificates	1	General Certificate (GC)
	Intermediate phase	4-6	n/a		n/a	
	Foundation phase	R-3	n/a		n/a	

[1] With going to press, legislation has approved the new degree structures

2.4.2 Teacher Education in South Africa

Teacher education in South Africa is offered in pre-service and in-service modes. Prior to 1994, the institutions which offered teacher education had developed unsystematically, generally out of mission schools, but were more forcefully planned and segregated along the lines of race and ethnicity after the 1960s (Chisholm, 2003). The qualifications of teachers were also varied: from certificates to diplomas and bachelors' degrees. As one of the measures to improve the quality of education after attaining democracy in 1994, South Africa instituted an audit on the state of teacher education in the country. Generally, the report indicated that the provision of teacher education was fragmented, there was a mismatch between teacher supply and demand, and there were high numbers of unqualified and underqualified teachers (DoE, 2006).

The Department of Education deemed it necessary to regulate teacher education provision for purposes of assuring quality in the sector. It was therefore important to streamline the teaching community into a single national system, and to bring in new curricula that would emphasize more professional autonomy for teachers and require them to have new knowledge and applied competence (DoE, 2006). Furthermore, the policy on curricula for teacher education were also reviewed. This included the revision of the Norms and Standards for Educators in 1997/98, which was concluded in 2000. The Teacher Education curricula were reviewed in line with the Outcomes Based Education (OBE), and a new qualifications framework put in place, where the main qualification for initial teacher training was an integrated 480-credit BEd degree. To cater for the older and under-qualified teachers, the National Professional Diploma in Education (NPDE) was placed in parallel but at a lower level to the BEd. The NPDE was a major upgrading programme which was funded through teacher bursaries.

In 2003, a Ministerial Committee on Teacher Education (MCTE) was set up to develop a National Framework for Teacher Education. The MCTE report differentiates between the Initial Professional Education of Teachers (IPET) and Continuing Professional Teacher Development (CPTD). At the time of the report, the system of IPET was contested and underfunded, while there was no CPTD system in place. Generally, any existing support systems were neither well-coordinated nor clearly focused on their main function. The MCTE report, therefore, made recommendations aimed at the improvement of these systems and their coherence as a comprehensive system of teacher education in South Africa (DoE, 2005).

Consequently, a National Policy Framework for Teacher Education and Development in South Africa was designed in 2006. This framework drew heavily on the MCTE report. The policy framework was designed to develop a teaching profession that would be able to meet the needs of South Africa as a democratic state in the 21st century. Through this policy, teachers would be properly equipped to undertake their essential and demanding tasks, their professional competence and performance would be enhanced continually, and the esteem in which they are held by the people of South Africa be raised (DoE, 2006). The belief that teachers are the essential drivers of a good quality education system supported this policy (DoE, 2006, p. 5).

Besides the short supply of qualified teachers, the other critical challenge reported was the insufficient conceptual knowledge of many teachers. Given that the main goal of the policy was to improve the learning achievements of children at school, the government had to have measures in place to strengthen the IPET and CPDT as well as the support system. This would be achieved by bringing about "the necessary coherence and impetus [in teacher education] to ensure a drive for more teachers, and for better teachers" (DoE, 2006, p. 27).

Currently, the recognised teacher education qualifications in South Africa are:

- Bachelor of Education (BEd) degree. This is a four-year 480-credit qualification for teaching in any learning area, subject and phase. For example, BEd-FET is a qualification to teach in the FET band.
- Post Graduate Certificate in Education (PGCE) is a 120-credit qualification offered to graduates with an appropriate first degree. In the new Qualifications Framework, PGCE will be replaced by an Advanced Diploma in Education (ADE).
- Higher Diploma in Education,
- National Professional Diploma in Education (NPDE) for upgrading unqualified teachers,
- Advanced Certificate in Education (ACE) for re-skilling practicing teachers.

Teachers teaching at Grade 12 level normally hold a BEd degree, PGCE or Diploma in Education. The 2012 School Realities report shows that there were about 425 167 educators

(teachers) in 2012 who worked in 25 826 schools nationwide (DoBE, 2012[2]). Of these teachers, 7.7% served in 1 571 independent schools, while 92.3% were in 24 255 ordinary public schools (*ibid*.). According to the same report, the Limpopo Province had a total of 1 715 778 learners enrolled in 4 078 schools; 1 665 013 of these learners were enrolled in ordinary public schools, and 50 765 in independent schools − serviced by 55 277 and 2 393 teachers respectively (DoBE, 2012[3]). In Grade 12 there were altogether 82 132 learners in Limpopo. Of these learners, 78 338 were in ordinary public schools and 53.78% of them were females (*ibid*.).

2.5 CURRICULUM REFORM IN SOUTH AFRICA

According to Ogunniyi (2007a, p. 963), "[t]he justification for introducing a new curriculum in any country is often based on historical, political, or socio-economic reasons". Similarly, the educational reforms in South Africa since 1994 have been politically motivated as a means of responding to the socio-economic disparities that existed during apartheid. The political change to a democratic rule was accompanied by changes in policies to redress the inequalities of the past by recognising the diverse nature of the South African people, regardless of their age, gender, race or religion. This major educational reform in South Africa, which took place at the onset of democracy, was informed by the Constitution of the country, which spells out the need for social transfomation in the 'post-apartheid society' (DoE, 2003a). The National Policy Act of 1996 would facilitate the democractic transformation of the national system of education into one which serves the needs and interests of all the people of South Africa and upholds their fundamental rights (RSA, 1996a). It seems therefore, that education was one of the mechanisms for bringing about transformation – socially, politically and in other respects. In a sense this implies acknowledging the differences among the people, and providing means to enable all to have access to similar conditions in education. At the crux of the change was the laying of foundations for a single national core syllabus. Curriculum change, therefore, started when the National Education and Training Forum began a process of syllabus revision and subject rationalization, immediately after the 1994 election (DoE, 2002). In this process, "curriculum decisions were made in a participatory and representative manner", (DoE, 2002, p. 4) with cooperation from various stakeholders.

[2] The figures given here are preliminary and final figures are to be published in a more comprehensive *Education Statistics in South 2012* to be released later (Department of Basic Education, 2011), subsequent to the writing of this report.
[3] See footnote 2 on page 27.

2.5.1 Outcomes-Based Education: From Curriculum 2005 to the National Curriculum Statement

In 1997, the government introduced the Outcomes-Based Education (OBE) system as Curriculum 2005. The year 1997 was meant for orientation of educators and the start of the training, while the actual classroom implementation was to start in 1998. The OBE curriculum, based on a constructivist philosophy, replaced the Christian National Education system. Smit and Oosthuizen (2011, p. 316) refer to the Outcomes-Based Curriculum 2005 as the most momentous curriculum reform in South African education of the last century. OBE was a guiding philosophy for Curriculum 2005, and for its initiators, a pedagogical route out of apartheid education (Chisholm, 2003). The OBE system of education considered the process of learning to be as important as the content. Thus, OBE introduced new learning styles embedded in change from passive, rote learning to creative learning involving problem solving, to be achieved through active participation in the learning process.

OBE emphasized, as suggested by Chisholm (2003), results and success, putting the focus on outcomes and the possibility of their achievement by all, at different paces and times, rather than on a subject-bound, content-laded curriculum. It was seen to constitute a decisive break with all that was limiting and stultifying in the content and pedagogy of education (*ibid*.). Through OBE, the curriculum aimed to enable all learners to reach maximum potential by setting Learning Outcomes to be achieved by the end of the education process (DoE, 2003a). As implied by its name, OBE was a system of education based on outcomes. The outcomes envisaged were meant to enable learners to achieve them by involving them actively in the learning process, irrespective of their background or circumstance. The critical and developmental outcomes, derived from the Constitution, were common to all the learning areas and subjects, while the learning outcomes were specific to individual learning areas and subjects.

Admittedly, the transition from a segregated past to one of unison has not been easy. In terms of educational change, challenges have been experienced in various sectors, including curriculum implementation. The curriculum newly developed in 1997 was termed Curriculum 2005 because its implementation cycle was to have been completed in 2005. However, before the cycle was over, its implementation was reviewed in 2000 by a Ministerial Committee chaired by Linda Chisholm (DoE, 2002). In May 2000, this Review Committee presented a report of their findings to the then Minister of Education, Professor K.

Asmal. The report indicated an overwhelming support for the principles of OBE and Curriculum 2005, which had generated a new focus on teaching and learning, yet the report (Chisholm, 2003, pp. 3-4; DoE, 2002) stated that the implementation had been confounded by:

- a skewed curriculum;
- lack of alignment between curriculum and assessment policy;
- inadequate orientation, training and development of teachers;
- learning support materials that [we]re variable in quality, often unavailable and not sufficiently used in classrooms;
- policy overload and limited transfer of learning into classrooms;
- shortages of personnel and resources to implement and support Curriculum 2005 (C2005); and
- inadequate recognition of the curriculum as the core business of education departments.

As recommended by the report, all these areas needed attention. Such weaknesses required to be addressed by adequate resourcing and manageable time-frames for implementation and regular monitoring and review (Chisholm, 2003; DoE, 2002). In order to offset the weaknesses of Curriculum 2005, the Committee proposed the introduction of a revised curriculum structure that would be supported by changes in teacher orientation and training, as well as by provision of better learning support materials. In addition, the organization, resourcing and staffing of curriculum structures and functions in national and provincial education departments needed to be addressed. Strengthening the curriculum implementation process would require a revised and streamlined OBE curriculum framework, as well as a strategy for a national teacher education that would locate teacher preparation and development for the new higher education curriculum. The Review Committee further recommended, among other strategies, a smaller number of learning areas including the reintroduction of history as a subject, and the development of a revised National Curriculum Statement which would promote conceptual coherence, have a clear structure and be written in clear language (*ibid*.).

The outcome of this review was the revision of Curriculum 2005, which culminated into the Revised National Curriculum Statement (RNCS). This was "not a new curriculum but a streamlining and strengthening of Curriculum 2005" (DoE, 2002, p. 6). The RNCS was designed in such a way that it would promote the values of a society striving towards equity,

social justice and development through the development of individuals with creative, critical and problem-solving abilities (Chisholm, 2003).

The learning outcomes described what learners should know and be able to do. In addition, the RNCS had assessment standards which were also subject specific. Whereas learning outcomes remained the same in the grades within a learning phase, the assessment standards were grade-specific. The kind of learner envisaged in the RNCS was one who would be imbued with the values of social justice, equity and democracy. The learner would, therefore, act in the interests of a society based on respect for democracy, equality, human dignity, life and social justice (DoE, 2002, p. 14). Furthermore, the RNCS encouraged, amongst all learners, awareness and understanding of the rich diversity of cultures, beliefs and worldviews which are optimistically supposed to characterize the unity of South Africa.

Like its predecessor, the Curriculum 2005 (C2005), the RNCS represented a pedagogy committed to reinventing education in South Africa. It opposed "the traditional separatist education which was the reproduction of inequality" (Msila, 2007, p. 152). The RNCS encouraged a democratic education system which would enable people to participate in public life, think critically and act in a responsible manner as they embraced the values outlined in the Constitution.

The RNCS was released in May 2002. It was later to be referred to only as the National Curriculum Statement (NCS) at FET level, but still remained as RNCS for Grades R to 9. The South African curriculum, as reflected in the National Curriculum Statement (NCS) Grades 10-12 (General) and the Curriculum and Assessment Policy Statement (CAPS), aims at "ensuring that educational imbalances of the past are redressed, and that equal opportunities are provided for all sections of population" (DoE, 2003a, p. 2; DoBE, 2011a, p. 4). It is stated further that NCS Grades 10-12 (General) is sensitive to issues of diversity such as poverty, inequality, race, gender, language, age, disability and other factors (DoE, 2003a, p. 4).

The curriculum, since the start of C2005, focuses on learning that builds on prior knowledge in the construction of knowledge, as opposed to the passive reception of information. The curriculum also recognizes different forms of knowing through which people make sense of the world they live in − an important endeavour considering the diversity of cultures and beliefs in the country. These forms of knowing include indigenous knowledge systems (IKS), which learners are encouraged to explore, evaluate and appreciate.

IKS have been introduced into the curriculum since C2005 in recognition of "the wide diversity of knowledge systems through which people make sense of and attach meaning to the world in which they live" (*ibid.* , p. 4). In the South African context, these IKS are recognized as "a body of knowledge embedded in the African philosophical thinking and social practices that have evolved over thousands of years" (DoE, 2003a, p. 4). The aim is to encourage learners to value IKS by "acknowledging the rich history and heritage of the country as important contributors to nurturing values contained in the Constitution" (DoBE, 2011a, p. 3). This is an interesting addition, and IKS are now enjoying a status they lacked in the past.

The introduction of IKS has been met with interest as well as questions regarding how best to incorporate them into the education system. IKS are seen as having the potential to address many social needs (Msila, 2007). However, IKS may not achieve this alone, particularly in a culturally and racially diverse South African society. The multicultural and non-racial education system outlined in the NCS could therefore involve other sectors of the community in enhancing democracy. Teachers could endeavour to instill in learners the democratic ideals and values defined in the NCS. This expectation, however, posed a new challenge for teachers, who had to assume new and perhaps 'foreign' roles in their profession.

2.5.2 The Curriculum and Assessment Policy Statement (CAPS)

The OBE system as presented in the RNCS and NCS was still not satisfactory. Some of the criticisms tabled against it were that teachers were experiencing excessive overload in terms of the curriculum and administrative roles they had to perform. Following these and other criticisms tabled against the OBE, a Ministerial Task Team was appointed by the Minister of Basic Education, Mrs Angie Motshekga, to review the implementation of the National Curriculum Statement Grades R-12. In July 2010, she announced new changes to the South African education system. While the OBE system would not be completely scrapped, matters relating to the administration of the curriculum and its assessment would be affected. The changes included a reduction in the number of projects for learners per year, or having projects as optional even though some activities had been suggested as possible projects. Also, the portfolio files and Common Tasks for Assessment have been taken off the curriculum. The NCS have been repackaged into a single, comprehensive and concise Curriculum and Assessment Policy Statement (CAPS) on a grade-by-grade and subject-by-subject basis (see DoBE, 2011a). The curriculum in CAPS is repackaged in a way that

reflects the aims of the South African national curriculum, the specific aims of each subject topic to be covered, and the required number and type of assessments per term. In this way, the assessment requirements are no longer mapped onto the achievement of outcomes and assessment standards, but are absorbed into more accessible aims. CAPS is being implemented in stages, and at the FET band, the curricula start in Grade 10 in 2012 to reach Grade 12 in 2014 (DoBE, 2011b).

The curricular revision happened during this study, and the implementation of CAPS took place afterwards, so that CAPS is not really relevant to the study. However, the nature and direction of the changes made will have a bearing on the making and carrying out of recommendations based on the current study.

2.6 LIFE SCIENCES (BIOLOGY) EDUCATION IN SOUTH AFRICA

With the onset of democracy in South Africa, science continued to be a significant part of the curriculum of South African schools. As in most educational developments, science education is expected to promote scientific literacy (DoE, 2002). Attempts to provide science education to all learners have been accompanied by policies meant to facilitate the design and development of inclusive curricula.

The specific subject of Life Sciences, previously known as Biology, has undergone significant changes in content and expectations (Dempster & Hugo, 2006; Johnson, Dempster & Hugo, 2011; Le Grange, 2008b). Following are some of the expectations concerning the teaching and learning of Life Sciences (see DoE, 2003a, p. 9).

> The study of Life Sciences enables learners to explore those concepts that are essential for understanding basic life processes and the interrelationship and interdependence of components of the living and the physical world. Learners will develop inquiry, problem solving, critical thinking and other skills, and will use them to interpret and use Life Sciences concepts in explaining phenomena. They will be able to apply scientific knowledge in their personal lives and as responsible citizens in ways that will contribute to a healthy lifestyle and the sustainable management of resources. Through the study of the Life Sciences, learners can develop an understanding of the nature of science, the influence of ethics and biases, and the interrelationship of science, technology, indigenous knowledge, environment and society.

The Revised National Curriculum Statement Grades R-9 (Schools) for Natural Sciences, on the other hand, states that through the teaching and learning of science, learners develop the ability to think objectively and use a variety of forms of reasoning while they use the process

skills to investigate, reflect, analyse, synthesize and communicate (DoE, 2002). In addition, concepts and processes in Life Sciences are studied through the use of contributions from the past, which inform the present, thus promoting the construction of new knowledge. Although this is an ideal, it gives impetus to teaching and learning of biology not only for its own end but for the sake of developing scientific skills and knowledge and for application to real life.

Besides, as learners explore IKS related to science, they will be exposed to different worldviews, which would allow them to appreciate, compare and evaluate different scientific perspectives. In particular, as stipulated in the Life Sciences National Curriculum Statement Grades 10-12 General, Learning Outcome 3 "raises learners' awareness of the existence of different viewpoints in a multicultural society, and encourages open-mindedness towards all viewpoints … [the] viewpoints based on scientific knowledge, beliefs, ethics, attitudes, values and biases, and [which] may change over time due to new information" (DoE, 2003a, p. 13). These are interesting and timely developments which could bring the education of science in this country to a level where learning is, perhaps, more meaningful. Giving an opportunity for learners to raise their views should make them aware that all views are important in learning, that science is not a finished product, and enable them to appreciate the nature of science and how concepts such as evolution came about.

Unfortunately policy documents do not spell out guidelines for the achievement of these requirements in teaching a curriculum which may be epistemologically unfamiliar. Furthermore, the teaching of science is still predominantly traditional; and learning involves the assimilation of factual knowledge, leaving learners with little choice but to memorize the facts. Besides, having evolution as a topic in the curriculum implies that there is an expectation for it to be learned and examined, and this has implications for the availability of the resources to implement such an expectation.

2.7 EVOLUTION EDUCATION IN SOUTH AFRICA

Evolution is a concept that has been researched and tested a lot. The current understanding of its mechanisms ensues from modifications of the original Darwinian evolutionary theory of natural selection. With recent developments in molecular biology which have decoded the genomes of a number of species, including humans, the theory has remained largely unshaken, attesting to a very stable foundation. Therefore, teaching learners about evolution is likely to enhance their understanding and appreciation of the NOS and promote scientific

literacy, as also recognised by Lever (2002). Evolution also calls on the historical context of biological knowledge, which should also enhance this understanding. As has been pointed out, "Darwinian evolutionary thought is part and parcel of scientific literacy in a variety of fields stretching beyond the life sciences" (Lever, 2002, p. 17).

2.7.1 Early debates about evolution education in South Africa

The teaching of evolution in schools in places like the United States of America has met with resistance from religious groups and given rise to debates suggesting its removal and/or inclusion of 'creation science' (Moore, 1998; 2002; Moore & Cotner, 2009; Scott & Branch, 2003; Tidon & Lewontin, 2004). It is interesting that the creation-evolution debate has not been experienced with the same depth and breadth in South Africa as in places like the United States of America, at least not in the general public domain. This could be because of "lack of exposure to Darwinian evolution at school level" in the past apartheid system (Dempster & Hugo, 2006, p. 106).

In South Africa, Lever (2002) recognizes the centrality of the three Dutch Reformed Churches (DRC) in the shaping of state policies and popularizing consciousness on the issue of Darwinism. These churches shared, with fellow Reformed Churches elsewhere in the early 20th century, a common dogmatic position regarding evolution and the Bible. Lever (2002) recounts the early rumblings in South Africa about Darwinian theories of evolution, albeit in a chequered record. He notes the presence of Charles Darwin in South Africa in 1836, long before publication of 'The Origin of Species', but acknowledges that the dating of arrival of the Darwinism debate is not clear. Yet, by 1870, controversy around Darwin's work began to flare up both in the church and educational circles (Lever, 2002, p. 20). As Lever comments, Darwinism first appeared in South Africa as a scientific analysis that threatened first and foremost certain theological doctrines in local Christian circles, yet by the first decade of the 20th century, the idea of an evolutionary ranking of human races, however erroneous, was clearly current in the popular mind.

As further noted by Lever, the stance on evolution taken by the local DRC was then in accord with the doctrine of the International Ecumenical Synod of the Reformed Churches. The Churches met in the Netherlands in 1949 and re-affirmed the historicity of the Biblical account of creation. Shortly after this meeting, a commission was set up to look into the issue, whereupon there was an argument that the strict fundamentalist interpretation was not

sustainable (Lever, 2002). Yet, as Lever further relates, the Churches in South Africa, with their fundamental position that if the Bible was a final and definitive authority on both matters of faith and fact, then not only a Christian science but also a Christian education was a matter of clear necessity (*ibid.*, p. 32).

Under the then Christian National Education, evolution was perceived as an attack on the Biblical view of creation and kept out of the school curriculum (Abrie, 2010; Lever, 2002) resulting in 'creationism', i.e., that all life forms were divinely created as they currently existed, as the prevailing paradigm. Lever (2002, p. 11) writes that "the minor skirmish between the clerics [mostly from the Dutch Reformed Churches] and the scientists occurred in the shadow of much larger [political] events". He further indicates that even the eugenicism of the 1920s and 1930s was frustrated prior to the World War II, since no consesnus existed around the pseudo-Darwninan ideology of race. Instead, Darwin's thinking only applied to species, and he never suggested that humanity divided into separate species. Lever states that the eugenicism was a result of 'Social Darwinism' which had developed in the previous century.

The debates around science and religion, mainly among the orthodox and liberal clergy continued, even though "references to Darwin began to disappear after the mid-1950s" (Lever, 2002, p. 36). Lever recounts the skirmish between one missionary, Du Plessis, whose highly qualified view of evolution and rejection of the literal truth of the scriptures was too much for many of his fellow DRC members. Du Plessis was later "accused of professing ideas regarding Scriptures that could not be reconciled with Reformed doctrine" … and "dismissed from the church" (Lever, 2002, p. 28). Regardless, evolution was excluded from the schools' curriculum. For example, the objectives of Biology sought "to develop through contact with the subject matter, a reverence for the Creator and an esteem for the wonders of the created universe" (*ibid.*). Lever alludes to this as "not so much an anti-Darwinism as a non-Darwinism" which was reflected in the hyperfactualization of the syllabus (*ibid.*). While acknowledging that, Lever's focus was on the three DRCs' rejection of evolution, and it is to be expected that all forms of religious fundamentalism could equally ascribe to that rejection.

2.7.2 Recent developments in evolution education

The latest major curriculum reform in South Africa was influenced primarily by internal socio-political developments. With the inclusion of evolution in the Revised National

Curriculum Statement for Schools (Grades R-9), there had been mixed reactions to the draft (Chisholm, 2002). As noted by Lever, the debates had resurfaced, in some newspapers and also in a recent book written by a retired architect, Pieter Pelser, entitled *Evolusie & Die Bybel* (translation: 'Evolution & the Bible') (Lever, 2002). Chisholm (2002) also notes that some, like United Christian Action and generally the conservative religious groups, criticized the move, while others like the universities, teacher unions, non-governmental organizations, governmental departments and other members of the public were in support of it. Chisholm argues that hostility to evolution in the curriculum was part of an ensemble of ideas, a structure of authoritarian populist thought (Chisholm, 2002, p. 56), and that the new curriculum is a product of the change that has occurred in South African society (Chisholm, 2002, p. 59). Lever assures us that, with a move from fundamentalism to mainstream modern Christianity, evolution is no longer the taboo considered by the theological journals from the seminaries of the three DRCs. After all, "[c]oncerns about evolution were balanced by arguments for more and better communication of science" (Chisholm, 2002, p. 58). If this is ascription to evolution being part of improving communication of science, then the challenge that remains is to ensure that the conditions exist for the change to occur. For Life Sciences educators, that means an education that places evolution as a central theme that contributes to making Life Sciences a unified subject.

The foregoing discussion has shown the influence of Christianity in the 'evolution versus religion' debates in South Africa, but not much from the other faiths. As indicated earlier, Christianity is the most prevalent religion in South Africa, with a following of about 80% of the population. Furthermore, the influential scholars of the past and the political decision-makers have also been predominatly Christian. There is a possibility that the other faiths existing in the country − Islam, Hinduism, and indigenous non-Christian religions − have similar attitudes towards evolution. Chisholm (2002) has shown that the Association of Muslim Schools welcomed the values incorporated in the curriculum and the discretion provided for schools and teachers to develop their own learning programmes, as explicated in the NCS. This was during the time when the draft NCS was open for public scrutiny. This of course does not necessarily mean that the general Muslim community accepts the inclusion of evolution in school curricula. However, the voice of the Christians has been, as Chisholm, (2002, 2003) would say, the loudest and most predominant in influencing policy and curricular decisions regarding evolution or creationism education, even barring its inclusion

in the curriculum during apartheid. What is notable, though, is that the voice of those with power has been more influential in shaping the past and present curricula in evolution.

The National Curriculum Statement of the Life Sciences (Grades 10-12) introduced for the first time in Grade 12 topics such as Origin of Species, Evolution Theories, and Biological Evidence of Evolution of Populations within the core knowledge area of 'Diversity Change, and Continuity'. Table 2.2 shows the appearance of biological content and the coverage of evolution in the curriculum at different levels of learning, as reflected in the NCS (DoE, 2003a) and RNCS (DoE, 2002).

Table 2.2: Biological concepts and Evolution in the Revised National Curriculum Statement and the National Curriculum Statement

Educational Bands	Educational phases	Grade	Biological concepts	Evolution and related concepts
General Education and Training Band (GET)	Foundation phase	R-3	Life Skills (integrated learning)	No evolution or related concepts
	Intermediate phase	4-6	Life Skills (mainly health); Natural Sciences and technology	**Evolution related concepts** Life and living: Living and non-living things
				Planet earth and beyond: Fossils
				Mains electricity: Fossil fuels
	Senior phase	7-9	Natural Sciences	Life and living: Biodiversity; Variation
Further Education and Training Band (FET)	Further Education and Training	10	Life Sciences	**Evolution related concepts** Biodiversity of plants and animals Adaptation and survival; Extinction of species, red data listing and endangered species; Fossil records, Populations changes over time; Beliefs about creation and evolution; Changes of knowledge through contested nature and diverse perceptions of evolution
		11	Life Sciences	**Evolution related concepts** Population studies, e.g. evolutionary trends in a population; Social behaviour
		12	Life Sciences	**Evolution concepts** Origin of species; Evolution theories, mutation, natural selection, macro-evolution, speciation Fundamental aspects of fossil studies Cradle of mankind – South Africa? Biological evidence of the evolution of populations Popular theories of mass extinction

The evolution concepts in South Africa are developed in each year of schooling at different levels of complexity, as reflected in the minimum achievement standards outlined for each year. Inspection of the content statements that relate to evolution shows that the term 'evolution' appears for the first time in Grade 12, even though the foundational concepts are developed in the Natural Sciences learning area (Grades R-9). Introducing a topic such as evolution in the curriculum has been interesting, but it also meant that there were certain implications accompanying that inclusion. The next section looks at some of the implications.

2.8 IMPLICATIONS OF INTRODUCING EVOLUTION IN TEACHING AND LEARNING

Having been introduced recently in the Life Sciences curriculum, evolution has been examined in Grade 12 in South African secondary schools for the first time in 2008. This meant that most teachers teaching Life Sciences in secondary schools were not likely to have received instruction which included evolution during their own secondary school education in South African schools, an idea that could have a bearing on their views about evolution. Furthermore, because of opposition from some people, evolution has been shown to attract controversy, a situation which is likely to affect its teaching and learning. The discussion on implications starts by looking at evolution as a central biological theme, and how teachers, might deal with it and/or the controversy about evolution in the classrooms.

2.8.1 Evolution as a unifying scientific concept

If evolution is regarded as a unifying and ordering frame for Life Sciences and other sciences, what impact can its absence in the curriculum have on the learning of Life Sciences and scientific literacy among the learners? This question is relevant, especially considering that the majority of children − at least in South Africa − find science boring and incomprehensible, and avoid it where possible (Lever, 2002). Regrettably, Life Sciences (Biology) has been regarded as lower in status than the other sciences, in that it has been what Lever calls "a sort of scientific stand-in", attracting mainly pupils with low mathematical skills and weak knowledge of chemistry and physics. The consequences of the absence of evolution in the curriculum have been, as contended by Lever, the withholding of the most powerful scientific perspectives from the youth and, by implication, the public at large. Furthermore, Life Sciences has not played a significant role in the promotion of scientific literacy in the country, as have the other sciences (Laugksch, 2000). With no ordering framework, Life Sciences becomes what Dobzhansky (1973, p. 129) refers to as "a pile of

sundry facts", some of which, though "interesting or curious", make "no meaningful picture as whole". Unfortunately this can promote a resort to memorization and rote-learning, leading to little regard for the worth of the discipline.

By including evolution in the teaching of Life Sciences, the various parts hanging together "can be organised in mental maps of great heuristic … as well as real theoretical … value" (Lever, 2002, p. 42). Some of the concepts in Life Sciences are of an environmental and ecological nature, while others are health-related. These concepts could possibly receive fairly regular coverage outside of normal school settings (Laugksch, 2000), thus making them more accessible to learners and easier to deal with as test items. However, because the learning of such concepts happens in informal settings, learners could find themselves lacking some of the scientific skills they would otherwise receive in a formal classroom. This could impact on their acquisition of scientific literacy.

The inclusion of evolution in the Life Sciences content, therefore, could be instrumental in enhancing the role of Life Sciences so that it can be a subject of choice which can enable a learner to acquire the same kind of literacy they would acquire from, say, Physical Sciences. Learners who are not enrolled in the Physical Sciences could develop the necessary scientific literacy through learning Life Sciences. This would provide Life Sciences with the recognition it deserves as a significant scientific subject.

2.8.2 Teaching from a historical perspective

Laugksch (2000) has found that, in South Africa, Life Sciences (Biology) plays a less significant role than other sciences in the achievement of scientific literacy. He suggests possible mechanisms for this, one of which is that, in comparison to biology, there is a greater number of topics placed in an historical context in the Physical Sciences syllabus (Laugksch, 2000, p. 8). Evolution is a concept that covers the history of life and, as a concept, it has a rich history which embraces the nature of science. Laugksch (2000) suggests that the historical contextualisation of topics in Physical Sciences could be responsible for students having a better understanding of the nature of science than students taking Life Sciences. Therefore, the historical perspective in Life Sciences topics could be strengthened.

Teaching about evolution requires an historical perspective, in order for learners to appreciate and understand the concept, and teaching it that way could possibly bring that historical contextualisation to those same topics for better understanding. For instance, the evidence for

evolution can be understood from three perspectives: circumstantial, direct and historical (Dagher & BouJaoude, 2005). Appreciating the convergence of these three types of evidence enables substantive understanding of the nature of evolution and the theories that are used to explain it (Dagher & BouJaoude, 2005, p. 380). Research has shown that this can also help learners understand evolution itself. For example, Jensen and Finley (1997) conducted a study with the aim "to develop an instruction that would change students' mixed bag of ideas into a more Darwinian form" (p. 209) and thus "improve students' understanding of evolution" (p. 211). They did this by altering the curriculum and instructional techniques, using a historically rich curriculum and pairing problem-solving instructional strategies. As suggested by Gevers (2002, p. 50), "[N]o one can today dispute that the basic phenomena of evolution need to be explained, illustrated and related to important real-life matters such as the natural history of HIV infection".

Furthermore, South Africa is endowed with a wealth of fossil evidence found in many sites where fossil remains of extinct creatures and hominids have been found. The Cradle of Humankind, Taung and Makapan are some of the renowned South African fossil hominid sites. The many sites yielding such evidence could offer a rich resource base for learner exposure, thus widening of their view of evolution and the enrichment of their understanding. This could emphasize the performance side of science, as suggested by Le Grange (2007, p. 587), which "refers to the doing of science" and recognizing "science [as] a human and social activity that is messy, heterogeneous and situated". Learners may then be able to appreciate science as being "locally produced through processes of negotiation based on social organizations of trust and not empirical verification [or] falsification" (*ibid.*). They will then be able to learn without being burdened, consciously or not, by whether to believe or not to believe. Furthermore, learning about evolution at an early age can enhance learners' scientific literacy, as they will learn to perform science within an historical perspective, and not just learn Life Sciences as 'history', which it is not. As Lever (2002) argues, it is better to get some of the tough technical slog over and done with as the young brain is still maturing.

The historical approach therefore involves an appreciation of the nature of science, which should also enhance achievement of scientific literacy. Thus, the past absence in South Africa of an awareness of evolution could have contributed to the insufficient historical context in the Life Sciences (Biology) syllabus. This could have subsequently impacted on the role biology plays in achieving scientific literacy.

2.8.3 Teaching evolution from a complementary approach

Lategan (2002) views both scientific and religious discourses as having a common element in providing the first building block for an alternative approach in schools. He recognises sense-making, often in the form of narrative structures, as an element in a wide variety of discourses, including those of scientific explanations and of religious traditions. According to him, both science and religion provide a way to understanding reality, the origins of the cosmos and of life (Lategan, 2002). He therefore suggests a complementary approach as a means of respecting the integrity of the different discourses and the different goals they pursue (*ibid.*, p. 70) and perhaps avoiding what he calls an 'either/or' or 'exclusivist' paradigm. His suggestion is therefore in line with the curriculum which is supposed to expose learners to different viewpoints (DoE, 2003a), a strategy that is relevant in a diverse country like South Africa that is going through transformation.

Thus it could be argued that the best way of promoting tolerance, respect for one another's views and maintance of integrity of those views, is by adopting the inclusivist paradigm mentioned by Lategan. The critical question, however, is whether the relevant stakeholders will be willing to implement and sustain an alternative approach (Lategan, 2002, p. 72). As Pandor puts the question, "Given our awareness that scientific ideas are shaped by the social and economic structures of their time, how do we construct a science programme that allows critical learning to stand alongside the promotion of sensitivity to the social and normative construction of scientific facts?" (Pandor, 2002, p. 64).

Naledi Pandor, the then Minister of Education, aware "that scientific ideas are shaped by the social and economic structures of their time", expressed reservations about the "proposed focus on Darwinian evolution". Firstly, she stated that the "South African responses to religious intervention encourage a sensitive and cautious approach …" (Pandor, 2002, p. 62) and, secondly, that "[the concept of evolution] has been used to give support to repugnant racial theories and racist movements" (Pandor, 2002, p. 63). Perhaps the time has now come for evolution to be looked at in a different light, that of uniting other biological concepts and contributing to a scientifically literate citizenry.

Perhaps a response to these questions is to be found in the design of the Life Sciences curriculum, which aims to raise learners' awareness of the existence of different points of view in a multicultural society, and encourage open-mindedness towards all points of view

based on scientific knowledge, beliefs, ethics, attitudes, values and biases that may change over time due to new information (DoE, 2003a). This would reflect Lategan's alternative approach, which recognizes the role of both science and religion, and other views as espoused in a myriad of abounding humanistic cultures within which the curriculum has to operate. This raises an issue of the approariateness of teaching non-science ideas in science lessons.

2.8.4 Implications for teachers

Questions about the plight of the teachers who have to implement the curriculum, especially teachers who mostly acquired their education through a paradigm different from that which they need to use in the new education system, are raised. Teachers have been given the freedom to design their classroom instruction, using the guidelines from the curriculum. However, compared to the traditional instructional systems approaches they are accustomed to, the advocated constructivism makes a different set of assumptions about learning and suggests new instructional principles (Karagiorgi & Symeon, 2005). Teachers are therefore faced with the task of translating the theory of constructivism into actual classroom practice in a multicultural context. The recoginition of evolution as a unifying framework, issues of pedagogy using a complementarity approach, from the historical perspective, and using the locally available resources to support evolution evidence, are all important for a teacher who implements such a curriculum. Now that the curriculum has been costructed, the issue of its implementation remains critical if learning has to promote understanding and application of what has been learned.

2.9 CONCLUSION

The post-apartheid society in South Africa is characterized by an amalgamation of beliefs, cultures and worldviews, as people from different backgrounds intermingle in various activities and events. As noted by Chisholm (2002; 2003), the politics of curriculum development have revolved around the weight and the role of particular players, and although there was a heterogeneity of actors and interests during the review of C2005, there was not a direct relationship between the 'loudest voices' and the eventual outcome. The loudest voices were those of fundamentalist Christians, but they did not influence the curriculum decisively (Chisholm, 2002, 2003), as had been the case before democracy. For this reason, the curriculum reflects a multiplicity of worldviews from wide-ranging perspectives. The present curriculum is now exposing learners to different ways of knowing, as well as encouraging awareness and understanding of the rich diversity of cultures, beliefs and worldviews that

characterize South Africa. For this reason, children may learn one thing about the world from their cultural and religious perspectives, another from their peers, and a different one from school. What they learn from home or culture or religion may form an understanding of the world which may, however, later clash with what they learn in science at school.

A study by Lawrenz and Gray (1995) in a South African university found that, despite the numerous science courses the students had taken, science was not well integrated into most of the student teachers' worldviews. The study also showed that prospective South African science teachers have diverse views, and that their views often do not incorporate science in the same way. Ogunniyi (2012) also recently found teachers who held dualistic and amalgamated worldviews, with the religious worldview being the most dominant. The diversity, therefore, has implications about issues such as curriculum design and pedagogy, especially considering the constantly developing knowledge that is so much a feature of contemporary life, while also taking into account the different styles of learning and grossly unequal resources and conditions in South African schooling (Chisholm, 2002, p. 51).

The way evolution is taught can therefore reflect teachers' worldviews and beliefs about, for instance, whether they regard evolution as a unifying Life Sciences (Biology) concept, or whether they are sceptical about it. This, then, could affect the way the curriculum expectations are met during the teaching of evolution. Also, the interaction between the teachers and learners can reveal whether the curriculum expectation of raising learners' awareness of different points of view in a society is considered in the delivery of the curriculum.

Notwithstanding the debates of the past, evolution is now in the curriculum, having been taught at Grade 12 since 2008. The curriculum reflects a dualistic and, to some extent, a pluralistic approach which recognizes the place of evolution in contemporary science education, but also considers that people have a myriad views and beliefs about the universe and themselves. Perhaps this was the best way possible to resolve the matter concerning the issue of either/or about evolution in the context of creation or other views. Whereas different people and the teacher unions in particular have been in support of this change, the teachers are the ones who have to implement the understanding of evolution in the classrooms. The onus, therefore, is on the teachers, operating alone in their classrooms, to fulfill the aspirations outlined in the curricula. This may in turn affect the way the scientific explanations are regarded during the teaching of evolution.

CHAPTER 3

TRENDS IN SCIENCE AND EVOLUTION EDUCATION

"A decent science education should result in students having some sense and appreciation of the interactive dynamic of science and culture; a good science education will result in a more refined and sophisticated understanding of that dynamic; an excellent science education will support and nurture students' decision making in those parts of the give-and-take of affirming, modifying or abandoning aspect of culture that science bears upon" (Matthews, 2009, p. 650).

3.1 CHAPTER OVERVIEW

A lot of work has been done on the teaching and learning of evolution (Alters & Nelson, 2002; Dagher & BouJaoude, 2005; Lombrozo, Thanukos, & Weisberg, 2008; Moore , 2002; Sanders, 2010). Some of the literature relates to its understanding, lack of of understanding or misconceptions about it (Lawrence & Sanders, 2012), acceptance or rejection (Chinsamy & Plaganyi, 2007), and also factors that affect the understanding and acceptance of evolution, including relating evolutionary learning and understanding to the nature of science (Lombrozo *et al*., 2008).

This chapter thus discusses science education, giving a brief history of the evolution of science as a discipline, globally and in Africa. First, the global developments in science education are discussed, as these have influenced and continue to influence developments in South Africa. Science is also discussed alongside religion and culture to understand how these two constructs influence the teaching and learning of science. Next, the chapter looks more closely at the concept of evolution, what it is and how it is perceived by scientists, the general public and science education specialists, including teachers. The debates in evolution, including the controversy as well as the challenges that evolution education has faced globally and in South Africa, are discussed. This chapter also discusses the beliefs of teachers and their possible influence on teaching and learning.

Therefore, in the context of this research, the purpose of this chapter is to present the literature relating to evolution education in the context of science and science education and the factors which have affected the teaching and learning of evolution. The purpose is also to provide a theoretical background and to lay a foundation for the methodology, present the theoretical framework and justify the choice and relevance of the theories for this research. This is done by identifying appropriate theories that inform the methodologies used, and by

reviewing previous findings in evolution education research. The worldview theory and logico-structural model proposed by Michael Kearney (1984) and expounded by William Cobern, as well as other theories related to the teaching and learning of science, have been discussed. Since evolution is a fairly recent addition into the South African curricula, literature from other countries is relevant and, together with current research in South Africa, is useful for contextualizing and rationalizing the research problem described in Chapter 1.

3.2 INTRODUCTION

Teaching and learning are domains which interface at the point where knowledge acquisition is enabled for the one who is learning. Learners and teachers meet in the classroom, where what the teacher believes about learning will affect the teaching and learning processes, leading to a varied range of possibilities in learning achievement, from no learning to mediocre or meaningful learning.

Teachers' understanding and views about what constitutes meaningful learning often relate to a certain identity applied to the teacher which is reflected in the choice of classroom discourse. While some teachers believe that learners learn best if they have opportunities to construct their own meanings (Wallace & Louden, 2002), a belief that may lead to egalitarianism in the classroom, others may see the fundamental job of a teacher as the ability to transmit knowledge as a neutral concept (Arora, 2005), which will translate into more authoritative practices in the classroom. These and other beliefs influence how teachers plan and put into effect particular instructional strategies which will influence how learning takes place. In addition, each individual learner enters the classroom discourse with ideas, beliefs, values, other predispositions and needs, all of which can − directly or indirectly, collectively or singly − influence both teaching and learning.

Whereas cognitive factors determine how learning occurs, the subject matter to be learned also has distinct characteristics which demand special instruction and environments. In order for meaningful learning to occur, the teacher has to create opportunities for each individual learner amidst a plethora of ideas, views and beliefs that the various learners bring to the classroom. Teachers function within structures that may be political, economic, social and cultural − or any other(s) posed by the society and community they are part of. Teachers therefore operate within a milieu of conditions and demands where they have to make choices and decisions about what goes on in the classroom. They often struggle to strike a balance

among competing educational goals, and this struggle often presents them with insoluble dilemmas (Wallace & Louden, 2002).

The literature abounds with research reports and other writings trying to explain the processes of teaching and learning, as well as the factors that influence them. Hypotheses have been proposed and tested, theories and models formulated, tested and retested to understand and explain the complex processes of teaching and learning. Over and above all this, technologies have been designed to remove impediments and add scaffolds to the discourse. These efforts are meant to help teachers perform their work of enabling learning to occur, and also to aid learners in their pursuit of acquiring new knowledge, skills and any other literacies.

This study looks at the teaching and learning of a scientific − or more specifically, a biological − model of 'evolution'. As a scientific concept, the formulation of evolution has employed scientific processes in an effort to understand and explain natural phenomena. The nature of the phenomena which comprise evolution can also be explained from other philosophical and non-scientific viewpoints. Depending on the philosophies espoused by an individual, one tends to either accept or reject evolution as a valid concept or as a valid source for the questions that arise.

3.3 A BRIEF GLIMPSE OF DEVELOPMENTS IN SCIENCE EDUCATION

The history of formalized science curricula in the West dates back to the nineteenth century, in the 1860s in the United Kingdom (UK) and the 1890s in the United States of America (USA) (Aikenhead, 2006). Even though the scientific enterprise associated with school science evolved within Euro-American cultural settings, ideas were appropriated from other cultures (Aikenhead, 2006; Grbich, 2007). During the eighteenth and nineteenth centuries, the industrialisation process of the Western countries was the main factor driving educational developments in that part of the world, whereupon subjects emerged as a response to the needs of industry. The eighteenth century in Europe is now regarded as an era of *Enlightenment*, where *positivism* − the school of philosophy that asserts that reality lies only in things that can be seen with the eye − and optimism, reason and progress became the dominant discourses, which is to say ways of thinking, speaking and writing, and all knowledge was believed to be accessible through processes of reason (Grbich, 2007, p. 4). This era, also referred to as the 'Age of Reason', was characterized by knowledge advancing through science. The Enlightenment ideas and ideals included a belief that only the discipline

of science can yield real, testable knowledge, not found in philosophy or theology or any other discipline. This belief amounted to unmitigated scientism (Gauch, 2009, p. 683; Matthews, 2009, p. 656), in which 'Positivism' was the epistemology at that time.

Furthermore, Grbich (2007) states that:

> … positivism views truth as absolute, and values the original and unique aspects of scientific research such as realistic descriptions, truthful depiction, studies with clear aims, objectives and properly measured outcomes, a focus on neutrality, objectivity (knowledge of reality gained by a neutral and distant researcher utilising reason, logic and a range of carefully pre-tested research tools) and theory testing that can distinguish between facts and values (p. 5).

Thus Positivism is associated with realism, materialism and objectivity. Grbich also writes that scientific knowledge gained from observation and based in logical thought processes was, at the time, seen as having the potential to displace ignorance and superstition and that scientific knowledge was seen as having the capacity to facilitate freedom from religious influences, and to lead the way to a new world built on the notion of a universal foundation for knowledge (Grbich, 2007). The universality of the norm of science is based on the belief that science is conceived and conducted in the same way, and not influenced by cultural and national characteristics (Aikenhead, 1997).

Towards the close of the twentieth century, the previously widespread commitment to Enlightenment ideas and ideals, including the primacy of science as the method of gaining truths about the natural and social world, was broadly questioned and rejected in many areas (Matthews, 2009, p. 644). Further, the view that the universe is deterministic changed, as freedom of events was recognized.

The revolution to modernism shifted focus to more industrialized societies and a different way of viewing and interacting with the world. The revolution in science meant a revolution in science education as well. Some of the major events that became instrumental in stimulating massive research projects in the West were the wars of the time. The launching of the first satellite, Sputnik, during the Cold War era, in 1957, by the then Soviet Union, into an orbit around the world (De Jong, 2007) added to speeding up of the space race. According to De Jong, this (launching) showed the relative inferiority in science and technology in other big industrialized countries, including the United States of America. This led to criticisms being re-tabled against the existing curricula for being old-fashioned, overloaded and facts-oriented (*ibid.*). Until then, the primary factors influencing the content of education were the

goals of a society and the organized body of knowledge available (Yoloye, 1998, p. 10) from experts rather than from student perspective (De Jong, 2007).

The discourse in science, including courses and curricula offered in schools, was influenced by different ideological perspectives which dominated a particular era. Volmink (1998) discusses two ideological perspectives that were influential in shaping the discourse on science and technology education in the twentieth century. These influences, Volmink states, could be discerned in the two waves of reform as described by Sylvia Ware (1992). While the first wave of reform in the early sixties was aimed at the initial training of scientists, the second reform targeted all learners under the rubric of 'science literacy for all' (Volmink, 1998; Ware, 1992). According to Ware (1992), the other motivation for this reform was "a belief that science knowledge was in some way important to the intellectual development of all students".

With the second wave of reform, science courses were less elitist, learners more active, teachers more open, and content focused more on societal issues than on disciplines (Volmink, 1998). Even those students who will not become scientists were targeted by the new approaches to science education as science was viewed in and from its cultural context (Ware, 1992). Efforts were made to make science more meaningful to the learners by relating science concepts and processes to everyday life situations (De Jong, 2007). De Jong (2007) adds a third wave of the 2000s, in which learning is a dynamic and social process where learners actively construct meanings from their actual experiences. The latter embraces a more humanistic approach which builds on the interests and experiences of learners, and takes into account the environmental and cultural aspects in which science is to be practiced. Furthermore, there is recognition that cognition is an active and social process (Schäfer, 2004). As stated by De Jong (2007), learning (science) can be considered as a change from one's socio-cultural environment to a new scientific environment.

During the 1960s and 1970s, science was still viewed as universal, value-free and as an objective way of knowing (Herbert, 2008). The aim to train scientists, coupled with the ethnocentric belief about the supremacy of the scientific enterprise, implicitly imbued scientific knowledge with an elitist status. The supremacy that science gained over other forms of knowledge during the Enlightenment era can be related to an ideological use of science defined Eurocentrically as an activity which governs all thought and behaviour. This ideology of the epistemic supremacy of science – also called *Scientism* − advances science as

sacred and with the highest standard of morality, giving it an elevated sense of value and compass in human history (Lessl, 2007; Odora-Hoppers, 2002). Scientism, or what some refer to as the view and absurdly reductionist belief that all (absolute) truth can be learned and all reality described through science (never defined), and 'only' through science (Astley & Francis, 2010; Roy, 2005), reflects a positivist ideology. The 'traditional Enlightenment position' endorsed the absolutist and positivist view by embracing and defending the methodologies and claims of science (Matthews, 2009). Roy points out that the term, 'only', is what distinguishes scientism from the mainstream science belief about science. Mainstream science acknowledges a view that there are other ways of describing reality, and the sources for constructing that reality are not only external but internal as well.

Science or Western science, therefore, evolved within Euro-American cultural settings. Although it is called 'Western', not all Western people accept Western science as the most legitimate knowledge system (Aikenhead, 2006). The Eurocentric way in which science was regarded is now being eroded by the various perspectives that a greater diversity of people bring to the science field, and other people can participate in it. Matthews (2009, p. 644) writes that, for some, Western science was just one of many ideologies, with its supposed truths being just an outcome of negotiations and the winning not so much by more truth or better agreement with the world, but simply having better rhetorical skills or more power.

To summarize this section, we see that the development of science education can be characterized by three waves. Through the first wave of reform, science gained an elite status in which the primary aim of science education was the production of scientists for the future, who would be the 'three percent' of science majors in universities and colleges. However, with the second wave of reform, as science education became open to all learners, science courses were less elitist, focusing more on active learning, and content focused more on societal and everyday life issues to make it more meaningful to learners (De Jong, 2007; Volmink, 1998). With the third wave, the discourse on science education was guided mainly by the social constructivist perspective wherein learning is a social and situation-based process.

3.3.1 Science education developments outside of the Western world

As would be expected, developments in science in Africa, as with the rest of the world, have been greatly influenced by developments in the West. Early developments in science

education saw physics and chemistry as "the leading subjects followed by botany and zoology" (Le Grange, 2008b, p. 89). The emergence of biology as a school subject later in Britain and in the United States of America (USA) was influenced by the knowledge aim as well as the personal and/or social aim of the subject. Europeans were utilizing the printing press and colonizing the world, and natural philosophy − or science as it was later known − was exported worldwide, along with Christianity, aiding the forces of colonization (Aikenhead, 2006, p. 11). In the middle of the 20th century many African states were attaining their independence from their colonial masters. This included importing knowledge systems from the colonizers in an effort to keep in line with the Western developments. African science education, therefore, has historically been influenced by a long history of theoretical and philosophical thinking in Europe and the USA (Yoloye, 1998, p.8).

However, following their independence from European rule, various African states embarked on efforts to Africanize education curricula (Omoleoa, 2007). Despite these efforts, the newly independent African states remained educationally tied to their former colonizers, who provided resources and expertise in subjects like Science. The importation of a Western form of education where the design of curricula, teaching and learning methods, as well as assessment, were often administered from abroad, and, leading to Western knowledge being uncritically transmitted in schools. Science, with technology, was seen as a subject that could influence developments and "bring economic and cultural advancements" (Volmink, 1998) in Africa, and 'civilization' to societies.

The advancement of the Western knowledge was seen as bringing Western modernization and facilitating the entry of traditional societies into the 'developed' world (Odora-Hoppers, 2009, p. 603), while also preventing 'underdevelopment'. Odora-Hoppers (2002, p. 78) also writes of 'developmentalism', a theory of linear progress which correlates with specific eras of western hegemony, as a discourse on power and subjugation, and constituted in what she calls 'partriachal global relations'. With this subjugation, the knowledge traditions of many were conquered and reduced to systems irrelevant to human existence (Odora-Hoppers, 2009). Elsewhere she states:

> In order for the so-called underdeveloped to think of and comprehend 'development' as stipulated, expected or demanded by the West, they are assisted, by means of various statistical and other forms of written material emanating from the West, to form and internalise the perception of themselves as underdeveloped,

> along with the whole burden of connotations that this carries (Odora-Hoppers, 2002, p. 80).

Thus, exporting Western science was synonymous with development. or release from underdevelopment (Odora-Hoppers, 2002), by the importers. As argued by Volmink (1998), the absence of scepticism regarding the dominant view of science led to the uncritical adoption of Western technologies and methods. This lack of scepticism was characterised by what Odora-Hoppers (2009) calls 'silence'. She writes that "the global elite in the knowledge producation enterprise had nothing to say, and that the silence of the democrats and of the ethicist" (p. 603) 'unwittingly' led to the dominance of the Western knowledge over other values and other forms of knowing people had held over the past generations. The global elite comprised the politicians who made decisions about what type of education to transfer, as well as those who were in the forefront of generating scientific knowledge.

Western science was therefore imported from the West with hardly any modifications, and Africa relied entirely on the West for its 'scientific' liberating knowledge. Thus, in South Africa and in the rest of Africa, early developments in schooling, including biology education, were mainly shaped by colonial influences. This was primarily because the subjects had become established in Europe and the USA (Le Grange, 2008b). The Science curricula, including those for Biology, are therefore 'Western' by virtue of their origin and nature. The importation included the personnel who staffed universities and schools, who not only brought the curricula, but also came with ideas from the West. To some extent this happened to the detriment of knowledge that people already had, the knowledge that was passed from generation to generation, and which informed the people's values, beliefs, and their way of life in general. This knowledge, or what could be termed 'Indigenous Knowledge Systems' (IKS), represents knowledge of philosophy, medicine, science, technology, religion, education, and other areas of thought common in non-Western societies (Odora-Hoppers, 2002, p. 83). These indigenous knowledge systems, according to Odora-Hoppers, are underpinned by a way of life, a way of seeing and a way of relating that brings to the picture a different set of propositions. IKS is a redemptive, holistic, and transcendental view of human experiences with the cosmos (Ogunniyi, 2007a, p. 965). As part of the fabric underlying their society, indigenous knowledge systems can make more sense to learners than what they learn in school science (Waldrip, Timothy & Wilikai, 2007).

The current study is undertaken at a time when South Africa, like most other African and world states, is in a reform process, recognizing the need for all citizens to acquire a knowledge of science. As stated in the National Curriculum Statement Grades 10-12 (General) for Life Sciences: "all South Africans have to be educationally affirmed through recognition of their potential" (DoE, 2003a, p. 2). One of the aims of the South African curriculum is "to develop a high level of knowledge and skills in learners" (*ibid*., p. 3). According to Cobern (1990, p. 3), the enlightened citizenry needed in a twentieth century popular democracy means a citizenry capable of making informed decisions concerning science and technology. As noted for South Africa, the knowledge gained from Life Sciences, in particular, should have "implications for the socio-economic and technological advancement of society" (DoE, 2003a, p. 9). The involvement of the public in making and implementing policy decisions therefore necessitates a relevant education to prepare them for that role. Scientists are part of the public and participate in public life like other citizens. Therefore, to attain the goal of scientifically literate citizenry, many nations have been rethinking their needs and priorities for school science in terms of 'science for all' (Jegede & Aikenhead, 1999, p. 45). The notion of 'science for all' requires that science is taught to every learner, irrespective of whether the learner will study science majors at tertiary level or not. This implies that teaching 'science for all' should emphasize the relevance of curricula to everyday lives of 'all' individual learners while also preparing some learners for science-based careers.

While the issue of 'science for all' is also a matter of equity (Cobern, 1990, p. 3), the range of 'whom' to teach is very diverse; therefore *what* is taught must also vary according to learners' educational backgrounds, abilities and goals (Yoloye, 1998, p. 10), as well as their socio-economic and cultural backgrounds. However, care should be taken when implementing such a system to avoid discrimination of other groups and perpetuating inequity, particularly if the suggestion is not properly applied. What is important is recognition of the diverse backgrounds and prepare for them accordingly.

After all, the continuous interactions that one has with his or her environment and with other people is what determines a person's view of reality. This implies that science education now considers the environmental and social factors within which learners grow and develop, factors for which it has to prepare them. This aspect brings to science education perspectives which need to be analysed critically and attended to in a manner that will promote relevance

in science teaching and learning. Science education researchers and writers have shown that science is not free of culture, but rather, as a value-laden activity, it is related to the values and cultures of people who practise it. In addition, science has an historical and also a philosophical role, and is therefore applicable to people's cultures and beliefs.

Thus, the supremacy of Western science in African and other non-Western Science classrooms, and the difficulties confronting some learners in those classrooms has become a matter of interest and research, as evidenced by events after the 'colonization' era. These postcolonial studies, according to Zembylas and Avraamidou (2008, p. 991), offer to science education the theoretical tools that enable pedagogues to witness how the dominant perspectives in the field have been implicated throughout the long history of colonial thinking. Science education has therefore been under scrutiny by many authors and researchers in Africa and the rest of the world, aiming to understand the factors influencing it in order to identify and unpack the best practices. Some research has explored the factors contributing to failure of traditional attempts to teach science, as is discussed in the next section.

3.3.2 Failures of traditional approaches to science

Aikenhead (2005, 2006) identifies from literature some major failures of the traditional science curriculum in which many learners experienced science as a foreign culture. The first of these failures concerns the chronic decline in student enrolment due to students' disenchantment with school science or due to students' cultural self-identies conflicting with their perceptions of science and technology (*ibid*.). This has led to advocacy for a humanistic content to schools science. Aikenhead characterizes the second major failure as resulting from various forms of discrimination, with a bearing not only on exclusion but also on equity and social justice. Discrimination may also happen if and when science is viewed as a form of intellectual isolation by either teachers or the society (Waldrip *et al*., 2007). Thirdly, Aikenhead mentions the dishonest and mythical images of science and scientists conveyed by school science. This also advocates some form of exclusion and, like the second failure, isolates learners from the learning of science.

The fourth failure which Aikenhead writes about and attributes to lack of relevance in school science and for most students not learning science content meaningfully, is "little enculturation, assimilation, or acculturation" (Aikenhead, 2006, p. 27). Furthermore,

Aikenhead (1997; 2006) states that enculturation characterises learning where scientific content harmonises with students' worldviews[4], while in acculturation students borrow some science content because of its utilitarian value. With assimilation, on the other hand, school science clashes in some way with students' worldview, leading to marginalisation or replacement of their own ideas with scientific ones. If it occurs, assimilation therefore alienate learners from their life-worlds or it can alienate them from science, causing them to develop ways or 'games' to pass their science courses without meaningful learning of the content (Aikenhead, 2005, 2006; Aikenhead & Jegede, 1999; Jegede & Aikenhead, 1999). This fourth failure, therefore, results in teachers and learners, albeit not all, developing clever ways or 'school games' to pass science without learning the content in a meaningful way. These games, discovered by Larson (1995), can have explicit rules and were named 'Fatima's rules', after an articulate pupil in a high school chemistry class. The games include rote "memorization and ingratiation" (Aikenhead, 2005; Larson, 1995) and playing them acts as a coping strategy for students who feel they are being assimilated into the culture of science and who want to resist indoctrination. Rather than achieve meaningful learning, learners who play Fatima's rules mainly achieve rote memorization of key ideas.

Waldrip *et al*. (2007) show that the view of science as being only for the clever leads to students facing a blockage to the learning of science even before attending their first science lesson. This view can thus lead to Aikenhead's (2005, 2006) first failure, which creates a negative attitude to science learning. For those who enter the classrooms, the "mental block is further reinforced by the introduction of glossary, principles, concepts, and the young minds are being 'short circuited' and end up assigning science into the 'too hard' category" (Waldrip *et al*., 2007, p.111). As this attitude unfolds, there is a mental preference for one's own cultural knowledge which offers a comfort zone, and a neglect of scienctific knowledge.

While, in general terms, the first of Aikenhead's (2005, 2006) failures seems to be more of a symptom of science education failure, the other three could be 'causes' of *the* failure. These three failures are strongly interconnected, and can be heirarchically placed, with the second at the lowest level and the fourth at the highest. The relevance stated in the fourth failure already loses ground in the second failure, and as this loss gathers strength, it culminates in the fourth failure. Hence all the four failures subsume an aspect of relevance, which is seemingly the major source of science education failure. To Cobern (1996), a serious and

[4]Literature presents the term as world view, world-view or worldview, sometimes depending on whether it is a noun or adjective. In this report, the term is used as noun and worldview only is used

long-term problem of science is loss of meaning to learners. It is these failures which are of essence to the research reported here, as they seem to be universally at the core of the difficulties facing education which deals with evolution. We may assume that, if one deemed the knowledge of biological evolution relevant or useful to one's life, one would most likely be motivated to learn about it. Any perception on the contrary, therefore, might alienate one from learning evolution.

Aikenhead (2006) indicates possible ways of ameliorating the four failures, by offering humanistic content in school science in order to reverse the loss of talented students (p. 26), ameliorating the under-representation of conventionally marginalized students (p. 27), correcting false ideas (p. 28) in science, and changing the meaning of *Science* in *school Science* (*ibid*). A humanistic approach requires that every school learner is given an opportunity to learn science and provides curricula catering for their circumstances, not only for those who intend to specialize in science or to follow science-based careers. The inclusion of IKS in curricula is seen as one of the ways to cater for and preserve cultural diversity in the classrooms. However, as pointed out by others, this poses a challenge to teaching, in that science is based on a hypothetico-deductive model of reality, while IKS are based largely on an anthropomorphic model of reality (Ogunniyi, 2012, p. 421). The former involves scientific processes which include hypothesis formulation and observation, while the latter may refer to subjective states in phenomena. Therefore, learning science as a way of gaining knowledge is different to the way customarily used by an anthropomorphist or user of IKS. This may therefore result in problems in learning. The problems of learning science would seem to relate in some ways to the characteristics of scientific knowledge, its nature and how that nature unfolds itself during the teaching and learning processes.

In the next section, the nature of science is discussed in relation to evolution education and beliefs.

3.4 THE ENTERPRISE OF SCIENCE

The quest for knowledge is part of human culture which may be fulfilled in various ways. The term 'science' actually comes from the Latin word '*scientia'* which means 'knowledge'. Science is now considered different from other disciplines, in that scientific knowledge is regarded as testable and verifiable. Science is distinguishable by its 'nature', which is how it works and generates knowledge. Although there are various forms of science, the modern use

is synonymous with disciplines like biology, chemistry, geology and physics. What is common among all the four disciplines is that they all employ the scientific method, although others also do so. Science education has been deemed important for producing scientists by teaching people to be 'scientifically literate'. One becomes more scientifically literate if one understands and values the concepts and methods of science (Cobern, 1996). In this way one comes to look at and understand the world differently, that is, from a scientific worldview. The nature of science discussed in the next section relates to all disciplines associated with scientific method.

3.4.1 The nature of science

The phrase 'nature of science', according to Reiss (2008, p. 158), "is used as shorthand for how science is done and what sorts of things scientists work on". It has been shown that there are disagreements among the scientific communities in relation to conception of the nature of science (Liu & Lederman, 2007). For instance, according to Lederman (1992), nature of science (NOS) refers to values and assumptions inherent to scientific knowledge and its development. According to Liu and Lederman (2007, *ibid.* p. 1283) the contemporary conception of NOS emphasizes a description of the characteristics of scientific knowledge, which are directly derived from the way in which the knowledge is developed as well as the values, beliefs and assumptions inherent therein.

Liu and Lederman (2007, p. 1284) give the seven defined and general aspects of NOS as the views that scientific knowledge is (1) tentative (subject to change), (2) empirically based (based on and/or derived from observations of the natural world), (3) subjective (theory-laden), (4) partly based on human inference, imagination, and creativity, (5) socially and culturally embedded, (6) clear on the distinction between observation and inference, and (7) an expression of the function of and relationship between scientific theories and laws. However, what aspects are emphasised when science is taught are often influenced by the context in which it is taught and the view given to science in that context. For instance, as noted by Liu and Lederman (2007, p. 1284), in contexts where students and teachers view science as being useful for future careers and the development of countries, science is interpreted as a materialistic benefit rather than as a way of knowing the natural world, and is usually not involved in the learner's everyday thinking. This can affect the way learners conceptualize science and their understanding and appreciation of the nature of what they learn.

Some theorists have suggested that the goal of science education should be to understand the nature of science (Smith & Scharmann, 1999). This would allow for learners the practice of scientific processes, and improve learners' understandings of science as both a discipline and a dynamic body of knowledge. As learners understand what scientific knowledge is and how it is developed, some of the challenges experienced in the teaching and learning of science may be answered.

3.4.2 The relationship between science and religion

Knowledge informs people's beliefs and how people live and act on an everyday basis. While science studies the observable world, using senses and the extensions of those senses empirically, religion does not follow a similar discourse. At the same time, religion is a form of knowledge that has a profound impact on many people and societies, influencing their beliefs and actions. Religious beliefs, in particular, have been a source of moral guidance for humans, and for many there are no other systems of restraint and no other sources of inspiration that come as close to motivating people to respond powerfully as do the systems of organized religion (Katz, 2002; Mansour, 2010).

Dating back to about 2000 years ago, there had been a change in the view and understanding of the universe, which was primarily dominated by Aristotle's scientific thought that the earth was at the centre of the universe, a geocentric model. This thought was rejected by Copernicus, a mathematician and astronomer, who taught, instead, that the earth revolved around the sun - the sun, and not the earth, was thus at the centre of the universe. Copernicus's heliocentric universe came at a time when the teachings of the church were in favour of the geocentric universe. His suggestion was therefore opposed by scholars as well as theologians in the Protestant and Catholic churches at the time.

Religion is therefore a distinctive feature of all cultures (Aikenhead, 1997, p. 424). Science, on the other hand, deals with questions about what the universe is made of, how it works and why it works the way it does – the empirical universe (Gould, 1999). As will be discussed in the next section, science is also a form of culture.

The relationship between science and religion has been researched and written about a great deal, particularly as it relates to teaching and learning (e.g. Astley & Francis, 2010; Ayala, 2008; Barbour, 2000; Dagher & BouJaoude, 1997; Dagher & BouJaoude, 2005; Deniz, Donnelly & Yilmaz 2008; Findley, Lindsey, & Watts 2001; Gauch, 2009; Gould, 1999;

Lever, 2002; Mansour, 2008a, 2008b; Mansour, 2010; Matthews, 2009; Reiss, 2008; Upadhyay, 2010). Studies have reported perceptions of conflict between science and religion. Whether the relationship is one of conflict or not, historically religion has nonetheless had an influence on the culture of science and on scientific developments. As Michael Matthews writes, the major religions in the world have been engaged with science on an ongoing basis, with the aim of determining how religions' ontological, epistemological and ethical commitments, or worldviews, are to be reconciled with scientific findings and putative scientific worldviews (Matthews, 2009, p. 642).

Often ontological and epistemological questions about reality lead to different responses, depending on the perspective one uses to view reality and to understand that reality. For instance, one may view religious and scientific knowledge as merely different, or one may view them as wholly or partially separated, leading to different consequences for the conclusions to be drawn concerning the relationship between religion and science (Hansson & Redfors, 2007a, p. 462). The relationship is therefore understood and presented in various ways, depending on the writer's or researcher's epistemological and ontological position, with some seeing a conflict while others do not. For instance:

> Science and religion concern different aspects of the human experience. Scientific explanations are based on evidence drawn from examining the natural world and rely exclusively on natural processes to account for natural phenomena. Scientific explanations are subject to empirical tests by means of observation and experimentation and are subject to the possibility of modification and rejection. Religious faith in contrast, does not depend on empirical tests and is not subject to the possibility of rejection based on empirical evidence (Ayala, 2008, p. 4).

Similarly, as stated by Odora-Hoppers (2002), both science and religion represent attempts by humans to gain mastery over the environment, and each represents a different way of understanding the world (Ayala, 2008). That mastery can be achieved through the acquisition of an understanding of the world and a capacity to interact with it harmoniously. Whichever of the two it is, or both as happens sometimes, should provide an understanding that makes sense to the individual and may be what informs an individual how to live in and interact with the world. That choice, which may not necessarily be conscious, will possibly be determined by the context in which an individual finds himself or herself.

For instance, where curricula and classrooms are concerned, some hold the position that the two, i.e. science and religion, should not meet, meaning that science classes should be for science only and religion has its place elsewhere, maybe in a religion classroom. This is what

some refer to as a "principled domain separation – a respectful non-interference" (Odora-Hoppers, 2002, p. 75). Separating science and religion in this manner suggests that they are independent of each other. Although they attempt to respond to the same questions concerning reality, they do so differently and even sometimes provide different answers, as each employs a different epistemology.

There also exists a view of reality as being constituted by the two irreducible elements, for people who see no conflict but may rather advocate co-existence of the two. This dualism of thought has been articulated by the evolutionary paleaontologist Stephen Jay Gould (1999) in a book entitled *Rock of Ages*. Gould advocates what he calls the 'Non-Overlapping Magisteria' (NOMA) in which he shows that the realms of science and religion cannot fuse or overlap. He refers to science as 'the age of the rocks', and religion as 'the rock of ages', and states that while "[S]cience studies how the heavens go, religion focuses oh how to go to heaven" (Gould, 1999, p. 6). According to Gould, science and religion each represents a legitimate magisterium, or domain of teaching authority. He states that science documents the factual character of the natural world – the empirical universe – while religion deals with questions of moral meaning and value. Even though neither of the two magisteria can respond to all possible inquiry, Gould's NOMA posits that they are certainly independent and there is no conflict between them. Gould's proposal of the NOMA theory has been challenged by those who do not see a conflict, and those who see a conflict but resolve it differently. For instance, the proponents of the Intelligent Design movement – by which evolution is seen as the result of a divine plan – see religion and science as supporting each other. Others see the two as being separate and totally independent of each other.

One of those with a position contradictory to Gould's is Gauch (2009). He argues that, even though science constitutes a worldview which is independent in terms of its presuppositions and methods, scientific evidence can have wider worldview import. This wider import, he states, has been shown to be possible methodologically and its actuality is revealed historically (Gauch, 2009, p. 656). Similarly, Fishman's (2009) critique is based on the premise that, while scientific evidence may ultimately support a naturalistic worldview, science does not presuppose naturalism as an *a priori* commitment, and supernatural claims are amenable to scientific evaluation (*ibid.* p. 813). Using the Bayesian confirmatory theory, Fishman (2009), a research neuroscientist, argues that supernatural claims, including religious claims about reality, are testable, and that a claim is testable if there can be evidence

of whatever kind, for or against the claim (*ibid.* p. 817). He goes on further to give three ways by which supernatural claims can be tested by science: by their prior probabilities, by their likelihoods, and by the availability of plausible alternative non-supernatural explanations (*ibid.* p. 825). Therefore, as stated by Fishman, there is no evidence in favour of religious beliefs. Hence, believers in the supernatural retreat to NOMA because of negative evidence, and claim that the supernatural phenomenon is beyond the reach of science to investigate (*ibid.* p. 827). Therefore, as Fishman (2009) continues, supernatural and religious claims do not belong in science classrooms – not because they have supernatual or religious content, but because there is either no convincing evidence to support them, or because science has debunked them. He concludes that science educators, including teachers, face the challenge of maintaining both the intellectual integrity and the receptivity of students to potentially controversial scientific material like evolution (Fishman, 2009, p. 832).

The testability as described by Fishman (2009) subjects religion to hypotheses requiring empirical assessment, the view of science that changed with the rise of Newtonianism in which, as stated by Cobern (1991), a mechanistic world view has triumphed amongst the literati over its competitors. The mechanistic view of Descartes compared to the views of philosophers like Aristotle, however, has deficiencies when it comes to addressing the social realities. Subjecting religious or other supernatural beliefs to testable hypotheses requiring empirical assessment arises from a bigoted view of scientific practice concerning the undersanding of natural causes. Associated with Positivism and Reductionism, this mechanistic view cannot analyse sufficiently well the component parts of social, cultural and philosophical realities. This explains the rejection of Fishman's view by writers such as Smith (2010b, p. 545), on the grounds that modern science should not take any position on the existence of the supernatural or make any claims about supernatural causes or designs.

Other writers have supported the position of leaving religion out of the science classrooms. For instance, Gunn (2004, p. 5) states that the concept of evolution does not presuppose either the absence or the presence of a creator, which means that evolution neither supports nor refutes creationism. Rather, evolution is silent on the matter and simply provides a concept for which a scientific explanation can be provided, so as to be examined experimentally. Gunn was not refuting the subjection of religion to empirical testing *per se*, but was showing that evolution provides answers to questions about the origin and diversity of organisms in a different manner from religion. Evolution responds to the 'why' questions about biology

(Johnson *et al*., 2011) and about biodiversity in particular. Therefore, as a scientific concept, evolution may be silent on religious matters.

Regardless of whether religion can or cannot be subjected to empirical scientific assessment, religion and science are both integral parts of people's lives, both trying to explain the existence of the cosmos and how an individual human fits into that existence. Establishing a relationship between science and religion therefore usually extends to understanding the presuppositions about science held by people, as these presuppositions may be an indication of their worldviews – that is, religious, cultural or other, and scientific worldviews. Regarding how such worldviews are reconciled with science, Matthews (2009, p. 647-648) writes:

> The ontologically rich worldview in which there is a Supreme Being, a God or Gods, angels, spirits, souls; and in which natural processes are interrupted and redirected by prayer, meditation, or supernatural agency is seemingly very different from the more austere and lawful world learnt about in physics, chemistry, geology or biology classes.

As the debates continue, some find the discussion of religious and other presuppositions about the world as being relevant in science classrooms (Hansson & Redfors, 2006). This relationship will therefore be further expounded in the section on theoretical perspectives, where the worldview theory will be discussed in relation to learners' and teachers' religious and other beliefs. The next section discusses science as culture, how science is affected by the societies in which it is being practised, and how culture affects the teaching and learning of science.

3.4.3 Science and culture, and science as culture

Culture is a concept with multiple definitions. It is best understood as everything that characterizes a society (Omoleoa, 2007, p. 600), the totality of socially-transmitted behaviour patterns, arts, beliefs, institutions and all other products of human work and thought (Odora-Hoppers, 2009, p. 604). Mesoudi, Whiten and Laland (2004, p. 2) define culture as acquired information – such as knowledge, beliefs, and values – that is inherited through social learning, and expressed in behaviour and artifacts. These two, and other definitions reviewed from other authors and from sites such as: http://www.tamu.edu/faculty/choudhury/culture.html indicate the symbolic nature of culture, together with aspects of learning symbols involved. They also indicate that culture is enshrined within people's knowledge, beliefs and values, is

expressed in behaviour and actions of individuals, and is usually ascribed to the social group(s) to which an individual belongs. The varying behaviours exhibited by different groups of people may thus be attributed to culture variations within groups.

Culture acts as a lens of perception, influencing how people view themselves and their environment (Omoleoa, 2007 p. 600). This contributes to making the cultural context in which people live into one of the factors that determine what individuals believe, how individuals learn and what they know. This cultural variation also contributes to differences in understanding the physical world by different cultural groups, influencing to some extent their understanding of phenomena. The different ways of understanding may in turn impact on people's ability and opportunity to learn (Wallace & Louden, 2002). For instance, it has been shown that some groups, like Africans, learn science differently from other groups (see Ogunniyi, 1987; Ogunniyi, Jegede, Ogawa, & Yandila, 1995; Omoleoa, 2007). Also, Western science, as the embodiment of 'true' science, may give rise to conflicts for some groups of people outside of the Western culture. As stated by Liu and Lederman (2007, p. 1282), "people in some non-western cultures may not see the natural world as an object of investigation or of exploitation for human benefit".

In the late 1980s and 1990s, the view of many researchers was that science was a sub-culture of Western societies, and therefore learning science was similar to learning a new culture, the culture of science (Herbert, 2008; Jegede & Aikenhead, 1999). This view challenges the traditional image of science, which assumes that scientific knowledge is purely rational and, as such, isolates science from culture and society. Science with its own values and views can itself be described as culture (Hansson & Redfors, 2006). As a culture, science is thus a shared way of living which includes knowing, valuing, feeling, and interaction with others (Jegede & Aikenhead, 1999, p. 46). The cultural ideology applied to science ensues from viewing it as a human or social activity laden with values and beliefs. Therefore, like other cultures, science is transmitted from one generation to another through learning. In the course of that transmission, errors can occur as a result of improvisation in learning or distortion in transmission, leading to cultural variation (Mesoudi *et al*., 2004), so that cultures diverging from the original one are learned.

The learning of a new culture, the process of enculturation, takes place when a new culture synchronizes with an existing culture. For instance, in learning science, enculturation tends to occur when the culture of science harmonizes with the life-world culture of the learner, and

science instruction supports the learner's view of the world (Aikenhead & Jegede, 1999, p. 274). Even though there may be universal conflict between science and traditional or everyday culture (Dzama & Osborne, 1999), research has indicated that African and other learners in non-Western cultures have difficulty in learning Western science because of their non-Western worldview. This has been supported by various scholars (see Jegede & Aikenhead, 1999; Le Grange, 2007; Liu & Lederman, 2007; Ogunniyi, 1987, 1988, 1995, 2012; Ogunniyi *et al.*, 1995; Omoleoa, 2007; Waldrip *et al*., 2007). Yet even though Western science was appropriated by Eurocentric Western philosophy, not all Western people accept Western science as the most legitimate knowledge system (Aikenhead, 2006, p. 10; Grbich, 2007, p. 10), nor do all Western learners find it easy to learn science.

As already stated, contemporary or modern science was established as a discipline in the West and then exported to other places in the world. This means that science is taught to people in cultures which are not Western. More often than not, and more pervasive within local cultures in less industrialized and non-Western regions of the world, the imported science curriculum or Western Science taught at school is considered to be superior to knowledge within the local culture (Jegede & Aikenhead, 1999, p. 47). Some reasons have been advanced for this dominance of Western science over knowledge from local cultures. For instance, if science is viewed as a form of intellectual isolation by either teachers or the society, students may conceptualize science as consisting of superior words and concepts and be unable to relate those terms and concepts to their life experiences (Waldrip *et al*., 2007), and they will view it as superior. Also, as Waldrip *et al*. (2007) state, the means and manner of presentation often masks the true objective of teaching, which is to scaffold and enhance students' knowledge and understanding. Inability to understand may cause the diversion of attention to other things, such as the terms used, and miss out on approaching the true meaning of science.

Western history is replete with clashes between science and established cultural values (Dzama & Osborne, 1999, p. 387), suggesting a form of 'competition' between the culture of science and the enshrined cultures of learners. As both science and the learner's personal culture 'compete' to fit into the learner's experience, problems in learning may arise. Evolution education, for instance, has been found to be problematic in non-Western societies where Western science is foreign to the learner. But evolution education has also been problematic in Western societies, where religious beliefs impede the smooth teaching and

learning of the theories supporting this concept (Findley *et al.*, 2001; Sinclair & Baldwin, 1996; Tatina, 1989). The first scenario presents a clash between Western and non-Western worldviews for a non-Western learner, and the latter scenario presents a clash for a Western learner between Western science and other belief systems, which may in this case be religion. This suggests that a worldview other than 'Western' is affecting evolution instruction in Western and other societies, or, as argued by Dzama and Osborne (1999), the learning difficulties confronting African learners may not be peculiar to non-Western cultures alone.

Science is, therefore, part of a plethora of cultures with which a school learner interacts: "the culture of home, the culture of peers, the culture of school, the culture of the science classroom, and an overarching culture determined by the community in which the [learner] lives" (Jegede & Aikenhead, 1999). By the time the learner comes to school, she/he has already interacted with many cultures at home and in the community. This would suggest that human functioning is socially interdependent, richly contextualized, and conditionally orchestrated within the dynamics of various societal subsystems and their complex interplay (Bandura, 2001, p. 5). In discussing the social cognitive theory, Bandura states that cultures are not static monolithic entities (Bandura, 2001, p. 15). Amidst the global cultural classifications exists "intracultural diversity" (*ibid.*), and also people of different cultural backgrounds do exhibit many commonalities.

People come across a variety of cultures in their environment. An encounter with a foreign culture, therefore, involves moving from one's familiar world into that culture, or border-crossing to the new culture (Jegede & Aikenhead, 1999, p. 46). Similarly, students' meeting with science is a meeting between two cultures, the culture of science and the student's own culture (Cobern & Aikenhead, 1998). To learn science, therefore, is to acquire the culture of science by crossing over from one's own culture to the culture of science. That is to say, the learner has to make a cognitive shift from his/her life-world – his/her ways of knowing, values, beliefs, norms and expectations – to that of science.

Strategies that can ease the learning of science for learners who have a non-scientific view have been suggested. For instance, Jegede and Aikenhead (1999) have elaborated strategies that can be used to make science learning in Africa and other places manageable. They and others have suggested a culture-sensitive science education which probes what happens in the minds and hearts of learners when they are being taught science (Jegede & Aikenhead, 1999). A culture-sensitive science education should be sensitive to the life-world cultures of learners

as well as to the culture of science, and allow learners to shift smoothly from their life-world to that of science, and back again.

However, shifting between life-worlds and world of science is not without obstacles, and learning in science, particularly the traditional canonical science curriculum, is more often than not accompanied by failure. Some of the failures can be attributed to three issues which, according to Wallace and Louden (2002, p. 86) work together to reduce some social and cultural groups' opportunity to learn. These issues are (1) science itself, in that, that western science is unproblematically seen as the agent of human progress; (2) school science, with its preference for linearity, abstractness and specialized language; and (3) the institution of the school rather than the specifics of science (*ibid*.). To learners where English is a foreign language, the complexity is further compounded by words and phrases that cannot easily be translated into local cultural contexts (Waldrip *et al*., 2007, p. 111) familiar to learners. Because of the complexity, some teachers resort to figurative language, sometimes resulting in a teleologic or anthropormophic effect (Moore, *et al*., 2002), leading to misconceptions.

Furthermore, as stated by Wallace and Louden (2002), the cultural diversity that exists in schools makes it difficult for teachers to interest learners to school science. Astley and Francis (2010, p. 196) suggest strategies which would be effective in combating a naïve 'conflict approach' to the science/religion debate, a naïve scientism and a naïve biblical fundamentalism. According to Astley and Francis (2010), ignorance of the nature of science often finds expression in an illegitimate expansion of the naturalistic methodological assumptions of science beyond their proper territory, a development that can easily tempt students to adopt an ideology or metaphysic of scientism.

People are usually pluralistic in their thinking, implying accommodation of a multiple of cultures. It is as possible to attribute culture to learning difficulties of learners from non-Western cultures as it is to learners in scientifically developed cultures. Thus, while Africans may be monistic and anthropomorphic in the domain of religion, in their daily lives they have flushes of pluralistic and mechanistic thinking (Dzama & Osborne, 1999, p. 401), making them amenable to other worldviews. Therefore, for an African or non-African learner who has religious and other non-scientific cultural views, difficulty in the learning of science may have its cause outside their non-scientific culture traits. Since learners from Western background also experience challenges with learning evolution, it is likely that the cause of the challenges relates to other traits that they possess, besides their Western culture.

This discussion highlights some of the problems which may be associated with the teaching and learning of science by people from a non-scientific cultural background. While learners may come to school with erroneous ideas already, teaching that confines itself to transmission of the content of science can lead to further development of misconceptions. Secondly, through lack of understanding of the nature of science, there is a possibility of falling into the trap of 'scientism' as indicated by Astley and Francis (2010). Both of these problems will result if teachers lack sufficient understanding of the nature of science. As they go about teaching, teachers may end up transmitting science as if it is a 'box of knowledge' that learners have to absorb without addressing its relevance to their life-worlds.

3.4.4 Implications of religion and culture on the teaching and learning of science

As already described, science learning is affected by culture and so a multicultural approach to teaching with a realistic understanding to conducting science is what should be practised today. This would institute a more culturally-relevant science curriculum in schools. Thus Cobern's (1996) suggestion for science education: to locate science within a broader view of knowledge. The important role that science teaching plays in the interplay between science and culture is certainly recognized (Matthews, 2009, p. 650). That being the case, teaching the same science to all learners demands taking into account the learners' cultures and the diversity they bring to the science practice. After all, modern science does not constitute the only form of knowledge (Odora-Hoppers, 2002, p. 84), but interacts with domains outside of itself and its presuppositions are worldview-dependent (Matthews, 2009, p. 650). It is therefore important to build closer links between science and those other forms and systems of knowledge and approaches thereto. This would require a form of teaching that recognizes that science can be bounded by culture and beliefs, in the sense that it cannot be conducted to the detriment of people's knowledge systems and cultures. This recognition places demands on teachers to be aware of the cultural context and beliefs of their learners, and to be aware of how that context contributes to the learners' knowledge. This includes being aware of the views that learners have about science, in order to deal with opposition from those learners who hold a different ideology to the one presented by science.

One explanatory frame used to understand the difficulties people come across in adapting to a new culture was uncovered by Phelan, Davidson and Cao (1991) in their investigation of students' worlds of families, peers and school. They describe students' migration between

these multiple worlds or cultures in terms of four patterns of adaptation from which emanated the typology of 'border crossings'. This typology has further been discussed in relation to science learning by others (Aikenhead, 1996; Aikenhead and Jegede, 1999; and Jegede and Aikenhead, 1999).

Aikenhead and Jegede (1999) have suggested 'Collateral Learning' and 'Border Crossing' as probable frameworks to apply in non-Western learning in order to address the failures experienced in the teaching and learning of Science. Le Grange (2008a, pp. 588-589) refers to these frameworks when he emphasizes the need of teachers to scaffold learners in different phases of science learning. This, according to Le Grange, would happen under the assumption that learning and teaching occur within the encultural paradigm, relating to and using learners' life-world as the focus and starting point of learning. Collateral Learning is generally seen as involving two or more conflicting schemata held simultaneously in the long-term memory (Jegede & Aikenhead, 1999; Le Grange, 2008a). This facilitates learning if shifting from one schema to the other is smooth or at least allows the learners to manage the discomfort they may feel.

Astley and Francis (2010, p. 195) suggest the importance of a pedagogy that prevents students from slipping into scientism, implying that such might free learners to adopt a more compatibilist stance in the debate between science and religion. The challenge for the teacher is to stimulate learning while not causing learners to become alienated from their society, knowledge, beliefs and values (Waldrip *et al*., 2007, p. 103). Teaching should stimulate interest in the learner, and at the same time enable the learner to function within their society and any other society without experiencing unwarranted conflict, but a learner should also have capacity to deal positively with any prospective conflicts.

Also provided is some sort of typology of the ways in which science education should feature, ranging from 'decent' science, to 'good' science, and to 'excellent' science:

> A *decent* science education should result in students having some sense and appreciation of the interactive dynamic of science and culture; a *good* science education will result in a *more refined and sophisticated understanding* of that dynamic; an *excellent* science education will *support and nurture* students' decision making in those parts of the give-and-take of affirming, modifying or abandoning aspect of culture that science bears upon" (Matthews, 2009, p. 650– italics for author's emphasis).

Therefore, whether we talk of a multi-cultural or culture-sensitive science education, what science education should aim for is learners who not only learn canonical science, but who are also in a position to make decisions about what works for them and what does not. Learners will be able to take a position if they understand properly what science is and how it works, in other words, if they understand the nature of science and its place in their life-worlds.

3.5 BIOLOGICAL EVOLUTION

3.5.1 Defining evolution

'Evolution' is often used as a synonym for change, development, and the history of natural things (Wiester, 1991). Although evolution is commonly used as 'change' or 'change over time', this use is not adequate for biology, since it limits change to only a 'pattern' of events. According to Douglas Futuyma (2005, p. 2), the word 'evolution' comes from the Latin *evolvere*, meaning 'to unfold or unroll'. Specifying biological evolution, Futuyma defines it [or organic evolution] as "change in the properties of groups of organisms [or populations] over the course of generations". Futuyma states that the changes are considered evolutionary if they are passed via the genetic material from generation to generation. The populations undergo descent with modification, and may subdivide whereupon different populations are derived from a common ancestral population (*ibid*.).

Biological evolution was formalized and profoundly sketched in *The Origin of Species* published by Charles Darwin in 1859. In the century before that, few scientists questioned the Biblical story of creation or the belief that species are fixed and perfect. The publication of *The Origin of Species* sparked "an explosion in biological research and knowledge that continues today" (Campbell, Mitchell & Reece, 1994). According to Matthews (2009, p. 642), the *Origin* provided not just a novel account of the origin of species by natural selection, but also initiated a transformation of modern worldviews and a new understanding of the place of human beings in the natural world.

As a domain of knowledge, evolution can be described by two elements: substantive knowledge which entails knowledge of evolutionary theory, and syntactic knowledge which entails knowledge of the nature of science (Rutledge & Warden, 2000). The concept of evolution and its supporting theories have undergone a lot of repeated testing over the years following the publication of *The Origin of Species*. Lever (2002, p. 13) refers to it as that

proposition of 19th century science that has best stood the test of time, while also being the most accessible. The current view of evolutionary theory and its substantive structure has therefore resulted from more scientific work on Darwin's original ideas. Darwin's view, according to Campbell *et al*. (1994, p. 257), was that the history of life is like a tree, with multiple branching and rebranching from a common trunk to the tips of the twigs. In this Tree of Life, species that are closely related share many characteristics because their lineage of common descent extends to the smallest branches of the tree of life.

In his proposals regarding the origin of species, Darwin disseminated ideas which stimulated a lot of subsequent research. And, as noted by Ayala (2008, p. 3), evolutionary research is nowadays still seeking to understand further and in more detail how the process of evolution occurs. Since Darwin's publications, a lot of evidence has accumulated from palaeontology and other disciplines. The discovery of the common genetic mechanisms programmed into the DNA of all organisms has, for instance, supported the hypothesis that all living forms derived from one original ancestral being (Lever, 2002, p. 15). Thus, in the 1940s and 1950s, classical natural selection theory – 'Darwinism' – coupled with genetic theory became known as the synthetic theory of evolution, or neo-Darwinism (Scott, 1997). Natural selection, proposed by Darwin, has been convincingly demonstrated to be the process that best accounts for the adaptive configuration and functioning of organisms (Ayala, 2008). Other explanations were proposed in the late twentieth-century, including 'punctuated equilibria' by Stephen Jay Gould.

A definition given by Futuyma (2005, p. 547) includes ideas of natural selection and genetics:

> Organic evolution, or biological evolution, is a change over time in the proportions of individual organisms differing genetically in one or more traits. Such changes transpire by the origin and subsequent alteration of the frequencies of genotypes from generation to generation within populations, by alteration of the proportions of genetically differentiated populations within a species, or by changes in the numbers of species with different characteristics, thereby altering the frequency of one or more traits within a higher taxon.

While this theory about evolution has explained a lot about biology, the Darwinian picture, i.e. descent with modification, was not without some gaps, the most notable being the mechanism for the transmission of inherited characteristics (Lever, 2002, p. 14) and the "formation of new species in the process" (Gunn, 2004, p. 2). Smith (2010b) refers to the current understanding as 'Modern Evolutionary Synthesis', presented as a series of facts and claims about them (Smith, 2010b, pp. 540-541). Modern Evolutionary Synthesis is therefore

a culmination of a lot of work by many scientists who worked on Darwin's ideas. While Darwin's idea did not include the most crucial mechanism of evolution, i.e. inheritance, the current understanding now does so. Modern Evolutionary Synthesis incorporates ideas of both natural selection and genetics.

3.5.2 The centrality of evolution in biological sciences

As mentioned in Chapter 2, evolution is described as representing a major scientific concept that is central and unifying to the biological sciences, as well as being accepted overwhelmingly by the scientific community (Clough, 1994, p. 410). In affirming the centrality of evolution in teaching, Theodore Dobzhansky's famous quotation; "Nothing makes sense except in the light of evolution" (Dobzhansky, 1973), is cited by many writers on evolution education (Ayala, 2008; Pennock, 2004; Tidon & Lewontin, 2004). Further, this centrality and unifying role of evolution is endorsed as such by major Science education policy documents (AAAS, 1993; NRC, 1996 cited by Deniz *et al*., 2008).

Biological evolution provides a scientific explanation for why there are so many different kinds of organisms on Earth, the relationships between and the origins of living things, and accounts for their similarities and differences (Ayala, 2008; Eldredge, 2009; Johnson *et al*., 2011). Evolution is therefore important for understanding the nature of science, and critical for the achievement of scientific literacy in the field of biology (Dobzhansky, 1973; Lever, 2002; Nadelson, 2009; Rutledge & Warden, 2000), and in a variety of fields stretching beyond the Life Sciences (Lever, 2002, p. 17). It enables an understanding of societal issues like genetic engineering, the resistance to antibiotics by bacteria, and many other environmental issues (Nadelson, 2009). The concept has been applied in fields such as forensics and software engineering (Ayala, 2008) and informs practice and progress in areas from medicine and biotechnology to environmental policy and public health (see Futuyma, 2005; Lombrozo *et al.*, 2008). In addition, evolutionary biology does not only integrate several disciplines of biology but also relates biological sciences to other areas of knowledge such as mathematics and computer sciences, and integrates content from biology, geology, chemistry, archaeology, genetics and ecology (Ayala, 2008; Futuyma, 1995, 2005; Lever, 2002; Tidon & Lewontin, 2004).

Apart from its importance in biology, understanding the concept of evolution also provides access to a way of thinking that can be applied where several lines of evidence are considered

in order to reach a verdict, such as in the criminal justice system (Dempster & Hugo, 2006). Furthermore, its unifying framework has the potential to synthesize the social sciences (Mesoudi *et al*., 2004), as in understanding the evolution of human culture. Therefore, because of its unifying nature and far-reaching social and economic benefits, strengthening evolution curricula in schools will strengthen teaching of the sciences in general and the understanding of other disciplines outside science (Antolin & Herbers, 2001). The requirement here is that the central nature of evolution should be reflected in all levels of evolution education, from curriculum design to classroom teaching.

3.5.3 The conflict between evolution and religion

Despite the global acknowledgement of the importance of the concept of evolution and its centrality in biological sciences, there are people who still have doubts concerning its validity, with some being merely sceptical while others oppose it altogether. Ayala (2008, p. 4) points out that some people might be sceptical that a natural process could account for the astonishing diversity of the living world and the marvellous adaptations of organisms to their ways of life, with people of faith wondering whether accepting evolution is compatible with their beliefs. The theories about biological evolution are therefore sometimes regarded as being in conflict with the theory of creation, a religious belief that all life forms were created in their present form by a superior being. More often than not, the conflict arises over the origin and evolution of humans, as shown in research (Clores & Limjap, 2006). Undoubtedly, as noted by Anderson (2007, p. 669), because of its philosophical dimension evolution interfaces with religion and other forms of knowing, generating questions about how scientific methodologies relate to other probable ways of knowing within one's personal worldview. Most often these other ways of knowing include religion, or reference to a superior power responsible for the origin and sustenance of life on Earth. Even though it is not ideal for religion to be included in science curricula because of a commitment to teaching the nature of science, it is not uncommon for evolution classes to include issues of religion.

The people who reject evolution are mainly religious fundamentalists who feel that evolution is in conflict with creation theories as given in the scriptures. Some fundamentalists hold to "a Protestant view that stresses the inerrancy of Bible" (Athanasiou, Katakos, & Papadopoulou, 2012, p. 240). Scott (1997, p. 264) identifies the Biblical-literalist Christians, ultraconservatives, Jews and Koranic-literalist Muslims as those who object to evolution in the United States. Those who believe this can be found among students as well as among the

general populace. Creationists hold that God created the various sorts of life, but not all creationists take biblical accounts literally, and not all are opposed to evolution.

Convictions about evolution and evolutionary thinking can sometimes be construed as 'evolutionism'. Thus religious opposition to evolution propels anti-evolutionism (Scott, 1997, p. 264), and this rejection of evolution is usually associated with the acceptance of literal scriptural descriptions of creation.

3.5.3.1 Evolutionism and creationism

A lot has been written on both evolutionism and creationism; for example, by Angus M. Gunn (2004); Brian J. Alters (1999), Eugene C. Scott (1997, 2000), John Staver (2010), Michael J. Reiss (2008), Philip, E. Devine (1996), Randy Moore (1998; 2008), and Wolff-Michael Roth (2010). Creationism has given rise to 'creation science', as reflected in the work of authors like Henry Morris and John C. Whicomb, who in 1963 published '*The Genesis Flood*'. This book outlined a scientific rationale for Young-Earth Creationism (see below) and led to the argument that evolution was not only religiously objectionable but also scientifically flawed (Scott, 1997). However, it is not all creationists who accept the literal translation of the scriptures.

(a) Different levels of creationism

Generally speaking, 'creationism' refers to the idea that a supernatural entity created the universe and humankind (Scott, 1997, p. 266), as well as all other organisms. Creationism exists in a number of versions in different places and contexts, from the general view that 'God created', to the specifics of exactly what, how, and when God did the creating (Scott, 1997, p. 266). Scott (1997, 2000) also gives an elaborate categorization of 'creationisms' in her description of the creation/evolution continuum. She also distinguishes between special creationism and deism as the poles of Christian theology explaining creation. Whereas 'Special Creationism' is a view that God created the universe and all that is in it, including humans, 'Deism', on the other hand, is the theological view that God set in motion the laws of nature and 'sat back' thereafter. Thus, Deists envision a far less 'hands-on' God than do Special Creationists, which is a major difference and source of conflict between the two theologies (Scott, 1997, p. 266).

Brian Alters (1999) distinguishes different types of rejection of the concept of evolution, where both religious and non-religious rationales are influential. The religious group from

which most of the resistance comes is associated with the Evangelical Christianity. The fundamentalist and evangelical churches, according to Spuhler (1985, p. 105), are a diverse group of theologically-conservative Protestant churches with origins in the millenarianism of the 19th century. Evangelical Christianity holds that the Bible is an inerrant authority (Alters, 1999). Furthermore, the fundamentalists stress a complete and often verbal inspiration from the Bible, accepting its full and final authority over their religious faith and practice (Spuhler, 1985). Spuhler (1985) further states that, generally, "fundamentalists of the 1920s claimed to defend the standards of orthodox Christianity against the liberals and modernists who accepted 19th century and early 20th century biblical criticism and wished to make the activities of the church more relevant to contemporary social problems" (in Alters, 1999, p. 106). In his review of research on evolution education, Smith (2010b) comes up with two common arguments against evolution put forward by anti-evolutionists and the proponents of 'intelligent design': (1) that a random process could never result in complex processes, species or organs – such as the blood-clotting cascade, a flagellum, or the human eye; and (2) that evolution alone cannot produce living things of increasing complexity over time.

The *literalists* are those who believe that the Genesis, as well as most other parts of the Bible, should be interpreted literally (Alters, 1999). The literalists believe that the Bible is a simple historical record and accept at face value that each of the days of the Genesis creation account is a natural solar 24-hour day, hence the Earth and all living things were created in 6 days. Most also accept the chronological record of the Bible where years are mentioned, contending that the age of the universe is 4,000-10,000 years old (*ibid.*, p. 104). These are the Young-Earth Creationists (YEC) who reject modern physics, chemistry and geology concerning the age of the earth, and deny biological descent with modification (Scott, 1997). Young-Earth Creationism (YEC) is an extreme form of creationism, which interprets the scriptural accounts of creation literally, even when they may contain inconsistencies and contradictions. Examples of such scriptural accounts are in the Book of Genesis of the Old Testament of the Christian Bible as well as in the flat-earth and geocentric passages. YEC insists that the earth is only thousands rather than billions of years old (Gunn, 2004, p. 180). Showing the age of the earth to be this young is a way to refute scientific claims made on the age of the earth, and to use this as evidence that the earth is too young for evolution to have been responsible for origin of life. Needless to say, this strict literalist view is not universal among the majority of Christians (Sanders, 2010; Scott, 1997; 2000) or of creationists in general.

Rejection of the concept of biological evolution, therefore, is not always from fundamental-literalist concerns (Alters, 1999). For instance, the *progressives* have more widespread beliefs and share the common view that the Earth is much older than the literalists contend it to be. They are therefore referred to as Old-Earth Creationists (Scott, 1997, 2000). Alters (1999) identifies three progressive literalist camps:

- First is the *Gap Theory* camp, which views life on Earth as supernaturally created as recounted in Genesis 1:1. According to this gap theory, which allows for some of the inconsistencies and contradictions in the scriptures, creation is followed by a gap in history when life became extinct and the new life was created as described in Genesis 1:2, accounting for the supernatural creation of Adam and Eve. Unlike the YEC views, this view allows for the great age of the Earth and fossils.

- Secondly, Alters (1999) identifies the camp that has the view "that each day of creation listed in Genesis should be interpreted to be indeterminately long periods of time, possibly millions or billions of years, equating somewhat to the ages of geology" (Alters, 1999, p. 104). This view is termed Day-Age theory (Scott, 1997, 2000). It was during these various long days that living forms were introduced through supernatural creation, while no microevolution took place.

- Thirdly, there is the camp that is commonly called Progressive *Creationists*, with a view that allows for limited evolution. Progressive creationists believe that occasional interventions occurred in which new kinds of organisms like horses and humans were created. This provides for "a theological explanation for gaps in the fossil record – a supernatural punctuated evolution" (Alters, 1999, p. 104).

In addition, Borczyk (2010) mentions the devolutionists and the intelligent design (ID) creationists. The former state that a reduction in genetic diversity is being documented, a view in direct opposotion to the YEC argument against evolution accounting for the diversity of life (Borczyk, 2010).

Another group of creationists described by Alters (1999) is formed by *Theists*. According to Alters, theists believe in the universe being very old, that the days in Genesis are indeterminately long, that evolution occurred but there were no interventions of special creation. They believe that nature is orderly because God created it, and this order, as discovered by scientists, can be testimony to the Creator (Devine, 1996). This is very close to

the views held by ID theorists. Theists also "contend that evolution did not occur to create new organisms including humans without supernatural intervention along the way" (Alters, 1999, p. 105).

The two views held by the theists differ in their view of the level of randomness involved in evolution. One group, the *Theistic Evolutionists*, contends that there is minimum or no randomness, while the other group, *Evolutionary Theists*, believes in authentic randomness, the random element responsible for creation of humans. Theistic evolutionism allows for some evolution to have occurred. It is a view that "God created but relied more on the laws of nature to bring about His purpose" (Scott, 1997, p. 271). Devine (1996), arguing for theistic evolutionism, maintains that it is a genuine alternative in debates about science education and the public role of religion. He argues that the statement that 'God created all things', however true, does not amount to a scientific theory (Devine, 1996, p. 332). Like other people who endorse theistic evolutionism, Devine argues that Darwinian theories are incomplete and that theists are entitled to point out their incompleteness. According to Devine, while it is known that evolution at least sometimes occurs, and consequently that some species are descended from others, there is nothing like a complete story of the origin of species and the descent of man (Devine, 1996, p. 336). As he himself puts it, his argument is a compatibilist thesis which has desirable scientific and social implications. To Devine, theistic evolutionism is scientifically desirable, as it enforces a policy of intellectual modesty and a willingness to revise existing paradigms, and is also socially desirable, as rejecting cultural, moral and religious traditions on Darwinist grounds can only lead to disaster (Devine, 1996, p. 337).

Rejection of evolution, however, is not always on religious grounds; it sometimes appears to be 'non-partisan' (Alters, 1999). As observed in the United States and some European countries, the evolution/creation debates alongside science/religion debates have also been influenced by politics. For instance, the isolation of Eastern Bloc countries in Europe after World War II cut them off from the Western world and prevented them from importing the idea of creationism (Borczyk, 2010). Borczyk (2010) shows that, in Poland, science (including evolution) was then used as a political tool, and solid science education served as part of the ideological struggle against the capitalist (Western) world. But Borczyk (2010) further states that with the political landscape transforming such as in opening door for church to enter schools and allowing the free flow of ideas, the number of creationists has grown after 1990. Furthermore, misunderstandings about the content and process of science

account for the rejection of evolution "and are usually some of the issues brought up at publicly-held evolution/creation debates" (Alters, 1999, p. 106), including the political debates, resulting in decisions based on false or misunderstood ideas. In South Africa, similar debates, which happened mostly among theologians and influenced political decisions and ideologies in the past, were at some point strongly linked to the debates in Europe (see Chapter 2).

(b) Levels within evolutionism

Evolutionism is characterized by the acceptance of biological evolution as a valid scientific theory. However, levels of acceptance differ, from those who accept it completely – that is, evolutionists – to those who accept some parts of it – the *theistic evolutionists* discussed in Section 3.5.3.1 (a) above.

As already stated, one extreme of evolutionism consists of people who accept evolution completely (Alters, 1999). This group includes naturalists who do not subscribe to any religious views (Scott, 2000). These people, sometimes called *materialists*, do not believe a superior power was involved in the origin of the Earth and its living organisms. According to them, matter is all that exists. However, it is worth noting that there are some who accept evolution and hold strong religious beliefs, hence evolutionism cannot be equated with atheism, or a state of not believing in the existence of God. As discussed earlier when considering the relationship between religion and science, not all people want to dwell on the conflict between creationism and evolutionism. Some suggest, as does Odora-Hoppers (2002), that we should look beyond the tension between evolutionism and creationism and reconstruct a future which may result in a new whole greater than the sum of its parts, referring to the sum of creationism and evolutionism, including their own parts.

3.5.4 Challenges facing evolution education

Although there is general agreement among the scientific and science education communities about the importance of evolution, evolution education has been faced with challenges worldwide. Some of the challenges are presented in the following sections. It should be noted that the challenges influence one another, and the order in which they are presented does not represent any hierarchy.

3.5.4.1 Coverage of evolution in curricula and classrooms

There have been concerns that the quality and quantity of the coverage of evolution in education were not satisfactory (Tatina, 1989; Tidon & Lewontin, 2004). For instance, evolutionary theory does not receive appropriate emphasis in the high (secondary) school biology (Rutledge & Mitchell, 2002) – as reflected in the insufficient coverage in curriculum documents as well as in classroom teaching. Its teaching has been found to be insufficient in many places (Chuang, 2003; Moore, 1998; Rutledge & Warden, 2000), by being cursory, absent, or fraught with misinformation (Moore, 2002; Rutledge & Mitchell, 2002). Because of the rejection of the very concept of biological evolution, teaching evolution was a crime in some American states (Berkman, Pacheco & Plutzer, 2008). Yet, even in places where teachers were not legally forbidden to teach it, some still avoided it altogether or devoted only a little time to it, despite their belief in its dominating role (Berkman *et al.*, 2008). What all these indicate is that evolution is not 'treated fairly' in education. By fair treatment we mean that evolution is not accorded the status it enjoys as a central and unifying theme in the biological sciences. The main implication of this is insufficient coverage or cursory treatment in its teaching, whereby evolution is either avoided or only mentioned briefly (Moore, 1998; Rutledge & Mitchell, 2002; Rutledge & Warden, 2000), and proper coverage of Life Sciences suffers accordingly. For Life Sciences to be properly understood, evolution should be given a fair amount of time to enable sufficient teaching in schools.

Some curricular programmes put both evolution and creation side-by-side, while some stick to evolution only. In the South African curriculum, creation has been mentioned in the curriculu, perhaps as an attempt to expose learners to varying worldviews. There are arguments that creationism is not a science, and that evolution is best understood and accepted if the nature of science is also understood. The inclusion of creationism on an equal footing might therefore distort this notion and affect the understanding of evolution. According to Astley and Francis (2010), ignorance of the nature of science often finds expression in an illegitimate expansion of the naturalistic methodological assumptions of science beyond their proper territory, a development that can easily tempt students *and teachers* [my emphasis] to adopt the ideology or metaphysics of scientism.

Besides too little attention being given to evolution in curricular documents, other factors resulting in insufficient coverage of evolution include teachers' knowledge, attitudes and beliefs, and learner beliefs. For instance, Findley *et al*. (2001) found that cultural beliefs and

understanding regarding science that students bring into the classroom may render science instruction [including evolution] less effective in rural places than anywhere else. Such cultural beliefs respond to questions about the origin and purpose of life. But not all people who believe in God deny evolution; there are many who believe in both evolution and creation and who do not see any conflict between the two. Should a class on evolution also teach creationism as an alternative explanation? Or should evolution remain in the science classroom while creationism can find its place somewhere else? These are some of the questions that heighten for some people the controversy concerning the teaching of evolution.

What remains as the main challenge to evolution education is therefore the paucity of attention given to it in curricular documents and in the classrooms. In order to correct this, curricula have to reflect the centrality of evolution, and teachers have to be aware of that and should be equipped with the skills to teach evolution in such a way as to reveal its centrality. This is something that teachers should learn from their own education, as the centrality should actually be integral to evolution education at all levels of education.

Some have blamed the deficiencies on the lack of understanding of the nature of science. Also, evolution is sometimes regarded as controversial because of the strong opposition it receives and the strong debates which usually take place around it. Some of these factors are discussed in the next sections.

3.5.4.2 Evolution as a controversial issue

Evolution is described as a controversial issue because of the strong rejection it receives from some people. Controversial issues in science can be described as those areas of science where the data itself and its collection, the empirical evidence or the ethics of the experiment are open to various interpretations and viewpoints (van Rooy, 1993). In the case of evolution theory, however, the controversy relates more closely to cultural influences on science than to the influence of scientific experimentation (Aikenhead, 1997). This explains why most scientists who understand how science should work and who generate knowledge are not opposed to the teaching of evolution. It is for this reason that Lever (2002, p. 13) can contend that evolution still stands stubbornly uncontroverted.

However, the controversy has been noted in places like Egypt (Mansour, 2008b), Holland (Schilders, Sloep, Peled, & Boersma, 2009), Lebanon (Dagher & BouJaoude, 2005), Poland (Borczyk, 2010); South Africa (Sanders, 2010; Sanders & Ngxola, 2009), the United States

of America (Fowler & Meisels, 2010; Hermann, 2008; Moore, 1998; Osif, 1997; Rutledge & Warden, 2000; Scott & Branch, 2003) and Turkey (Deniz *et al*., 2008), sometimes leading to its widespread rejection a serious concern for the public (Lombrozo *et al.*, 2008, p. 290). As already mentioned, evolution is commonly cited as an example of an area of conflict between science and religion (see Mansour, 2010, p. 296), using the evolutionism vs creationism debate. Because of the percieved controversy, some, the religious fundamentalists, do not accept evolution as supported by valid scientific theory.

The lacklustre treatment that evolution sometimes receives in education may not therefore be a surprise, considering the controversy that surrounds evolutionary theory. The opposition to evolution has propelled anti-evolutionism, resulting in evolution being excluded from the curriculum in some schools in the United States (Hermann, 2008; Moore, 1998; Osif, 1997; and Scott & Branch, 2003), supported by law. As a consequence of such laws, in a famous case in 1925, John T. Scopes was tried in the state of Tennessee for violating a law that barred the teaching of evolution. Scopes's conviction was seen as a victory against evolution by fundamentalists (Moore, 1998) at the time. The decisions made in this trial have been reversed by later trials.

In these places, it should be noted, it is the fundamentalist religious groups and not scientists who require the removal of evolution from the curriculum and/or the inclusion of 'creation science' and/or intelligent design (Moore, 1998; 2000; Moore & Cotner, 2009; Scott & Branch, 2003; Tidon & Lewontin, 2004). Most biologists regard 'creation science' as bad science, or no science at all. In South Africa, such religious debates of the late 19th century and early 20th century influenced the re-awakening of the Christian National Education, which would resist or refute the teaching of evolution. As Lever (2002, p. 34) relates, the South African government at the time believed "that the spirit and direction in every subject taught was to correspond to the Christian and National life – and worldview – and in no way was any subject to convey 'anti-Christian' or 'unChristian' propaganda, and this included evolution education".

It would seem that this controversy revolves around the type of knowledge conveyed through the concept of evolution and the conflicts this knowledge might have with other, perhaps more subjective, ways of knowing. These other ways of knowing may be entrenched in the cultures of the people, or in religion, or any other value system that people might have. It is mostly through trying to justify or to disallow teaching about evolution in school curricula

that the controversy has arisen. According to Nickels, Nelson and Beard (1996), while there is no idea more central to modern biology, there is in the popular mind no topic more controversial in all of science.

Against the background of this debate, some people have attempted to justify the inclusion of evolution in schools. However, questions such as who should learn evolution, what should be learned about evolution, when, why and how it should be taught and learned, not to mention legal issues associated with teaching what is controversial, all these often come not only from students, parents and school administrators, but also from science teachers (Moore *et al.*, 2003, p. 766). For instance, Alles and Stevenson (2003, p. 333) answer the question of 'why teach human evolution' by stating that studying 'human' evolution is important in telling us about our origins, providing information necessary for self-knowledge. They state that scientific answers to questions about our origins are now available and can therefore replace the earlier stories given which were unique to one's culture of birth. This answer is provided from a scientific perspective, however, so while it can be convincing to some, it is what usually evokes antagonism and rejection from those people who reject the very notion of science because they are religious fundamentalists and believe in divine creation.

Smith (2010b) responds to a similar question by referring first to arguments in favour of education about the nature of science by Driver, Leach, Millar and Scott (1996), which are: (1) economic – for production of scientists who produce knowledge that can be translated into technological advance and prosperity, (2) utilitarian – understanding of the scientific aspects of objects and processes encountered in everyday life so as to manage them effectively and responsibly, (3) democratic – provision of an educated public that can make well-reasoned decisions when questions relate to science, (4) cultural – appreciation of the nature of and extent to which science impacts our daily lives and culture, and (5) moral grounds – practicing science in ways that are consistent with ethical and moral norms and values in order to function. Smith adds a sixth, referring specifically to evolution: "that a working understanding of evolution is simply part of science literacy that is expected of the modern high (secondary) school graduate" (p. 544). From a teacher's specific perspective, Eldredge (2009, p. 344) points out that evolution has generated good science and theories that can be used to make testable predictions to solve problems of the natural world. This could well be a summary of Smith's points, as it touches on all of them.

It is in responding to such questions that divergent viewpoints arise. These viewpoints are usually informed by varying factors, which include people's epistemological and ontological underpinnings. Although Smith's and Eldredge's responses are given from a scientific point of view, they revolve mainly around the nature of science, which in some ways removes attention from what could have a metaphysical connotation, to a pedagogical stance. Most writers acknowledge the conflict that exists between evolution and creation, pushing for evolutionism on the one hand or for creationism on the other hand. Some, therefore, holding the view that evolution and creation are so disparate that they cannot co-exist in class, support the teaching in biology classes of only evolution and others of only creation, while there are others who see no conflict at all and support the teaching of both creation and evolution together. For example, Michael J. Reiss is a British science educator who advocates the teaching of both. On the other side are Angus Gunn, Karen Kraemer and Randy Moore and others, some of whom would emphasize evolution as the foundation of biology, but do not regard creationism as a science and therefore not to be admitted to the biology classroom (Gunn, 2004; Moore & Kraemer, 2005).

3.5.4.3 Rejection of evolution on account of perceived irrelevance

While among practising scientists there is general acceptance of the importance of evolution to the science community, the concept is rejected by far too many college students, high (secondary) school Biology teachers, and adults, resulting in a conflict between scientific importance and public resistance (Nickels *et al*., 1996). The question of relevance and importance is crucial, since a concept and/or theory may suffer cursory treatment in instruction simply because it might not be perceived to be 'relevant' to the learner. Relevance is, as recognised by Aikenhead (2006, p. 31), an ambiguous term. Also, the different role-players in education might view relevance differently, depending on their individual or corporate perspectives. For instance, a learner might perceive the usefulness of the concept at personal level, either in the present or for the future of that learner's life. Relevance, or perception of relevance, of a concept by teachers and learners may serve as a motivation for its teaching and learning. Learning, as considered in this study, applies to school and tertiary levels, with the former referring to school learners and the latter referring to teachers in pre-service and/or in-service programmes. For the learners, the perception of relevance or importance of a concept may relate to its perceived usefulness in their everyday life.

3.5.4.4 Rejection of evolution on account of beliefs

As has been discussed above at some length, evolution is not accepted by some people on account of their beliefs (see Hokayem & BouJaoude, 2008). People's religious beliefs, in particular, have been found to impede learning about evolution. The perception is that evolution contradicts creation, causing a conflict. So as not to repeat what has already been discussed, it is perhaps sufficient here to mention that learners and teachers with strongly entrenched religious beliefs, especially Young-Earth Creationists, find it hard to learn and accept evolution. This discord between religion and evolution, accompanied by lack of acceptance of evolution, has been a major source of the controversy around evolution, and a major cause of poor understanding about evolution.

3.5.4.5 Poor understandings and misconceptions about evolution

As also discussed in earlier sections, the rejection of evolution is due to a number of factors. In addition to people's entrenched religious beliefs, understanding has been found to be an equally significant factor. Biological evolution is by far one of the most misconceived and widely-debated scientific phenomena (Nadelson 2009). Some researchers have found the teaching of evolution to be complex at both secondary and college levels (Sinclair & Baldwin, 1996; Tatina, 1989). Lack of understanding of evolutionary concepts is widely reported for teachers (Sanders & Ngxola, 2009) and learners (Kagan & Sanders, 2012; Lawrence & Sanders, 2012), including tertiary students. This naturally makes the acceptance of evolutionary concepts difficult (Chinsamy & Plaganyi, 2007). Further, as suggested by Chinsamy and Plaganyi (2007), lack of understanding on the part of teachers is one of the problems resulting in a poor foundation in the knowledge of evolution among first year students. These authors propose that a concerted effort should be made to ensure that teachers are better informed about evolution.

This lack of basic understanding of the biology underlying evolutionary theory is due to many public-derived and teacher-propagated misconceptions to be found among learners (Chuang, 2003; Nadelson, 2009). Chuang (2003) pinpoints a lack of awareness about the evidence for evolution based on the notion that evolution is 'only a theory', and the widespread misconception that evolutionary theory states that humans are descended from monkeys (Clores & Limjap, 2006) as some of the factors contributing to this lack of understanding (Chuang, 2003, p. 673). Nadelson (2009) suggests that what contributes mostly to the misconceptions is the view that the process of evolution is deterministic – that

is, organisms aspire to become more efficient and improved. Furthermore, sources of misconceptions develop from factors such as the fallacious understanding of the operation of chance (Nadelson, 2009), lack of understanding of the nature of science, and attitudes towards it (Kagan & Sanders, 2012).

Understanding evolution is, however, influenced by many factors. Moore *et al*. (2002) attribute the metaphors of everyday knowledge, where in everyday usage words have a certain meaning, to the difficulty experienced in the grasping of complex, abstract, and counter-intuitive theories like evolution. For instance, evolutionary theory is often misrepresented as 'just a theory' with no 'hard evidence' (Chuang, 2003; Dagher & BouJaoude, 2005). Yet, in scientific usage, the term 'theory' refers to "rigorously established and strongly supported ideas about, and the description of, real world data that were obtained through observation, experimentation and analysis (Gunn, 2004, p. 9). Misunderstanding could come about because the common daily use of the term 'theory' usually refers to ideas, conjectures, anticipated outcomes or unsubstantiated knowledge claims (Nadelson, 2009, p. 491). Gould (1981) states that in American vernacular, 'theory' often means 'imperfect fact' – part of a hierarchy of downward confidence running 'from fact to theory to hypothesis to guess'. It is therefore common for people incorrectly to apply the everyday use of *theory* so as to misconstrue *evolutionary theory* as a tentative prediction lacking reliability (Nadelson, 2009, p. 491). This of course indicates that the issue is one of language, where varying perceptions of what 'theory' means will influence how one understands the use of the term in a scientific context, particularly that of evolution. The extent to which one has been exposed to the use of the term in scientific settings can also be a factor. For instance, as agreed by most scientists, evolution is a valid scientific 'theory' or body of theories, it is not just a 'guess' as it may appear in common conversation, but it is comprised of a set of well-tested hypotheses that are highly consistent with evidence found in the natural world (Chuang, 2003, p. 673). As pointed out by Sinatra, Southerland, McConaughy and Demastes (2003, p. 514), natural scientists, in contrast to laypersons, "use the term theory to describe a relatively robust and dependable explanation of a phenomenon, and understand theories to be essential components of scientific knowledge".

Some studies have found that even the abounding evidence for evolution is misunderstood. For instance, students in a study by Dagher and BouJaoude (2005) found the theory of evolution to be missing the hard evidence they usually expect of credible scientific theories.

These students expressed the view that scientific theories are supported by evidence. The problem faced by these students, and many others who express similar views, is "not one of acknowledging the need for evidence as much as one of understanding and evaluating the nature of that evidence and what makes it valid in the context of evolutionary theory" (Dagher & BouJaoude, 2005, p. 388). Using a framework of 'nature of evidence for evolutionary theory' which distinguishes three types of evidence, *circumstantial*, *direct* and *historical*, Dagher and BouJaoude (2005, p. 388) found that the students showed "a misunderstanding of the nature of evidences and how they relate to one another". They further found that the students seemed to want to subject the historical evidence to 'tests' appropriate for direct evidence (*ibid.*). These researchers thus inferred that the students' reference point captured one or more elements from a simplistic and generic model of theories in physical science. This generic model is "a set of abstracted qualities, or overgeneralized characteristics of theories, that the students used to describe evolutionary theory" (p. 386). The authors also inferred that these students could be using this generic model to evaluate evolutionary evidence. They warn against the "cost of cultivating a generic understanding of science, as it leads to false conclusions and compromises students' understanding of science as well as the plurality of scientific methods and understandings" (Dagher & BouJaoude, 2005, p. 389).

The understanding of evolution is not only significant for achievement in tests and examinations, this understanding is also necessary to the acceptance of evolutionary theory. Also insufficient understanding causes conflicts with one's beliefs, particularly if they are creationist beliefs (Hokayem & BouJaoude, 2008), especially if those beliefs are entrenched. Chuang (2003) suggests this lack of basic understanding of the biology underlying evolutionary theory is, to a large extent, the source of many public-derived and teacher-propagated student misconceptions (p. 673), citing Hemenway (1999) and Lord and Marino (1993). Ingram and Nelson (2006) distinguish between acceptance and understanding of evolution, by relating acceptance with attitude, showing, like others (e.g. Tatina, 1989), that neither understanding nor attitude was a prerequisite or a necessary condition of the other (Ingram & Nelson, 2006, p. 10). This implies that attitude can lead to acceptance or to rejection, just as much as acceptance can lead to a positive attitude about evolution. Further, as also noted by Smith (2010a), Ingram and Nelson (2006) recognize that understanding evolution can be the first step towards accepting the validity and utility of evolution.

Furthermore, the unifying and integrative role evolution plays is progressively transforming it into a 'complex and interactive science', and to understand it deeply requires knowledge from different areas of Biology as well as Geology, Mathematics, Philosophy, among other disciplines (Tidon & Lewontin, 2004). Such knowledge is often not accessible to many specialized professionals, including teachers who are involved with its transmission (Tidon & Lewontin, 2004, p. 124). Therefore, teaching evolution requires highly specialized teachers who have a deep understanding of evolution and its powerful role in the field of biology so that they are able to put the pieces of curriculum together as a coherent whole, whereby evolution clearly emerges as a dominating principle (Dempster & Hugo, 2006).

Teachers must also be cognizant of how knowledge is generated in the sciences, and the nature of science as a way of knowing (Rutledge & Mitchell, 2002) in order to be able to make appropriate pedagogical choices to communicate this unifying role of evolution. To have a pool of such teachers remains a challenge to science education and teacher education programmes. Besides this, Hokayem and BouJaoude (2008) question the wisdom of including the nature of science in teaching when empirical studies have not settled the issue of how to teach it and at which developmental level. Despite this, teachers are faced with the demanding task of crafting a learning environment that mediates colliding agendas (Meadows, Doster & Jackson, 2000, p. 102), some of which arise out of competing educational goals.

One of the factors putting biology teachers in a difficult position is the discrepancy between the scientific and social importance of evolution and its outright rejection by some students (Schilders *et al.*, 2009). The importance of evolution extends beyond the classroom into technology and other fields – but the public, including teachers, may not be aware of this, and only relate evolution to dinosaurs and fossils (Futuyma, 1995). For the public, their lack of awareness of evolution's worth is what makes it easy for people to reject it. However, in the case of teachers, lacking this insight would affect their teaching. Consequently, curriculum programmes not emphasizing the need for considering evolution in biology might give the message to students that evolution is not very important to biology (Chuang, 2003).

With teachers, the importance of learning to teach a concept may relate to their perception about the importance of the concept, not only to themeselves but to the learners as well. For instance, Nadelson and Nadelson (2010) found that the K-8 teachers in their study, who had received instruction at a Master's level, still perceived evolution not to be relevant to the K-8

science curriculum. Such a perception can lead to resistance to the learning or teaching of evolution. Alternatively, some may apply *Fatima's rules* during learning, which can enable them successfully to complete their learning, without necessarily accepting it. And because of the entrenched negative perception such teachers hold about the concept, they may not be able to teach it later. As teachers show resistance to learning about teaching evolution, efforts to prepare them for the role are thus impeded.

Some studies have found correlations among the understanding of evolution, understanding the nature of science, and acceptance of evolution (Cavallo & McCall, 2008; Lombrozo *et al.*, 2008; Nickels *et al*., 1996; Rutledge & Warden, 2000; Schilders *et al.*, 2009). For this reason, lack of understanding of the nature of science has been suggested as one of the factors contributing to the problems in evolution education. Understanding the nature of science is important if one has to appreciate the difference between knowledge acquired in a scientific context and knowledge acquired in a daily-life context (Schilders *et al.*, 2009, p. 120), including how theoretical perspectives are developed, tested, and used for explanatory and predictive purposes (Anderson, 2007, p. 675). It is assumed that learners will need and later use the understanding and the skills acquired to develop new scientific insights and paradigms, such as appreciating concepts like evolution better.

3.5.5 Implications of challenges of evolution education for teaching and learning

The educational context in which evolution is taught at secondary and college levels is complex (Sinclair & Baldwin, 1996; Tatina, 1989) and challenging to both teachers and learners – as described above. Apart from the educational context being a multifaceted, complex and influential one, requiring the teaching to be understood in its social, intellectual and pedagogical milieu, the students also have varied personal epistemologies and underpinnings of reality – which is to say, varied worldviews (Anderson, 2007).

Teachers play a crucial role in determining the quality of instruction in the classroom (Rutledge & Mitchell, 2002) as, together with the learners, shape much of the discourse on science in the classroom (Volmink, 1998). As stated by Meadows *et al*., (2000) teachers from various religious and philosophical backgrounds face conflicts between their beliefs and the notion of biological evolution that range from simply thought-provoking to deeply disturbing. Therefore, teaching evolution is more often than not likely to evoke conflicts between

teachers' and learners' beliefs. While teachers themselves struggle with their personal beliefs about evolution and dilemmas about teaching evolution, learners' beliefs might agree or disagree with what is being taught. As teachers teach evolution, they want learners to understand what they are being taught. At the same time, teachers may be aware that evolution might clash with the learners' worldviews and/or beliefs, and equally would not want to undermine but to support the values of learners whose worldviews might oppose the teaching of evolution. Trying to change learners' personal worldviews is in fact dangerous and unethical (Meadows *et al*., 2000), and can amount to indoctrination (Smith, 2010a), of which teachers and educators may be wary. Rather, teaching should seek to integrate science with life experiences, and thus recognize alternative views as well as celebrate diversity of opinion (Fysh & Lucas, 1998, p. 425). Considering the dilemmas and potential challenges in the classroom, teachers have to make pedagogical decisions and choices that will foster learning without compromising curricular expectations. Teaching about evolution therefore poses a pedagogical predicament for teachers (Nickels *et al*. 1996), who have to provide meaningful instruction in evolution amidst potential conflicts, whether they themselves believe in it or not.

Conflicts about evolution teaching involve not only philosophical perspectives but also perceptions about the importance of evolution. The conflict between the scientific importance of evolution and public resistance (to evolution), according to Nickels *et al*. (1996, p. 332), "makes the effective teaching of evolution perhaps the single most important task in reforming the teaching of high school Biology". As argued by Pennock (2004), science teachers have a special responsibility to reveal not just the science of nature but also the nature of science, and Biology teachers have a special opportunity to do that when they teach evolution. With evolution being the cornerstone of the learning of Biology and high-order causation models (Dempster & Hugo, 2006; Rutledge & Mitchell, 2002), quality instruction in evolution is of paramount importance for the promotion of literacy in biological sciences. The role of teachers is therefore crucial in determining the quality of instruction (Rutledge & Mitchell, 2002), as they want their students to deepen their understanding of evolution in order to become scientifically literate (Meadows *et al*., 2000). The extent of learning or non-learning about the concept of evolution and its supporting theories can affect the development of critical inquiry skills in science. This can in turn impact on the aim of South African education: to develop scientifically literate citizens who are able to take part in important national debates and developments.

In case of cognitive conflicts, teachers need to use appropriate strategies to assist learners to resolve the conflict and understand biological evolution. Mansour (2010, p. 306) states that science teachers are much more likely to encounter questions that require them to determine whether or not such questions should best be answered using, among others, the methods of science, or politics, or religion, or a combination of these methods. He argues that, if teachers are able to make that assessment, they can decide on the relevant evidence applicable in their case. This requires teachers who are aware of various forms of knowledge as well as the worldviews that their learners hold.

Several approaches and strategies towards improved understanding have been suggested for the teaching of evolution. Some have suggested that the goal of teaching science should be the understanding of the nature of science (Smith & Scharmann, 1999) for the practice of scientific processes so as to improve learners' understanding of science as a discipline and as a dynamic body of knowledge.

Jensen and Finley (1997) suggest improving teaching and learning of evolution by promoting conceptual changes. They claimed to accomplish this by altering curriculum and instructional techniques, using an historically rich curriculum and a paired problem-solving instructional strategy. This was with the aim of developing an instruction that would change students' mixed bag of ideas into a more Darwinian form (p. 209) and improve students' understanding of evolution (Jensen & Finley, 1997, p. 211).

Suggestions to improve the quality of instruction about evolution are in some ways aimed at teachers. Suggestions to improve the teaching of evolution include targeting the preparation of teachers, to enhance prospective biology (Life Sciences) teachers' understanding of evolution and the nature of science (Rutledge & Mitchell, 2002, p. 26). Tidon and Lewontin (2004) suggest the continuous training of school teachers, revision and reinforcement of the curricula of sciences, Biology in particular, and (to improve content coverage) the analysis of textbooks used in secondary education. Further, they suggest recognizing and dealing with teachers' misconceptions so that they will be able to foster students' understanding. This should enable teachers to assess and correct students' errors and misconceptions regarding theories in general and evolution in particular. Teachers should be able to give learners opportunities to engage with and explore the abundant and available evidence about evolution, the processes involved in the investigation, as well as how the theories are arrived at and validated.

Scharmann and Harris (1991) used peer discussion in small groups, and they advocate use of student-student and student-teacher interactions. They argue that "teachers in rural districts, when confronted with challenges regarding curriculum and instruction considerations, especially confrontational issues, do not have the luxury of being able to conveniently discuss the issue with a science teacher peer" (Scharmann & Harris, 1991, p. 12). They suggest peer reinforcement for accurately portraying the nature of science and a variety of principles associated with evolutionary theory. This is a move away from exclusively teacher-centred towards student-centred and interactive instructional strategies, involving the history and philosophy of science with respect to the teaching of evolution.

A problem-solving strategy using a computer simulation was investigated by (Soderberg, Beloit & Price, 2003). They state (p. 36) that, "understanding of expert and novice cognition and behaviour during problem-solving sessions provides useful knowledge for assessing and improving student learning". They examined problem-based teaching and learning of population genetics and evolution, with the intention "to provide an example of best practice by documenting a lesson about microevolution using *EVOLVE*, a Macintosh software simulation" (Soderberg *et al*., 2003, p. 36). Stating that their study increased awareness of the possible misconceptions and naive conceptions that can be expressed by students when using *EVOLVE*, so that educators can prepare to encourage and support student ideas, they also add that this would increase opportunities to help students recognize problematic statements, beliefs, procedures and conclusions.

Another problem-solving strategy proposed by Brewer (1996), is problem-based teaching and learning, using a computer simulation developed by Soderberg *et al.* (2003). Brewer explored the use of the phylogenetic tree construction as a model-building activity and, at another level, as a form of model-using problem-solving. Desantis (2009) also describes a module that has the potential to improve science process skills through interdisciplinary content. This module builds student understanding without using the 'e-word' (evolution) in the lessons, so that students maintain open minds while they engage in the scientific processes used to study evolutionary biology (Desantis, 2009, p. 106). Later, when they are taught about evolutionary biology, they can make connections between their experiences and the module. Desantis included cladistics, a method of classification that provides students with the background knowledge required to reconstruct evolutionary changes over time (Desantis, 2009, p. 108) as in phylogenetics (see Catley, 2006 for a detailed explanation of cladistics). Catley (2006, p.

772) describes phylogenetics as a branch of biology that constructs and tests phylogenies, but does not necessarily require the discovery of new species. He contends that phylogenetic thinking is a "way of looking at the world" and a method of teaching children that can bring about an understanding of evolution as a whole, and not just of its parts.

Smith (2010a, p. 526) states that students should be provided with learning experiences that present them with ample opportunities both to understand the precepts of evolutionary theory and to consider the evidentiary basis for those claims. This is in line with a more general approach suggested by Moore (2002), that of improving the status of "evolution-related education" by emphasizing to students and teachers that evolution is the unifying concept in biology, and "that biology cannot be taught effectively without the inclusion of evolution …" (Moore, 2002, p. 380). For this to be achieved, teachers need to accept evolution as a unifying concept, and to possess sufficient pedagogical content knowledge about the concept so as to be able to teach it effectively. They should also be able to accept its validity as a scientific model so that they can provide students with the experiences that will foster that understanding.

3.6 BELIEFS OF TEACHERS AND LEARNERS ABOUT TEACHING AND LEARNING

People have diverse beliefs. And, as diverse as the beliefs of people are, so are the meanings of the term 'beliefs' and the contexts in which they are formed and operate. Often these beliefs become established as people come to accept something which they consider to be true. But beliefs may differ in terms of their degree of certainty, whereby some may form a strong conviction about something, or a mere opinion about something, even a surmise or suspicion (Encyclopaedia Britannica, 2008). This feature is one of the factors contributing to the diversity of beliefs, the diversity of which makes defining beliefs difficult. According to Pajares (1992, p. 307), the definitional problems, poor conceptualization, and differing understanding of belief structures contribute to the difficulty in studying teachers' beliefs.

Some definitions have been suggested, though, such as that given by the Encyclopaedia Britannica (2008), which defines belief as a "mental attitude of acceptance or assent toward a proposition with no full intellectual knowledge required to guarantee its truth". Beliefs can be an indication of faith (Cobern, 2000; Nespor, 1987). This can be faith in the usual sense, where faith means a belief in something not based on proof; or a conviction about someone or something – such as a religion, a political leader or a supreme being. Some beliefs are

adopted from culture, while others are shaped by experiences framed by culture (Mansour, 2008b, p. 1605). Beliefs are therefore usually context-bound, defining the experience, character and behaviour of people in particular contexts. Thus people will exhibit particular beliefs in different contexts. Since beliefs drive people into certain actions and because they are context-bound, they determine people's actions in specific situations. But, according to Nespor (1987), beliefs can be unbounded and applied readily to situations that may be unrelated to the context in which they were formed. Drawing from the given definitions, it can be recognized that beliefs in relation to evolution may be convictions about evolution, not necessarily based on proof, yet guaranteeing its truth or reality, and these beliefs may be context-bound or unbounded. Beliefs have been described as the best indicators of the decisions individuals make throughout their lives (Albion & Ertmer, 2002; Mansour, 2008a; Nespor, 1987; Pajares, 1992), since people's actions relate to what they believe. Beliefs about evolution may therefore relate to decisions to accept or not to accept evolution.

People will exhibit particular beliefs in different contexts. But because they occur inside people's heads, beliefs are unobservable. They cannot, therefore, be easily captured, but instead can be inferred from people's actions and behaviour. Such actions may take place as people take proactive measures or as they react to a particular occurrence. For instance, teachers will exhibit beliefs about teaching and learning in the way they teach, and such beliefs will further be contextualized as teachers deal with specific topics and for specific groups of learners. Their actions and behaviour regarding a certain topic, or a certain group of learners, will perhaps be an indication of their beliefs. These beliefs can include each teacher's own convictions regarding certain teaching practices and their effectiveness in bringing about meaningful learning outcomes, or they may be beliefs about the worth of the topic being taught – or simply about their learners and about themselves. This implies that teachers' beliefs will influence the decisions they make regarding how and/or what to teach. The resulting classroom action, based on what is being taught and how, is an individual and personal matter based on a teacher's beliefs and context, the context of which may include the teacher's perceptions about learners' perceived convictions. Learners will also behave and act in certain ways depending on what and how they are taught, perhaps even depending on who is teaching them.

The following sections will deal with the beliefs of teachers and learners regarding teaching and learning.

3.6.1 Beliefs of teachers about teaching and learning

Teachers' beliefs, like those of other people, are difficult to define because of differences in understanding, conceptualization and belief systems, a "messy construct" as indicated by Pajares (1992, p. 307). And, because teachers can follow similar practices for very different reasons, as shown by Kagan (1992), teacher beliefs cannot be directly inferred from their behaviour. This is further compounded by the fact that teachers' knowledge or beliefs about their craft is tacit and they are often unaware of their beliefs (Kagan, 1992, p. 68). Beliefs are therefore personal (Dewey, 1906; Snider & Roehl, 2007). Yet, as stated by Errington (2004, p. 40), central to a teacher's belief system are likely to be dispositions regarding teaching and learning. According to Richards (2000, p. 66), a teacher's beliefs form a structured set of principles that are derived from experience, from school practice, personality, education theory, reading, and other sources. Some refer to these beliefs as a form of personal knowledge (Kagan, 1992; Nespor, 1987), which according to Nespor, is more powerful than [subject matter] knowledge in influencing the way teachers teach. Teachers' beliefs can be embodied in, among others, their expectations regarding their learners' performance or in the teacher's theories about a particular subject area's learning and teaching approach (Fang, 1996). The beliefs of teachers can also be reinforced by their learners' expectations in classrooms (Albion & Ertmer, 2002), but may also differ significantly from learners' beliefs, leading to misperceptions about various dimensions of teaching (Richards, 2000). Teacher beliefs are, to say the least, complex.

Part of what makes it difficult to define teacher beliefs centres on determining if, and how they differ from knowledge (Ertmer, 2005, p. 28). But in some quarters, as shown by Pajares (1992), belief and understanding – or knowledge – have been used interchangeably as the distinction between them is elusive. Yet both beliefs and knowledge are constructs in their own right, and both do influence each other. According to the Encyclopaedia Britannica (2008), belief becomes knowledge only when the truth of a proposition becomes evident to the believer. Thus, belief in someone or something is different from belief that a proposition is true, where the latter indicates knowledge. This implies that beliefs are related to knowledge or understanding as well as to 'truth' about that knowledge. Clores and Limjap (2006, p. 66) distinguish between them in this manner: beliefs refer to suppositions, commitments and ideologies while knowledge refers to factual proposition and the understanding that informs skilful action. Therefore, unlike knowledge systems, beliefs do

not require validation (Snider & Roehl, 2007, p. 873). As stated by Ertmer (2005), after gaining knowledge of a proposition, one is still free to accept it as being either true or false. In other words, one can have knowledge about something, without necessarily believing that it is true. As knowledge, one can falsify or validate it, perhaps even leading to a stronger conviction and belief in it or otherwise outright rejection. On the other hand, one may not falsify or validate a belief.

As an example, a teacher might understand a theory – such as that underpinning the concept of evolution and the evidence provided in support of the theory – but may fail to accept the truthfulness of evolution or its validity. Beliefs are therefore based on judgment and evaluation, whereas knowledge and facts represent objective and verifiable phenomena (see Snider & Roehl, 2007). Beliefs may be guided by knowledge which, for teachers, could be acquired through education and training. But beliefs are components of knowledge, and both arise from one's experience (Alexander & Dochy, 1995). Beliefs create a teacher's professional expertise, and as teachers progress in their teaching profession, they acquire beliefs and habits through experience and reflection.

Another characteristic of beliefs critical to teaching and learning is that they are relatively stable and resistant to change (Kagan, 1992; Raths, 2001), particularly those beliefs central to one's disposition. These beliefs may arise from some or all of the following: upbringing, reflection on one's life experiences, and/or socialisation processes in schools (Raths, 2001) and communities. Teachers, therefore, start their formal teaching career with beliefs already ingrained, formed throughout their childhood and student years. Some of the deep-rooted beliefs remain resistant throughout their teacher education and teaching career and may hinder learning of new teaching practices. For this reason, Raths (2001) suggests changing some of the beliefs of teachers and student teachers early in their teaching programme to optimize the learning of new practices. Further, a change in their belief systems might assist teachers when addressing their learners' learning problems.

While the change of teacher beliefs seems desirable so as to enable teachers to learn and to adapt to changes in the classroom environment, there are implications associated with the changing of beliefs. These implications include technical problems, theoretical problems and ethical problems. Furthermore, the task of changing beliefs is complex and possibly hopeless. Raths (2001, p. 8) suggests that, instead of conceptualizing the problem as one of beliefs, teacher educationists could see the problem as one of dispositions, a summary of actions

observed. This is in contrast to beliefs, which cannot be observed. Therefore, Raths argues, dispositions already existing in student teachers can be strengthened. Nevertheless, as indicated by Nespor (1987), a change of beliefs is not a matter of completely abandoning beliefs, but gradually replacing them with more relevant ones. The implications here are that those 'relevant' beliefs need to be known by the designers of teacher education programmes. Alternatively, following Raths's (2001) suggestion will require that the relevant dispositions are selected and addressed. Considering that beliefs (and propositions) are context-bound, such measures would need to be context-related.

As difficult as it might be to define teacher beliefs, Pajares (1992) has suggested making a distinction between teachers' broader, general beliefs systems and their educational beliefs. The educational beliefs are those which will inform the decisions teachers make and are usually beliefs about the nature of knowledge and learning, or epistemological beliefs, and beliefs about the practice of teaching and learning, or pedagogical beliefs. In the next sections, teacher educational beliefs are categorized in relation to specific teacher roles. The categories relate to (i) the nature of knowledge – *epistemological beliefs*, (ii) beliefs about teaching and learning – *pedagogical beliefs*, in addition to (iii) perceptions of self and self-worth – *self-efficacy beliefs*, and (iv) beliefs relating specifically to the content – *content-specific beliefs*. These four belief categories are further described in the next sections, 3.6.1.1 to 3.6.1.3. This will be followed by a discussion of learners' beliefs, as well as religious beliefs and how they influence science and evolution education.

3.6.1.1 Beliefs of teachers about knowledge and knowing

Epistemology is the branch of philosophy that deals with the origin, nature and limits of human knowledge (Johnson, 2009). Two opposing perspectives; objectivism and subjectivism, have been used to discuss epistemology. An objectivist perspective holds that knowledge is absolute, separate from the knower, corresponding to a knowable, external reality. Subjectivism, on the other hand, holds that knowledge is not separate from the knower. Rather, knowledge is shaped by inner characteristics or structures of the mind, language and culture. Objectivism posits that the purpose of the human mind is to mirror objective reality via thought processes, while subjectivism holds that knowledge and reality do not have an objective or absolute value. Beliefs about the nature of knowledge and learning, or *epistemological beliefs* (Schommer-Aikins *et al.*, 2003, p. 347) can therefore be aligned with these two perspectives. Teachers' epistemological beliefs will determine how

teachers plan the instruction they give and what strategies they put in place. These beliefs have an influence on pedagogical beliefs, self-efficacy and content-specific beliefs, and are therefore vital for shaping the classroom discourse and to a certain extent influencing learning as well.

3.6.1.2 Beliefs of teachers about self and self-worth

The first set of beliefs, beliefs about self-worth or *self-efficacy*, refer to a teacher's generalised expectancy concerning the ability of teachers to influence student learning and growth, as well as the teacher's beliefs concerning his or her capacity to perform certain professional tasks (Kagan, 1992; Settlage *et al.*, 2009). Efficacy beliefs are the foundation of human agency (Bandura, 2001, p. 10). Thus, self-efficacy describes "beliefs in one's capabilities to organise and execute the courses of action required to produce given attainments" (p. 3). It describes the strength of a teacher's conviction in his or her ability to provide the 'inputs' necessary to influence learning, and perception that certain actions will contribute to particular outcomes (Settlage *et al*., 2009).

Self-efficacy implies that a teacher may for instance believe in the value of evolution as a unifying framework significant for the acquisition of literacy in biological sciences, yet may not teach it as such because of lacking confidence in his or her capacity to teach it amidst the conflicts. Among teacher behaviours positively related to self-efficacy is the accepting of student opinion and a tendency to praise rather than criticize (Kagan, 1992). Therefore Life Sciences teachers with high self-efficacy are expected to allow their learners to express their opinions about evolution and not criticize them for any alternative conceptions that they might have.

3.6.1.3 Content-specific beliefs of teachers

Kagan (1992) identifies another form of beliefs as those that are *content-specific*, that is, teachers' orientation to specific academic content. This form includes a teacher's epistemological conception of the field to be taught. Kagan further states that content-specific beliefs usually reflect the actual nature of the instruction the teacher provides to students, but may be mediated by epistemological differences inherent in respective content areas (*ibid*., p. 73). Beliefs may also relate to a teacher's philosophical predisposition about the content to be taught (see Hokayem & BouJaoude, 2008; Mansour, 2008a; Mansour, 2010), if the teachers accept or reject the content, or if they believe it should be taught to the learners. Therefore, a

Life Sciences teacher may have beliefs which are specific to evolution, and teach this topic differently to other topics. Also, the context in which evolution is being taught can dictate variation in instructional strategies to suit the specific demands placed on the teacher by the topic. Such strategies, including the actions of the teacher, will also relate to the teacher's perception of the validity of the content to be taught.

While there is strong evidence for consistency between teacher beliefs and practice, Fang (1996) and Pajares (1992) also point to inconsistencies occurring in classrooms, when teachers' abilities to attend to their beliefs and provide instruction aligned with their theoretical beliefs are constrained by the complexities of the classroom. Pajares suggests further that these inconsistencies illustrate the difficulties inherent in trying to measure beliefs, accounting for inferences made in trying to understand the beliefs. However, "regardless of the forms they take, a teacher's beliefs or philosophy can affect teaching and learning in one way or the other" (Fang, 1996, p. 50). Given that teacher beliefs inform their classroom decisions, actions and practice, it is critical that teacher education programmes understand these beliefs in order to inform the designs of such programmes.

3.6.2 Beliefs of learners regarding learning

That beliefs remain unchanged with teacher education is to be expected of learning in schools as well. Learners may also be resistant to learning about a concept like evolution because, depending on their belief systems, evolution might be seen as "less relevant, less important, subjective..." knowledge than other "relevant, essential and indisputable" forms of knowledge (Hedley & Markowitz, 2001, p. 197). This realization has prompted suggestions that the goal of science education should not be to change learners' beliefs but to promote knowledge and understanding (Cavallo *et al.*, 2008; Clores & Limjap, 2006; Smith & Siegel, 2004). Some have suggested the goal to be the nature of science (Smith & Scharmann, 1999) for the practice of the scientific processes, so as to change learners' understanding of science as a discipline and as a dynamic body of knowledge. These suggestions are based on the premise that learners may later use these understandings and skills to develop new scientific insights and thinking, appreciating concepts like evolution better.

Therefore, a question one may ask regarding science learning and what is tested at the end of learning, is whether it is about knowing or believing. Anderson (2007, p. 673-4) responds to the question of whether the big concern about what students come to know is the knowledge

content or what they come to believe about more philosophical matters. He states that the stance that belief is not an issue as long as learners know what it is they are learning and know how it works is the only one realistically possible. This stance seems to have been adopted by those who would advocate separating one's beliefs from what one is learning, hence keeping one's beliefs outside of the classroom.

3.6.3 Metaphysical beliefs regarding the teaching and learning of evolution

South Africa is characterized by people of diverse cultures and beliefs. Some of these beliefs have a bearing on the teaching and learning of science. In addition to the forms of belief discussed above, people also have metaphysical beliefs. Metaphysical beliefs relate to what people believe which is beyond 'physics' or perception. Hewson *et al*., (1999) and Posner, Strike, Hewson & Gertzog (1982, p. 216) mention metaphysical beliefs and concepts as constituting the conceptual ecology of individuals. These include beliefs about the relations between science and commonplace experience and concepts which have a metaphysical quality, such as "the nature of time" (Hewson, *et al*., 1999, p. 251). Such beliefs tend to have an influence on the teaching and learning of science or at least some scientific concepts. As an example, a study by Lawrenz and Gray (1995) in a South African university found that, despite the numerous science courses the students had taken, science was not well integrated into most of the students' worldviews. Furthermore, their study showed that prospective South African science teachers have diverse views and that their views often do not incorporate science in the same way.

Studies in evolution education done elsewhere have shown that beliefs, particularly religious beliefs of the general public and the teachers, have influenced the teaching and learning of evolution in many places (Deniz *et al*., 2008; Mansour, 2008a; Mansour, 2010; Moore & Kraemer, 2005). One possible reason for this is a perception that evolution is against one's beliefs, resulting in a teacher leaving it out of the teaching altogether, or giving it a cursory treatment. There is also a possibility that the beliefs could cloud one's understanding and interpretation of curriculum expectations concerning what is to be taught, resulting in inadequate coverage or inaccurate representation. Anderson (2007, p. 665) states that, for many students, scepticism about evolution is related to their religious perspective. Many studies, locally and abroad, have found that learners' deeply-ingrained religious beliefs interfere with their ability to view scientific evidence objectively and to appreciate scientific theories and concepts, as has been the case with evolutionary theory (e.g. Clores & Limjap,

2006; Chinsamy & Plaganyi, 2007; Dagher & BouJaoude, 2005; Sinclair & Baldwin, 1996; Trani, 2004). Dagher & BouJaoude (2005) acknowledged that generic descriptions of the 'theory of evolution' may have been motivated by affective factors shaped by learners' religious beliefs, worldviews or social expectations (p. 388). As stated by Ertmer (2005), a learner may gain knowledge of a proposition but may still decide, thereafter, if it is true or false. This decision is based upon the judgments and evaluations a learner makes, which in their turn could be influenced by his or her existing belief system and worldview. However, it is also possible that an individual may lack understanding, whereupon the misinterpretation may have nothing to do with beliefs. In this case, teachers may teach wrongly or learners not understand because of factors outside their belief system.

3.6.4 Implications of teachers' and learners' beliefs on teaching and learning about evolution

The foregoing discussion pointed out that teaching evolution is likely to evoke conflicts between teachers' and learners' beliefs, as the learners' beliefs might disagree with what is being taught. In case of conflicts, teachers need to use relevant strategies, not only to resolve the conflict but to assist learners to understand biological evolution and value its importance in Life Sciences. This requires in teachers an awareness of learners' views and ideas about evolution. Such awareness is likely to be useful to teachers as a starting point for instruction in evolution. Herbert (2008, p. 980) maintains that "... science teachers must be cognizant of students' prior knowledge about topics being addressed, and that they must use this knowledge in the classroom during science teaching". Considering learners' views and ideas will assist teachers to assist learners to examine their views in line with evolutionary concepts. But, as shown by Schilders *et al*. (2009), this may evoke inner tension, cognitive conflict and/or the temporary retirement of students' active participation, and teachers need to be able to deal with such conflicts if and when they happen.

Knowledge of teachers' belief systems is therefore an essential and vital element to be considered when developing teacher education programmes. Knowing what teachers are doing should provide teacher educationists with a starting point (Griffith & Brem, 2004). This implies that the belief systems of prospective teachers should be identified when designing teacher preparation programmes (Bryan, 2003; Tabachnick & Zeichner, 1984, 1999), and practising teachers' belief systems can be used when designing in-service education programmes. This requires a knowledge of these belief systems by those who

design such programmes, and knowing how to incorporate them into teacher education programmes.

Given the confusion in the literature concerning the explanations or definitions used to describe beliefs, this study does not stick to a specific definition of beliefs. However, the beliefs that are being investigated are those that influence learning and teaching. Epistemological, pedagogical, efficacy and religious issues are some that have an impact on teaching and learning. This study therefore takes as a starting point the philosophical beliefs that teachers and learners develop outside of their classroom experiences. These beliefs may be religious or cultural, formed by exposure to scriptures or other cultural experiences. Of interest to this research is how these philosophical beliefs influence the teaching and learning processes. The assumption is that philosophical beliefs have an impact on educational beliefs, which in turn have an influence on teaching and learning. Later in this chapter, beliefs are related to worldviews, as the worldview theory is used to guide the research conceptualization and processes. In the next section, the discussion looks at research in evolution education in South Africa in the context of the recent curricular developments.

3.7 EVOLUTION EDUCATION RESEARCH IN SOUTH AFRICA

The historical developments in approaches to evolution, biology (Life Sciences) and science education in general were discussed in Chapter 2. As mentioned earlier, a lot of interesting research has been conducted already, and a lot written about evolution and its inclusion in the South African schools' curriculum (see Abrie, 2010; Chinsamy & Plaganyi, 2007; Kagan & Sanders, 2012; Lever, 2002; Molefe & Sanders, 2009; Sanders, 2010; Sanders & Ngxola, 2009). Research is reported at international and local conferences as in, for example, the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) annual conferences held in South Africa and in other Southern African countries. Reports also appear in international and local databases and journals. These endeavours highlight the fact that 'evolutionary theory' is in South African schools, and it is such an interesting topic that its presence sets the country into motion. Lever (2002, p. 18) argues that it would be foolish for South Africans not to tell children about evolution, and even more senseless not to take advantage of evolution's immense integrating properties for pedagogical and public discourse. This is a challenge to South Africa, considering the diversity of cultures and beliefs in the country. If some countries, some of them as Western as the United States of America, have experienced challenges with evolution education, it would

be useful to understand their experiences and evaluate them in the context of South Africa, and aim at implementing a more informed evolution education.

Some of the research conducted lately in South Africa reports lack of understanding by teachers (Sanders & Ngxola, 2009) and by tertiary students (Chinsamy & Plaganyi, 2007). Abrie (2010) has reported on the attitudes and willingness of pre-service teachers to teach evolution. Chinsamy and Plaganyi (2007) and found the university entry-level students in their study to be having very little understanding of evolutionary concepts and that most of them held deeply religious views that block the acceptance of evolutionary concepts. They suggest the lack of understanding of evolutionary concepts by teachers as one of the problems resulting in poor foundation in first-year students' knowledge of evolution and propose that a concerted effort should be made to ensure that teachers are better informed about evolution. Sanders and Ngxola (2009) found that the commonest source of some of the teachers' concerns in their study related to *inadequate knowledge* followed by *the controversial nature of evolution*.

Comments on the latter concern relate mainly to the "evolution versus creation conflict" and "conflicts between [teachers'] own religious beliefs and what they have to teach". Sanders and Ngxola (2009) report that teachers felt the controversy could cause problems for learners. This indicates a predicament for teachers concerning what and how to teach regarding evolution, particularly as they have to deal with their own personal beliefs and those of the learners. The concern is that many teachers are ill-equipped to teach evolution, feeling frustrated and unable to cope, and most learners still have only minimal understanding of the basic concepts of evolutionary biology (Chinsamy & Plaganyi, 2007; Sanders & Ngxola, 2009). As stated elsewhere by Griffith and Brem (2004), teachers' perceived lack of knowledge can cause concern and some embarrassment, and this can be true for South African teachers as well, especially if they consider the topic to be controversial and dwell on this. Their concern is that they may not be able to handle a situation where conflicts with the learners arise. The implication is that if teachers have insufficient knowledge, but at the same time have opposing beliefs about evolution, their beliefs may dominate their decision-making regarding what and how to teach. Nespor (1987) has suggested that teachers' beliefs are more powerful than their knowledge in influencing the way they teach. This explains why teachers may have similar scientific knowledge but teach in different ways.

Apart from concerns arising from factors internal to them, teachers feel that there are some factors which lie outside of their control. Most recently, a study by Sanders (2010) seeking, among other things, to understand personal and contextual factors which affect how teachers with firm religious beliefs approach the teaching of evolution, identified internal factors relating to teachers and external factors which lay outside their control (p. 23). One of the internal factors, according to Sanders (2010), is teachers' belief systems which lie at the heart of all successful educational endeavours, while learner-related factors are external and lie outside the control of the teacher (p. 30). Sanders (2010) found, as was also observed by Schilders *et al*. (2009) in Holland, that most teachers were unaware of this importance, as they did not consider learners' existing views or engage them in discussions about those ideas and evolutionary concepts. For Sanders, these teachers were coping by using a strategy whereby they informed learners that they should learn about evolution for the examination and assured them that it would not impact on their belief systems. While this enabled some teachers and their learners to cope, it denied both the learners and evolution a fair deal, as the teachers openly revealed their scepticism about evolution (Sanders, 2010, p. 29-30; also see Schilders *et al*., 2009). That study did not, however, look at the impact of learner belief systems on their learning, but on whether teachers were aware of the importance of accommodating learners' beliefs, and how best to handle that.

The scepticism revealed is a signal pointing to teachers' lack of confidence in what they are doing: that is, teaching evolution. The lack of confidence can be a result of lack of knowledge due to insufficient training on how to teach evolution. It may also be an indication of insufficient understanding of the nature of scientific knowledge as being dynamic and tentative. The scepticism can also be a reflection of their belief system. Moore (2002) cites Lerner (2000) in showing that "individual teachers' decisions, beliefs, and teaching behaviours are complex, as is the intermingling of factors that influence the teaching of evolution, including textbooks, tests, curricula, political pressures, and religious beliefs" (Moore, 2002, p. 380). Sceptical or conflicted teachers do not address learners' views out of fear of conflict. A display of scepticism is most likely to evoke doubts in the learners, resulting in rote learning as they try to cope, and poor understanding. This is an indication of what Raths (2001, p. 2) calls "academic failure" resulting from "problematic teaching". Teachers doing this are not demonstrating "advocacy" dispositions (Raths, 2001), since they do not seem to appreciate the importance of learners' views and of relating what they are teaching to learners' lives and experiences. Alternatively, teachers may not invite learners'

views because they are trying to avert any potential conflict in the classroom. This predisposes learners to being, as Raths states, victims of teacher belief systems (Raths, 2001, p. 2). This situation is similar to what Fang (1996) suggests; that teachers have to call upon the conflicted 'self' and build a working identity that is constructively unambiguous in order to combat the pedagogical dilemmas they face. Having to cope in situations of conflict could be a source of inconsistency between a teacher's theoretical beliefs and instructional practices, as teachers have to negotiate among, for instance, curricular requirements and learners' aspirations and predicaments, while also still continuing with their own ruminations and struggles.

Most recently, a study by Stears (2012) has given a glimmer of hope for the learning of evolution and avoiding conflict due to religious beliefs. She found out that, with improved understanding of Nature of Science (NOS), students' understanding of why evolution is a regarded as the guiding principle in biology also improved. This is because understanding of the NOS helps students understand what constitutes scientific evidence as well as what is meant by a scientific theory. Separating religion and science avoided putting students in a situation where they had to choose between their religious beliefs and evolution, making their learning smooth. However, this indicates that teachers should be able to separate religion and science, and at the same time they should be in a position to avert conflicts arising out of learners' contributions in class.

This study aims at exploring how people's beliefs affect the teaching and learning of evolution. It is trying to understand how the beliefs of teachers affect how they teach and how the learners' beliefs affect their learning of evolution.

3.8 SUMMARY OF LITERATURE ON BELIEFS AND EVOLUTION EDUCATION

It is clear that the way in which evolution is taught can reflect teachers' beliefs about it, such as whether they regard evolution as a valid theory, as a unifying biological concept, or whether they are sceptical about it. This in turn will affect the way the curriculum expectations are met during the teaching of evolution. Also, the interaction between teachers and learners can reveal whether the expectation of raising learners' awareness of different points of view in a society is considered. Also, as suggested by Mansour (2010), teachers remain confused due to the fact that the link between science and religion for them comes from informal sources. He suggests, as have others (e.g. Aikenhead & Jegede, 1999) that

science education should take into consideration the distinction between the different cultures of science and religion. Mansour (2010) further makes the point that, if teachers are knowledgeable about the domain of science and religion, they can engage in discourse on either subject in an informed and knowledgeable manner.

South Africa is endowed with a wealth of evidence in the fossil remains of the first *Homo sapiens* in places such as the Cradle of Humankind around Maropeng. As suggested by Lever (2002), this richness is now relevant, and South Africa can contribute meaningfully to efforts to bring historical order to the dispersion of modern humans throughout the globe. This plethora of evidence should thus offer a rich resource base for learner exposure and a widening of their view of evolution, contributing an enrichment of their understanding. In addition, a strong point for South Africa could be that, unlike in some places in the United States, teachers in South Africa have not been receiving negative images of evolution from the public, which could result in a predicament about the teaching of evolution. On the other hand, as indicated by Meadows *et al*. (2000, p. 102), on a private and often unspoken level, many biology teachers must face their own unresolved conflicts between evolution and their personal worldviews. Similarly, learners have to deal with their own personal beliefs and worldviews, while at the same time trying to learn conflicting information in order to pass examinations, as well as to attain relevant and sufficient knowledge and skills for their future.

The next sections of this chapter present the theoretical framework for the research which was conducted for this thesis. This is done by identifying the theorerical perspectives underpinning the research, which include theories about how teachers and learners relate to evolution in the classroom, arising from the foregoing discussion.

3.9 THEORETICAL PERSPECTIVES FOR THIS STUDY

This study uses different theoretical frameworks drawn from the literature on people's worldviews including teacher and learner beliefs, particularly religious beliefs, and science and evolution education. The literature reviewed indicated that learners come to school with knowledge and ideas about the world, its origin and origins of all living organisms including humans. This knowledge and these ideas, or prior conceptions, are shaped by the culture and context within which the learner is socialized. As stated by Cobern (1991), each person has a fundamental, epistemological microstructure which forms the basis for his or her view of reality. Since people's worldviews are formed even before they start formal schooling, these

worldviews shape people's prior conceptions about reality. The assumption is that these prior conceptions are significant in the learning and understanding of new concepts, and that learners construct their own meaning, using their prior conceptions as basis for understanding the world.

According to Clores and Limjap (2006, p. 76), constructivism provides a dynamic epistemological framework for science education research, in order to clarify problems about learning and teaching, especially difficulties learners may encounter when learning science concepts like evolution. This research was thus conducted on the premise that a complete education demands attention to varied epistemologies, students' personal worldviews, and the methods by which science educators go about formulating their subject matter in a broad context that facilitates constructivist learning (Anderson 2007, p. 665).

The literature abounds with different views about learning, all sharing two main features: that learning takes place with the active involvement in knowledge construction of the learner; and that the learner's "previous and alternative ideas play a fundamental role in the learning process" (Mortimer, 1995, p. 267). Mortimer's statement brings together two commonly-used constructs in science education research and teaching and learning: constructivism and conceptual change. Constructivism as a theory of learning, and conceptual change as a model, have both been much studied to understand how they influence learning in various disciplines. Science education has embraced both in its practice in research, and in designing curricula and pedagogical practices.

Considering that any meaningful learning of evolution is usually impeded by pre-instruction conceptions that may work against scientific understanding, a theory that deals with such alternative conceptions, such as a conceptual change model, would be desirable. However, the focus of this research is on how individuals' beliefs, which are part of the preconceptions with which learners enter the classroom, connect to evolution education in particular. The study looks at how evolution education relates to individuals' broader worldviews (Anderson, 2007). As suggested by Sinatra *et al*. (2008, p. 189), conceptual change in evolution requires an individual to see the world in new and different ways, an indication of change not only of conceptions but of worldview. Beliefs are philosophical ideas, and as such relate to individuals' epistemological and ontological presuppositions about reality. Beliefs, as already described, are formed from within an individual's social, cultural and religious predispositions, as well as the socio-environmental context of that individual.

Cobern (1991) argues that misconception is a complicated phenomenon and the cognitive bridges as currently construed may not be effective in dealing with them. If a learner's ideas are logically grounded in the learner's view of nature, they are alternative conceptions, some of which might be science misconceptions. Therefore, for those individuals who encounter difficulty in accepting a scientific idea such as evolution, there may be a need to break with their everyday or prior concepts (Cobern, 1996) so that conceptual change can occur. However, considering what happened with Tax (1983) in Cobern's (1996) thesis, if a concept like evolution is already consistent with what an individual believes about the world, one need not break with everyday or earlier conceptions to understand and accept a science concept like evolution. For this reason, and the fact that there are difficulties with students giving up everyday notions, various models have been suggested to deal with alternative conceptions in science learning. In recognition that beliefs are part of an individual's conceptual framework, the research reflected here calls on a constructivist philosophy of teaching and learning. This also takes account of the fact that evolution education responds to issues in cosmology, and cosmological issues are influenced not only by scientific views but by other philosophical presuppositions, including religious beliefs. This study thus focuses mainly on the knowledge of both teachers and learners as influenced by the teaching and learning variables, with the teaching and learning being influenced, in turn, by teachers' and learners' worldviews. As a result, this research adopts the worldview theory in an effort to cater for the various perspectives and outcomes involved in evolution education. Also, this study takes Cobern's (1991) view of extending misconception research, by seeking to know more about students' and teachers' fundamental views of the world, and hence the relevance of the worldview theory.

According to the worldview theory, a scientific misconception can be an explanation scientifically unaccepted but logically deduced from an alternative worldview (Cobern, 1991). This kind of misconception differs from the one where factual understanding results from misinformation, insufficient or flawed instruction. Cobern argues that even when a student's worldview does not hinder science understanding, meaningful learning requires that the science concept is linked to student's worldview. Cobern uses this distinction to differentiate between proper misconceptions and alternative conceptions, with the latter being informed by alternative frameworks. In adopting a worldview theory, this research focuses on how the alternative frameworks affect the teaching and learning of evolution. Worldview theory is expounded in the next section.

3.9.1 Defining a worldview

Worldviews develop under various ways (Schäfer, 2004), and even the concept of worldview can be used in a variety of ways. Dating back to the late 1800s, the concept has been a subject of interest in areas like cultural anthropology, as noted in work by Michael Kearney (1984), and in social psychology, counselling psychology and cultural psychology (Ibrahim, 1991; Yang, 1998), as well as in physics education (Hansson & Redfors, 2007b), science education (e.g. Cobern, 1991) and in the Christian and philosophical perspectives as reflected in the writings of David K. Naugle (e.g. 2002) and James W. Sire (e.g. 2004; 2009). The term worldview is borrowed from the German word *Weltanschauung* consisting of *welt* ('world') and *anschauung* ('view' or 'outlook').

According to Naugle (2002, p. 9), "[w]orldviews are generated by the mind's aspiration to a unified comprehension of the universe, drawing together facts, laws, generalizations, and answers to ultimate questions".

A set of beliefs that one holds to be true forms the worldview by which an individual makes sense of what is real, based on what 'reality' is to that individual. How one makes sense of reality is determined by one's worldview. However, the lens that an individual uses to understand reality is not stable. As James Sire writes in his evangelical view, postmodernism, pluralism and syncretism are some of the worldviews that have had an influence in shaping the way we make sense of reality in contemporary existence. In one of his books, *Naming the Elephant: Worldview as a Concept*, Sire defines worldview in this manner:

> A worldview is a set of presuppositions (assumptions which may be true, partially true or entirely false) which we hold (consciously or subconsciously, consistently or inconsistently) about the basic make-up of our world (Sire, 2004, p. 19).

Somewhat later, in *The Universe Next Door: A Basic Worldview Catalog*, Sire provides the following definition:

> A worldview is a commitment, a fundamental orientation of the heart, that can be expressed as a story or in a set of presuppositions (assumptions which may be true, partially true or entirely false) that we hold (consciously or subconsciously, consistently or inconsistently) about the basic constitution or reality, and that provides the foundation on which we live and move and have our being (Sire, 2009, p. 20).

Cobern (1991) defines worldview as "the culturally-dependent, generally subconscious, fundamental organisation of the mind" (Cobern, 1991, p. 3). This organization, Cobern states further, manifests itself as a set of presuppositions or assumptions which predispose an individual to feel, think, and act in predictable patterns. According to Kearney (1984, p. 41) the worldview of a people is their way of looking at reality. Yet assumptions about reality vary from one group to another, depending upon and affecting the actual perception of it (*ibid*.). As stated by Sire (2009), the assumptions may be true, partially true or false. Eventually people agree or disagree about which reality is true. Therefore, worldviews vary from group to group according to each group's perceptions of reality. For the individuals in a group, what is important is being part of an arrangement of ideas and the behaviour of the group to which they belong, and being able to relate to other humans in the group and to their environment. A worldview is, therefore, an overall collection of beliefs about the universe and life through which an individual sees and interprets the world; it is an individual's understanding of prime reality (Anderson, 2007, p. 671; Kearney, 1984, p. 42; Smith, 2010b, p. 544). Thus, a worldview is what Kearney (1984, p. 1) refers to as "culturally organised microthought: those dynamically inter-related basic assumptions of a people that determine much of their behaviour and decision making, as well as organizing much of their body of symbolic creations". According to Cobern (1997), a worldview defines the Self, and sets boundaries of who and what an individual is, defines everything that one is not, including the individual's relationships to the human and non-human environments. It shapes the individual's view of the universe, his or her conception of time and of space, and it influences the norms and values of the individual (*ibid.*).

3.9.2 The effect of worldviews on learning

For every person there is a worldview that frames their understanding of reality, and for most people that worldview includes more than one way of knowing (Anderson, 2007). For instance, a child may learn something about the world from one context, such as religion, which is different from what is taught in another context, like school science (Le Grange, 2007). Having a religious background and learning science at school therefore brings about an interaction between science and religion in the classroom. Science and religion each has a distinct way of looking the world, and thus the two have distinct worldviews as well as epistemologies. The interaction of religion and science in the classroom thus brings about an interaction of worldviews which has the potential to bring about epistemological conflict and

confusion in the learning process. This comes about because science requires commitment to empirical processes and objectivity in what is being observed, whereas religion relies not on empirical evidence but on faith. Learning in science involves employing a hypothetico-deductive model of reality, but religion engages anthropomorphism, where what is not human may be interpreted in human and personal terms. Therefore a learner with a non-scientific worldview may not be committed to understanding the world through experimentation, while a learner with a scientific worldview could judge and evaluate reality in terms of empirical and material evidence. Any knowledge from either perspective, while esteemed as truth and reality by people with that worldview, will however be viewed with scepticism by one with a different worldview. For instance, as stated by Staver (2010) "science … does not consider God as a factor in its quest for knowledge". This does not mean that there are no people who are both scientists and believers in God. However, any quest for knowledge that includes God might be viewed with scepticism by those who don't believe in God's existence.

Cobern (1990) has argued that worldviews have variants. According to this argument, children operating within a certain worldview may exhibit variants of that worldview due to various socio-cultural factors (*ibid.*). Yang (1998, p. 66) points out, too, that values may not be constant over time, due to individual acculturation in relation to a given cultural frame of reference, or to external societal changes. Therefore, a group of learners having a 'Western' background have variants of the Western worldview due to their varying backgrounds, and these will determine how each individual relates to the Western cultural frame. Similarly, learners having a non-Western worldview would have variants of that worldview, also due to their backgrounds and acculturation processes. Yang (1998) reports a study (Yang, 1982) where Taiwanese college students, at the time of the study, tended to hold value orientations similar to those of White American students, showing a deviation from their Chinese traditions and an acculturation to the worldview of the White Americans. This deviation, Yang suggested, could have been influenced by industrialization.

It is to be expected, therefore, that for South African learners, an African or other worldview exists which reflects their indigenous and/or cultural upbringing. This 'African worldview' has been formed by the milieu of cultures within which African learners have grown up, cultures which translate into worldview variants for the learners, the worldview variants they bring with them to class. The socio-cultural context within which these learners have been socialized further affects their individual worldviews. Such a context can be gender, religion,

education, economic or social status, personal identity, politics, technological advancements and even their future aspirations. A worldview is therefore an individual's perception of his or her relationship with the world (Ibrahim, 1991 citing Sue, 1978), and influences an individual's goals and behaviour (Ibrahim, 1991, p. 14). It is to be expected, therefore, that a class of learners will possess various worldviews which express themselves in various behaviours and goals.

In a context where a phenomenon being studied has both scientific and non-scientific explanations of its reality, one may have to choose which explanation to accept as representing that reality. It is people's worldviews that may lead to a rejection or acceptance of classroom content, such as evolution. Learners might refuse to learn a science concept or resort to exercising what Cobern (1996, p. 588) terms "cognitive apartheid", by simply walling off concepts that do not fit their established way of thinking, thereby banking them for retrieval during examinations. This would be similar to what Aikenhead and Jegede (1999, p. 278) refer to as a "compartimentalization technique" whereby any conflicting concepts are categorised into distinctive and coexisting cognitions. Similarly, teachers who experience cognitive dissonance could wall off evolution concepts that do not fit their view of reality, and only retrieve them for teaching purposes, especially if required for examinations, although they may end up demonstrating 'scepticism' in their classrooms.

It is therefore essential to understand various worldviews as regards the learning of certain content. As pointed out by Hokayem and BouJaoude (2008, p. 399), "probing into individuals' worldviews and presuppositions about universals constitutes the first step toward understanding and appreciating various worldviews". The nature of the education process and the personal and social position of the learner are some of the aspects that should be noted when selecting learning-contents in view of specific life experiences and worldviews (Mentz, 1992). A worldview analysis begins by assuming that learners' responses to questions related to given phenomena are meaningful to the learners, if not to the teacher (Cobern, 1991), even though they might be regarded as misconceptions by others. The responses are indicative of epistemological presuppositions within the worldview universals: Non-Self, Causality, and Classification (Cobern, 1996; Lawrenz & Gray, 1995).

3.9.3 Worldviews and the teaching and learning of science

The notion of worldview has gained ground in science education, where some authors use Pepper's 'world hypotheses' while others use Kearney's (1984) worldview theory. Cobern (1991) argues that worldview theory has the potential of being an integrator and generator of research in science education, even though this potential is not realized in Pepper's approach, which greatly oversimplifies the concept. The worldview theory has been used extensively in science education research (see Anderson, 2007; Cobern, 1991, 1993, 1996, 2000; Dzama & Osborne, 1999; Hansson & Lindahl, 2010; Hansson & Redfors, 2006; Hokayem & BouJaoude, 2008; Lawrenz & Gray, 1995; Liu & Lederman, 2007; Reiss, 2009) as well as in mathematics education (Schäfer, 2004). Hansson and Redfors (2006, p. 256) see a worldview as an aspect of culture which is also an aspect relevant to science education.

Science curriculum documents worldwide advocate the goal of 'scientific literacy' for science education. Cobern (1996) asserts that this goal entails the concept of worldview – that is, 'scientific worldview' – which suggests that all concepts, including beliefs which are not scientific, should be discarded in favour of the scientific ones. Other researchers have indicated that a scientific worldview represents "a foreign subculture in all countries and cultures" (Aikenhead, 2006; Aikenhead & Jegede, 1999; Thijs & van den Berg, 1995, as cited in Dzama & Osborne, 1999). The implication of this is that, in all cultures, individuals learning science have to switch to a foreign worldview, the worldview of science. Such switching of cultures involves switching from one worldview to a different one, where not only the concepts but also the epistemological orientation and learning styles may be different. Cobern (1996) argues from a worldview perspective that "some students may fail to develop orthodox scientific conceptions even after the best of instruction", not because they fail to comprehend what is being taught, but simply because "the concepts are either not credible or not significant" (Cobern, 1996, p. 601). This does not necessarily happen to a specific culture, but to all cultures where science is 'foreign' – foreign in content and in method. For individuals who maintain their culture and their worldview as well, learning may be difficult. This supports the notion that people who have a monistic worldview in which all things can be explained in terms of a single reality, have difficulty in becoming scientists. This suggests that a change to a Cartesian dualism, which distinguishes between physical and mental events, can help (Ogunniyi in Dzama & Osborne, 1999). And, as further argued by Dzama and Osborne (1999), aspects of monism and anthropomorphism, being basic

characteristics of human thought, are found among 'Western' people as well as among people of other cultures. The implication is that the problems of science education, including those to do with the teaching of evolution, in the United States and Europe are similar to those in places outside the 'West', including South Africa.

Learners who have a well-grounded indigenous framework or worldview might find science foreign and end up playing Fatima's rules if they feel they are being assimilated into a culture they do not want to embrace. For example, in learning about evolution, learners may find it to be not credible or not significant and that it has no effect on their everyday life (Cobern, 1996, p. 588). This can happen even when the concept is intelligible and plausible, but the learners' worldview framework is so resilient that learning modern science, including evolution, is not easy. This resilience may exist because learners' indigenous knowledge framework or any other worldview they exhibit seems more or equally logical and valid (Ogunniyi, 2012), resulting in a duality of thought being created in the learners' memory and schemata, or collateral learning (Jegede & Aikenhead, 1999).

Le Grange (2007, p. 548) maintains that discussion around 'African worldview' and 'Western worldview' frames these two worldviews as disparate. This, Le Grange states, takes place if science or knowledge is understood as *representation* only, but the two worldviews are not disparate if science is also viewed as *performance*. He argues that much of Jegede's work, and his thesis of collateral learning, remains focused on the representational aspects of knowledge, so that modern science and indigenous knowledge are consequently seen as disparate. He recognizes that, although science embodies representation and that it is useful to distinguish between Western (modern) science and indigenous knowledge, it is also important for science to be viewed as performance (Le Grange, 2007, p. 589). Similarly, Cobern (1996) has argued that science is taught with the aim of understanding scientific concepts and not so much with the aim of achieving scientific understanding. When science is taught as representation only, or from a "static view" (Cohen, Manion, & Morrison, 2011), that is when the goal is conceptual understanding, but teaching science as performance or "dynamic" (*ibid.*), promotes scientific understanding. The view of science as representation characterizes the traditional and canonical view of science, a manner of teaching which should promote a scientific worldview. As argued by Dzama and Osborne (1999, p. 394), not all people in the West (Europe or America) have acquired the scientific worldview or its methods which give pre-eminence to abstraction, rationality, and reductionism. Viewing

science as performance negates the universality of science and enables the inclusion of non-Western cultures in the practice of science. Therefore, Le Grange's suggestion could be seen as complementing the multicultural approach to teaching science, which recognizes that people are diverse in the ways in which they view reality and truth about the world.

There have been various suggestions on how to deal with the predicament when it comes to teaching and learning science. Cobern and Loving (2001, p. 64) advocate an epistemological pluralism and the ability to discriminate wisely amongst competing claims. In a similar vein, Treagust and Duit (2008, p. 388) suggest a multi-perspective approach to science teaching and learning. They argue that the aim of science instruction should be to make students aware that, in different contexts, different conceptions and views are appropriate and that, in scientific contexts and discourses, the scientific conception is more viable than the everyday conception. In other words, when teaching a scientific concept such as evolution, teachers should be aware of the worldviews of their learners and should contextualize their scientific generic understanding. From a counselling perspective, Yang (1998, p. 66) suggests sensitivity by a counselling practitioner to the clients' distinctive styles as to what could facilitate dyadic communication between the counsellor and the client. We can learn from these suggestions that in teaching science, teachers should assess, understand and be sensitive to learners' individual and social or group worldviews. Teachers should also not try simply to impose the knowledge of a scientific concept like evolution, as some students might just learn it for examinations without necessarily accepting it. Rather, we can take a multi-perspective approach to teaching, which should embrace other cultures in the science discourse, in order not to alienate teachers and learners who hold non-scientific worldviews.

3.9.4 Rationale for a worldview framework in this research

People have diverse beliefs concerning themselves and what goes on around them. Often these beliefs become established as people attempt to understand the world around them, to understand their own being, their existence, and the existence of something else that is out there, the existence of the world and of the universe or of the cosmos. One can have a belief in something by accepting mentally that the thing exists, is real, true and/or valid.

This research takes the position that worldviews influence people's beliefs and therefore people's beliefs reflect their worldviews. It was shown earlier in this chapter that people's beliefs influence how they act and behave. A distinction was also made between knowledge

and belief, wherein one may gain knowledge about a proposition but still decide thereafter whether to accept it not. The reason for this has been advanced, for example by Cobern (1993), who noted the fundamental difference between thinking and knowing. This difference leads to a distinction between comprehension and apprehension. Cobern describes thinking as the epistemological process leading one to conceptual comprehension, while knowing is the metaphysical process by which one comes to apprehend phenomena. In apprehension, one accepts that the concept comprehended is true or valid, that is, one believes in the validity of the concept, or one may reject a concept that is fully understood. This suggests that any scepticism about what learners have learned is related to something inherent to the metaphysical foundations that support epistemology.

As stated by Anderson (2007, p. 665), for many learners, scepticism about evolution is clearly related to their religious perspectives, and to ignore this connection is seriously to thwart their learning. Because of their religion and/or culture, people will exhibit certain beliefs. In this research it is accepted that people's beliefs reflect their worldview, and we can therefore speak of worldview variations according to beliefs, which might be religious or cultural. Furthermore, although beliefs might be shared among people irrespective of their context, variations still exist from one individual to the next due to individual preferences or inclinations. Thus the religious worldview may vary according to compatibility to science and, more specifically for this research, to evolutionary theory. The expectation in this research is therefore that an insight into teachers' worldviews would provide an understanding of those variations and their compatibility to evolution teaching and learning. This insight may further point to how teachers' beliefs and worldviews are established, and the influence these beliefs and worldviews have on their pedagogical beliefs and practices.

This study is about evolution, a concept describing a phenomenon in nature that reflects causality. Therefore, learners' presuppositions about causality should provide an insight into their preference for scientific, or other than scientific, causality (Hokayem & BouJaoude, 2008, p. 401) when explaining evolution, and hence an insight into their worldviews. Such insights can enable an understanding of the worldviews within which beliefs are embedded, and their effect on the teaching and learning of biological evolution. Thus we may be able to have an insight into classroom practices that can build bridges that connect with learners' "fundamental presuppositions about the world" (Cobern, 1990, p. 2).

The concept of worldview has received much attention in the science education literature as a topic of analysis, discussion and empirical research (for example Anderson, 2007; Cobern, 1991, 1996, 2000; Dzama & Osborne, 1999; Hokayem & BouJaoude, 2008; Keane, 2008; Lawrenz & Gray, 1995; Lewis, 1998; Liu & Lederman, 2007; Ogunniyi *et al.*, 1995). The recognition that individuals and their culture play a significant role in the interpretation and understanding of concepts, has advanced science education towards a more subjective and less positivist view (Lawrenz & Gray, 1995). Worldview research has been expanded to investigate variations existing within groups of people and the compatibility between such worldview variants and science. Lewis (1998) gives three possible categories of the use of worldview in research: thematic, paradigmatic, and logico-structural. In thematic use, worldview refers to particular cognitive dispositions or assumptions which are given thematic labels (p. 9). In paradigmatic use, the worldview refers to shared assumptions and the resulting group perceptions (*ibid.*). In the logico-structural category, the worldview is taken as the total of a person's understanding of himself or herself, the world and his or her place in the world (*ibid.*). Lewis (1998) gives two advantages of using the logico-structural model: (i) it differs from (other) previous attempts that give theoretical underpinnings to worldview which rely on philosophy rather than empiricism, and (ii) it defines worldview as the total of a person's thinking and as belonging to the individual. The main assumption in this research is that all human activity, including the bestowal of affection, proceeds from a cognitive root (Cobern, 1991) in an individual. This model is further discussed below, and its use is not only confined to the presuppositions shared by groups (Lewis, 1998), as is underpinned within the paradigmatic worldview, but the worldview approach as used in this study rests with the individuals, and acknowledges that the social, cultural and historical environment is critical in modifying a person's worldview, and treats each person as having a unique worldview (Lewis, 1998). In addition, the assertion is that a person's behaviour is directed by their worldview (*ibid.*).

This study, therefore, aims to focus on the dynamics of teachers' and learners' knowledge as formed by their beliefs, and the worldview theory is the guiding pillar for identifying the focus. This is in recognition, as argued earlier, that while philosophical and religious beliefs are not identical with worldview, they are, as noted by (Cobern, 1991), intimately linked and hence an important part of the worldview content. Cobern (1991) refers to religion and philosophy as visible expressions of worldviews and beliefs. The assumption here is thus that

worldviews, like beliefs, cannot be observed unless they express themselves in something observable.

3.9.4.1 The logico-structuralism model

The approach to worldview theory by Michael Kearney, a cultural anthropologist, has been described and expounded in relation to science education by William Cobern. Kearney proposed the logico-structural model, and Cobern (1990, p. 4) describes the use of logico-structuralism as due to its sensitivity to intra-worldview variation, and avoidance of artificiality from oversimplified scientific approaches. Kearney's *logico-structuralism* model begins with the idea that a worldview is an organized set of fundamental, cognitive presuppositions about reality (Cobern, 1991). The power of this model to assess the individual's knowledge rests on four assertions, articulated by Lewis (1998) as follows:

- that a person's worldview is modified by the historical, social and cultural environment;
- that this model asserts that behaviour is directed by their worldview, and explains why learners experiencing similar learning practices or demographic variables exhibit different behaviours;
- that all worldview content can be organised into 1st- and 2nd-order assumptions; and
- that the worldview can be organised into seven universal categories (Lewis, 1998) that are interconnected, interdependent, and common to different cultures: Self, Other (Non-self), Classification, Relationship, Causality, Time, and Space (Cobern, 1991, 1996; Lawrenz & Gray, 1995; Lewis, 1998; Hokayem & BouJaoude, 2008).

This results in a worldview that is internally consistent, with the presuppositions being logically integrated and universals structurally integrated (Cobern, 1991). According to Lewis, these seven universals represent boxes into which all worldviews can be placed (Lewis, 1998, p. 15).

The logico-structural model, with the seven interacting universals, provides an analytical tool for studying worldview at the individual level as well as for studying elusive worldview variations. This can happen without sacrificing the ability to draw broad generalizations about worldview in a society. When he first selected these universals, Kearney (1976) stated

that such units were the skeleton of a cross-culturally applicable model, indicating their usability across cultures. In science education, where scientific worldview is the main goal of learning, there will be many variations due to factors such as gender, religion, ethnicity, and economic status, indicating that the scientific worldview has attributes and presuppositions of its own. Therefore, the framework for this study is informed by the logico-structural model of Kearney (1984) shown in Figure 3.1.

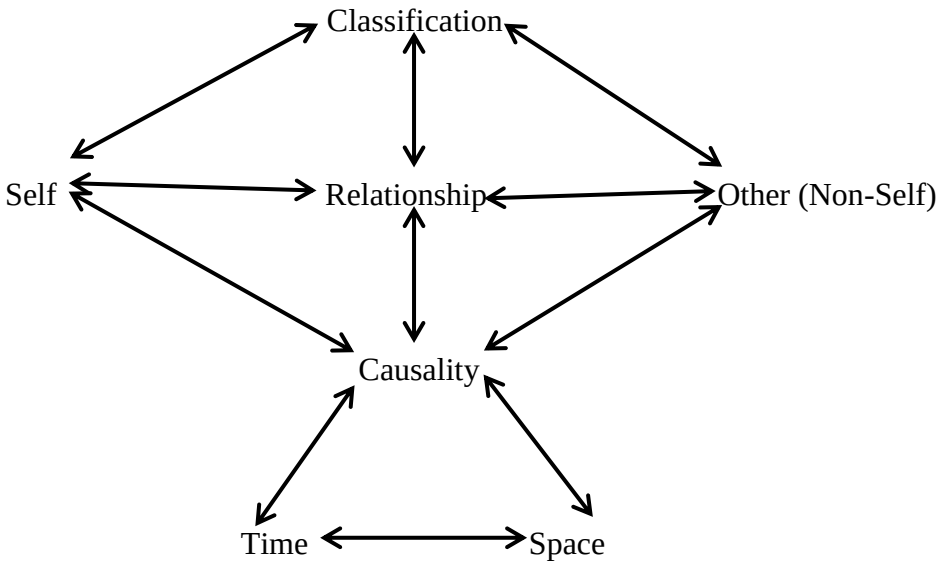

Figure 3.1: Kearney's Logico-structural World View model (from Cobern, 1996)

Cobern has modified the model by substituting 'Non-self' for 'Other' to indicate that anything that is not Self is outside of the Self, and so it is Non-self. A similar assertion, also made by Kearney, is that all humans are aware of Self and of anything that is non-Self – only that Kearney named this non-Self category 'Other'. Cobern asserts that the ultimate inclusiveness – or universe – is composed of the Self and all that is not the Self, or Other (Cobern, 1991). The Self and Other (Non-Self) categories are the 1st-order universals forming the principal axis of a worldview (Cobern, 1991; Kearney, 1984). Humans in their Self operate among the Other, which indicates a relationship between the Self and the Other (Non-Self) represented by the pole, and hence the Relationship is universal. The opposite ends of this pole represent extremes of the relationship between the self and the cosmos. At the Self extreme, all is Self, whereas at the opposite extreme, nothing is Self and all is Non-Self (Other) within the cosmos. This Non-Self can be further divided. Cobern gives two probable examples of the Non-Self split: (1) Society and Nature, and (2) Redfield's tripartite division of Society, Nature, and the Supernatural or God (Cobern, 1991). As Lewis reports, awareness

of Self, Other and constituent parts within each group necessitates some kind of organization, such as the Non-Self split, and hence the classification 'Universal'. Any interactions existing between the Self and the Other, together with their constituent parts, are delimited to the notion of cause, hence the Causality universal. The Causality universal, according to Lewis (1998), contains assumptions or presuppositions about the nature of the interactions between the Self and Other, while these interactions are understood in terms of the time and space in which they take place. Relationship, Classification and Causality belong to 2nd-order universals, while time and space are 3rd-order universals. Time and space are intimately related to the Causality and Relationship universals. This is because, as stated by Cobern, the understanding of Causality is dependent upon the relationship between the Self and the Non-Self (Other) and upon understanding space and time. The view of Self or Non-self (Other) in the individual therefore influences the rest of the categories and is in turn influenced by society, shaping a common worldview specific to a certain society, but with personal differences of worldview between individuals (Cobern, 1996; Hokayem & BouJaoude, 2008).

Evolution is a theory explaining phenomena in nature. Nature has been defined as the notion of the 'Other' (Cobern, 1990; Liu & Lederman, 2007), therefore by exploring beliefs about evolution, the research is investigating the "Other" subunit. Furthermore, when expressing views about evolution one is bound to reflect on one's own position in relation to the natural processes defining one's existence, thereby relating the 'Self' to the 'Other' in nature which includes other species. By attempting to explain the events such as the origin of species, the notion of "Causality" comes to the fore as one explains the causes. Therefore, the logico-structural notions of "Self", "Other", and "Causality" are directly relevant in this study, while others like 'relationship', 'time' and 'space' are inferred.

With evolution sometimes being such a contentious issue, the worldviews that are usually related to evolution controversy are discussed next. Since the controversy over evolution often relates to religious views, the worldviews presented relate to religious predispositions.

3.9.4.2 Naturalism and theism as worldviews

Anderson (2007) gives two examples of worldviews from Sire's eight categories (Sire, 2004) as *naturalism* and *theism*, which may shed some light on the source of controversy surrounding the teaching of evolution. According to Smith (2010b, p. 545), two common worldviews germane to the conflict between evolution and some religions are materialism

and theism. Naturalism is a form of materialism, in that it treats matter as all that exists, with no supernatural, no history, no purpose (Smith, 2010a, 2010b). It is the notion that only natural or physical laws operate in the world, while any phenomena considered to be supernatural are false or explainable by natural causes. Theism is a state of believing in the existence of God. However, Sire (2009) shows that theists (those who believe in God's existence) differ on some issues including how one comes to know God; and whether the universe is matter only, form only or a combination. Therefore, theism and naturalism may be considered to be two ends of a continuum. According to Sire (2009, p. 67), in theism God is the infinite personal creator and sustainer of the cosmos, while in naturalism, God loses his existence. Placing deism in between the two, Sire shows that from theism through to naturalism, God is 'reduced', where in deism he begins to lose his personality though he remains creator and sustainer of the cosmos, until he totally ceases to exist in naturalism.

Anderson asserts that, while there is some correlation between worldviews and religion, a person with a theistic worldview is not necessarily religious (Anderson, 2007, p. 672). Similarly, Mansour (2008a, 2008b) distinguises between individual personal religious beliefs that are based on "Holy scripture and the sayings of God's Prophet" and personal religious beliefs which the individual forms through life experiences (Mansour, 2008a). The latter type of religious belief, therefore, does not necessarily have roots in religion. In one study, Moore *et al*. (2002) found students who had a grasp of the evolutionary concepts, but groped for a larger frame of reference with which to reconcile evolutionary theory. They stated that these wider frames of reference were not just faith systems of formal religion, but might include a wider modernist worldview (Moore *et al*., 2002, p. 70). The foregoing therefore suggests that, even though religion is a distinctive feature of all cultures (Aikenhead, 1997, p. 424), it need not necessarily be 'scriptural' – based on, for instance, biblical or scriptural beliefs. In the same vein, theism need not be influenced by scripture, but may result from other factors which may be cultural, social and environmental.

Therefore, naturalism, used in this study, refers to the belief that material forces are the basis for evolution, whereas theism considers, the involvement of God, or the supernatural in the processes of evolution. Thus, naturalists are those who believe only in the material and physical causes, while theists believe in the supernatural causes.

3.9.4.3 Evolutionism and creationism on a continuum

Concerning conceptions about the origin of the Earth, and of humans in particular, the two most prevalent views are *creationism* and *evolutionism*. Scott (1997) states that the public defines the 'creation versus evolution' controversy dichotomously, with creationists on one side and evolutionists on the other, but asserts that there is a continuum of positions rather than a dichotomy. Similarly, a continuum exists between naturalistic and theistic beliefs regarding evolution which correlates implicitly to the evolutionism and creationism continuum. Lawrenz and Gray (1995, p. 566) found that students at the University of the Western Cape could be placed along the naturalism and religion continuum. In other words, the students' worldviews ranged along a continuum from a position of naturalism at one end to one of religion at the other. In this study, therefore, a simplified version of Scott's continuum (Scott, 2000) would be a useful framework for an understanding of beliefs about evolution. Table 3.1 shows a simplified creationism-naturalism continuum presented by Scott (2000) used by Sanders (2010).

Table 3.1: The simplified creationism-naturalism continuum of Scott (2000) in Sanders (2010)

Creationists ↑	**Young-Earth creationists**	Interpret religious books literally. Earth and all living things created in six-24hr days and that the Earth is 6-10 thousand years old. Deny biological descent with modifications.	
		Flat-Earth	Believe that the earth is flat and circular, not spherical,
		Geocentrists	Accept earth is a sphere. Deny that the sun is the centre of the solar system. Accept flood geology
	Old-Earth creationists	Accept some scientific evidence (e.g. that the universe and earth are as old as described by astronomers and geologists) and accommodate some aspects of evolution in a number of possible ways.	
		Gap creationists	Assume a gap exists between Genesis 1:1 and 1:2, and that pre-Adamic creation destroyed before Genesis 1:2 when a divine being created the world in six days, and created Adam and Eve
		Day-age creationists	Recognize each of the six days of creation as long periods of time (thousands of millions of years) instead of 24 hours long
		Progressive creationists	Accept the fossil record as an accurate representation of history by explaining that divine being created "kinds" of plants and animals sequentially over a long period of time.
		Intelligent design creationists	Believe complex organisms could not have evolved by chance, and so must have been controlled by an "intelligent designer" – a divine being. Do not accept macro-evolution
	Theistic evolutionists	Accept evolution, but believe it is managed by a divine being, or that the divine being is controlled by laws of nature	
Naturalists ↓	**Materialist evolutionists**	Have a non-religious belief system which accepts only scientific explanations for life and its diversity. Some are neutral to religious ideas, while others say that the supernatural does not exist and thus reject the ideas of creationists	

3.9.5 Other theoretical perspectives

Besides the worldview and the logico-structural model, other theoretical perspectives have been incorporated for use in this study. These perspectives look into the classroom situation where science or evolution is taught and learned. For example, they include the relationship between science and religion, as perceived by the teachers and translated into classroom action, also the perspective describing the teaching and learning of science and evolution and the way in which it is managed by both teachers and learners.

3.9.5.1 Relating science to religion

In order to further understand the worldview influence on the teaching and learning of evolution, the relationship between science and religion is revisited. Barbour's (2000) four relationships between science and religion which are *conflict*, *independence*, *dialogue* and *integration* are useful in revealing how the teaching of evolution could be approached in schools (see also Anderson, 2007). These relationships may be used to categorise teachers according to their view of this relationship.

- *Conflict*. This category represents people who see religion and science as being at war, and therefore diametrically opposed. According to such people, science and religion cannot be at home with one another. These people contribute to the larger debates in religion and science which perpetuate the 'conflict'. While in one camp there are theistic religious fundamentalists such as Biblical literalists, the opposite camp contains atheistic scientists who claim that science is incompatible with the theistic religious outlook.

- *Independence*. In this category are people who do not see science and religion as being in conflict, because each serves a different function and purpose. Each domain resorts to a different language, epistemology and addresses different questions. They are therefore independent of each other, each in its own compartment. Although it avoids conflict, this compartmentalization also prevents constructive interaction. The position held by Stephen Gould, for instance, in proposing the *non-overlapping magisteria* (NOMA), is an example of this independence.

- *Dialogue*. As the term implies, this perspective views science and religion as being in conversation or dialogue with each other. This dialogue can present itself in the methods employed by each of the two, leading to an understanding of any similarities or differences between them. People with this view promote openness about the different approaches, and support critical discussion about the differences between religion and science.

- *Integration*. In this category, advocates seek a closer partnership between science and religion, and conceive of a possible integration between the two. Some people interpret scientific and theological ideas as being within a common conceptual framework. Others start from a scientific framework and subject religion to that, such

as looking for naturalistic evidence of the existence of God, while others start from a religious framework and want to reformulate some of their religious concepts in the light of science (Anderson, 2007). In the latter case, people seek to understand faith, for instance, in the light of science.

Table 3.2 represents the assumptions of potential teaching strategies for this study, based on the Barbour (2000) typology.

Table 3.2: Relationship between science (evolution) and religion (adapted from Barbour, 2000)

Type of relationship	Description of relationship
Conflict	For this study, a teacher who categorically states that there is conflict between evolution and religious beliefs and firmly believes in the conflict is placed in this category. The teaching does not allow discussions from religious vantage point and if students bring religious issues they are discouraged from doing so – specifically creationism in evolution class.
Independence	A teacher in this category emphasises that evolution is a scientific theory and religious views are based on faith, thereby responding to questions about natural phenomena differently. Teaching emphasises the two as co-existing but independent of each other.
Dialogue	A teacher in this category uses either evolution or religion to explain the other using any method to compare or distinguish the two by using their similarities or differences. Both evolution and creationism form part of the discourse. Conflicts are not necessarily done away with.
Integration	A teacher in this category may interpret evolution from a religious perspective or explain creation from a scientific perspective, or might have a common framework to explain the two. There is no loss of any one form of knowing.

These four relationships have been used to interpret and analyse classroom actions in studies looking at the role and influence of religion on science teacher performance (Anderson, 2007; Mansour, 2008a; Mansour, 2010) and investigating effective approaches for dealing with evolution controversy (Sanders, 2010). In the current study, these four perspectives are used to analyse and understand teachers' classroom actions in terms of how they present the content of evolution and engage with the learners during lessons.

3.9.6.2 Strategies for coping with teaching and learning of evolution from a controversial issue perspective

In view of the controversy surrounding evolution and other science topics, some researchers have explored the coping strategies used by teachers when dealing with such topics. Models such as the one presented by Hermann (2008) resulted from such research and is used in this

study. He defines four approaches: *advocacy*, *affirmative neutrality*, *procedural neutrality*, and *avoidance* (Hermann, 2008, p. 1017), with the strengths and limitations of each approach in the context of evolution instruction as reflected in Table 3.3 below.

Table 3.3: Teaching approaches for addressing controversial issues [compiled from Hermann (2008)]

Approach	Description
Advocacy	In this approach to evolution instruction, teachers enact curricula that move student thinking on evolution to be more in line with scientifically accepted understanding of evolution without discussing alternative views of evolution (p. 1018).
Affirmative neutrality	Affirmative neutrality occurs when the instructor presents an understanding of a controversial issue, like evolution from a variety of vantage points without emphasizing which vantage point they support (p. 1021).
Procedural neutrality	Procedural neutrality is an approach of eliciting perspectives on a controversial issue from students or resource material (p. 1022, citing Bridges, 1986).
Avoidance	Teachers avoid teaching evolution for one reason or another (Hermann, 2008, p. 1027).

Hermann contends that avoidance is not regarded as an effective approach to teaching controversial issues (including evolution). He argues that avoidance by teachers perpetuates the notion that evolution is controversial and that controversial topics should not be discussed (Hermann, 2008, p. 1027), so that this is unlikely to increase student understanding of evolution. Hermann concludes that only *affirmative neutrality* and *procedural neutrality* provide students with opportunities to address other ways of knowing about evolution, such as religious understanding (Hermann, 2008, p. 1029). In view of his analyses of these four approaches, this study explores the approaches and strategies teachers use when teaching evolution. Results from the study, while not intended to generalize teaching approaches in schools in South Africa, may give an insight into how teachers in their classrooms deal with evolution as a controversial topic.

This study has also been extended to assess the stress levels of teachers as they deal with evolution. Griffith and Brem (2004) use a framework adapted from Gray and Freeman (1988) who use the terms *personal*, *situational* and *external* to describe areas of stress that teachers go through in teaching. From their analysis, Griffith and Brem (2004) identify three categories of teachers: as *scientists*, *selective* and *conflicted*, depending on the strategies they use in coping with teaching evolution. *Scientist* teachers teach evolution by refusing to talk about anything but 'science' in their classroom; *selective* teachers avoid sensitive topics and

use highly-structured instructional strategies that help them maintain full class control; and *conflicted* teachers explore students' feelings in great depth while continuing with their own struggles and ruminations (Griffith & Brem, 2004). Smith (2010b, p. 546) finds the last category pejorative, and prefers to call it 'respectful' instead, since elsewhere Griffith and Brem (2001) state that these teachers convince students that they are not trying to change their beliefs. This model was used to place the teachers in that study into the three categories, with no intention to generalize. Table 3.4 below describes the relevant strategies, and has been extended to include the possible outcomes expected when such strategies are employed.

Table 3.4: Types of teachers and coping strategies used to teach evolution (adapted from Griffith & Brem, 2004)

Type of teacher	Strategies used	Possible outcomes of strategies (author's expansion)
Scientist	Talk only about 'science' in the classroom. Non-scientific issues not entertained in the classroom. Mainly empiricist approaches employed.	Should enhance understanding of nature and limits of science and the methods of science and promote scientific understanding of evolution, but might promote scientism[5]; might not deal sufficiently with alternative views including misconceptions; there is a possibility of alienating learners with alternative frameworks.
Selective	Avoid sensitive topics; use highly structured teaching style	Avoids controversy or getting into conflict, maintains control over class events and outcomes. Students' opposing views are not catered for, and any misconceptions they hold may remain, impeding meaningful learning.
Conflicted	Explore students' views in great depth; assure students' they are not trying to change their views	Students free to talk about their own views, and given opportunity to interrogate their own understandings, beliefs, values as well as learn from peers' contributions; however, conflicted students may remain as such, promoting mistaken views of both science and religion and hence scientism and / or creationism[6].

The in-depth data generated by the interviews gave an indication of the teachers' stressors, stress levels as well as how they cope with them. The categories generated from these data were correlated with the worldviews, using the naturalism-creationism continuum to find out if the teachers' beliefs correlate with the type of teacher as well as the way in which they cope with teaching evolution. However, this study has made no claims about the efficacy of any one coping strategy, since the strategies were not compared to reveal that information. Such efficacy would be interpreted in terms of reducing the conflict, preserving scientific content, maximising students' content knowledge, increasing teacher job satisfaction, or other

[5] Astley and Francis (2010, p. 198)
[6] Astley and Francis (2010, p. 198)

ways (Griffith & Brem, 2004, p. 805). More details on the procedures and analyses are given in Chapter 4.

3.9.6.3 Crossing borders when learning science

As outlined in earlier sections, the learning of modern science by learners whose worldview is not scientifically oriented, may encounter problems. The learning of science for them is similar to interacting with a foreign culture where they need to find a means of crossing from their everyday life-world culture to the scientific culture (see Aikenhead & Jegede, 1999; Jegede & Aikenhead, 1999). Such border-crossing is therefore seen as essential to enable learners to be comfortable with science. As emphasized by Jegede and Aikenhead (1999), border-crossing is used by 'indigenous' as well as 'Western' learners.

Four types of border crossing, from Phelan et al. (1991) are shown in Table 3.5.

Table 3.5: Types of border crossings (adapted from Phelan *et al.*, 1991)

Border-crossings	Learner categories	Influence on learning
Smooth	Potential scientists	• Cultures are congruent • Borders are easy to cross • Learners are comfortable
Managed	Other smart kids	• Cultures somewhat different • Borders can be crossed • Learners tend to just manage to learn
Hazardous	I don't know learners	• Cultures different • Borders impervious • Learners have difficulty crossing the borders
Impossible	Outsiders	• Cultures incongruent • Borders are impermeable • Learners' belief system too strong; learning is next to impossible

3.9.6.4 Positions on evolution

Dagher and BouJaoude (1997) identified seven perspectives which they collapsed into four major personal positions of students toward evolution: *for evolution*, *against evolution*, *compromise*, and *neutral*. The three that were left out were *noncommitted*, *confused* where the first reflects *unwillingness* to take a stand, and the latter the *inability* to take a stand, and *objections to evolutionary theory* (Dagher & BouJaoude, 1997). The four remaining positions are shown in Table 3.6.

Table 3.6: Positions that people might hold against biological evolution (adapted from Dagher & BouJaoude, 1997)

Position	Description of position
For evolution	Accept evolutionary ideas using arguments from an evolution or reconciliation perspective
Compromise	Reiterate the theory of evolution presenting arguments from a compromise perspective
Neutral	Neutral and reflect either a noncommitted or a confused perspective
Against evolution	Do not accept evolutionary ideas presenting arguments from a religion or anti-evolution perspective

Broadly, these are the positions toward evolution which may be adopted by teachers and learners. The choices teachers and learners make is determined by a number of factors, such as their conceptual understanding of evolution, acceptance of evolution as a valid scientific theory and their presuppositions about reality and the world – hence their worldviews.

3.10 SUMMARY OF THE THEORETICAL PERSPECTIVES

The decision to adopt the worldview theory as a frame of reference is in recognition of the fact that the worldview is shaped by environmental experiences and that it influences behaviour to some degree (Lewis, 1998, p. 23). This research took an approach that regarded worldview as a factor determining how and why people think and behave as they do (see Lewis, 1998; Moore *et al*., 2002). Furthermore, the worldview is viewed as the totality of person's understanding of the world, himself, and his place in the world. Notwithstanding this, the presuppositional variation in worldview universals gives rise to worldview variations in groups of people. It is therefore expected that the teachers and learners who informed this study would also show variations in their worldview, while in principle they may have an African, indigenous, religious or other worldview. The variations would be due to social, economic, religious, gender, ethnic or other cultural influences (Cobern, 1990; 1991). The logico-structural model is used because of its sensitivity to these intra-worldview variations (Cobern, 1990). Of course one takes into account, as specified by Yang (1998), that researchers' ways of knowing also affect their perceptions of cultural realities and their interpretations of differences. As argued in Ogunniyi (2012, p. 426), researchers should not denigrate teachers' and learners' beliefs by analysing their worldviews only in terms of the scientific paradigm, as this might be tantamount to violence against worldviews.

As the concept of evolution is taught in the classroom, the worldviews of both the teachers and learners which are inherent of their belief systems become crucial in fostering and

facilitating the learning of evolution. Teachers need to come up with strategies to cope and deal with their own conflicts – or, if not conflicted, to cope with dealing with learners who could experience conflict during learning. They therefore need to find suitable approaches that would facilitate learning about evolution regardless of their personal beliefs and the beliefs of their learners. As learning takes off and proceeds, learners may need to cross the borders between their life-worlds – in this case the life-world of the creationism worldview for religious learners, into the naturalist worldview of evolution. Depending on how easy the borders are for learners to cross, evolution can be understood or misunderstood, and it can also be accepted or not accepted as a valid scientific concept. The assumption here is that learners whose life-world does not clash with the naturalist view of evolution will cross the borders easily, to an understanding and acceptance of evolution, while the opposite happens for learners whose life-world clashes with the concept of evolution.

3.11 CONCLUSION

Although the worldview theory has been adopted to inform the methods and interpretations of this research, the idea is not to change the worldview of learners to a scientifically compatible worldview, nor are the teachers expected to have this scientific worldview. Also, the expectation is not that an evolution classroom will exhibit this scientific worldview. The main purpose of this research is to explore and understand what is going on in schools with regard to teaching and learning about evolution, and specifically to understand the effect that the beliefs of both teachers and learners have on evolution teaching and learning. The view that each individual has their own way of understanding the world through interacting with himself or herself and others in the world – the universe around himself and herself – led to the use of the worldview theory.

The complexity of evolutionary theory is acknowledged as well as the profound effect it has in classroom discourse. Also acknowledged is the complexity of the worldview theory when applied to research in science education. However, the introduction of evolution in the South African curriculum alongside the recognition of alternative forms of knowing requires that education looks at theories that engage people's knowledge and belief systems and, as a result, the multiplicity of worldviews that they bring to the educational discourse. This way of thinking challenges ideologies such as scientism, and calls for science education that best prepares individuals to practice science in their own, albeit not necessarily in universal ways. The fear of scientists is the erosion of scientific thinking and all that science is about, yet the

question would be: for what purpose does one learn science if one cannot use that knowledge in one's daily life?

What this chapter has tried to address is the idea that science, though it might itself be regarded as a worldview, has always been influenced, by and large, by the worldviews that prevailed at different times throughout its evolution and revolution. The dynamism of science is being felt now as it has been throughout its history. Learning from that history, realizing that science is for the people and not people for science, are what should inform the present day curricular and pedagogical decisions. The inclusion of evolution in the South African curriculum attests to this. Evolution is regarded by scientists as a unifying framework in the learning of biological sciences and beyond. The assumption is that, if this is realized, taught and learned as such, learners would be well-informed scientists who will be able to accept a concept like evolution. The question is whether this means changing their worldview, if they previously had a different one, and how this should happen if other forms of knowing, some with a practice different from that of science, are acknowledged and appreciated – as is required by the National Curriculum Statement (NCS).

Embarking on this kind of reform, when other parts of the world are still battling with debates around science and religion, for instance, requires a lot of diligence in the practice of science by the South African scientists and science educators. Such practice should foster appreciation and respect for other forms of knowing, while at the same time maintaining the advantage of science in providing answers about the world. While this is happening, the debates continue: is it science or religion, science or culture, science or indigenous knowledge, evolution or creation, or all of the above? Whereas the response should be: the 'best' of all, yet another question arises: as to which one is the best, for whom, where and in what context? For the teacher in the classroom, faced with curriculum requirements to fulfil, students from various backgrounds to teach – each with their own way of seeing and understanding the world, but eager to learn and use the knowledge gained to contribute in developments of their society – a teacher who also has his or her own way of viewing and understanding the world, the challenges abound. In addition, the teacher in the classroom has his or her personal way of understanding knowledge and of ways to enable learning to occur in his or her learners. The belief that the teacher has about his or her power to produce desired effects by his or her actions (Bandura, 2001) is a crucial element in the teacher's functioning. The challenge that remains is to understand the kind of belief system and

thought structures that science requires from learners and teachers alike. There is a need to have in place an epistemological foundation that would provide meaningful education in evolution and science in general.

CHAPTER 4
METHODOLOGY OF THE RESEARCH

4.1 CHAPTER OVERVIEW

This chapter outlines the methodology employed in this study, first presenting a brief background to the research. This is followed by a section outlining the design of the study, where the research paradigm and choice of methods and instruments used are discussed. This section also describes how the research population was identified and how the sample was selected. Next is a discussion of the development and pilot testing of the research instruments. This is followed by a presentation of data collection procedures. The section after that describes how data were analysed. The chapter ends by describing the quality assurance measures and the ethical considerations applicable to the research.

4.2 BACKGROUND

The aim of this study was to understand how the beliefs of teachers and learners about evolution influence evolution education in South Africa, focusing on secondary schools around the Vhembe District of the Limpopo Province in South Africa. It was expected that, at the time of the research, teachers would have had sufficient classroom experience with evolution to reflect upon and provide valuable insights for the study. Exploring the teaching strategies used would add to this understanding and identify any gaps that may exist in teaching about evolution. The study thus aimed at understanding what was going on at the classroom level regarding the teaching and learning of evolution. Teachers' and learners' experiences were explored to determine the factors that influence the formation of their beliefs and add to an understanding of their characteristics, and how these relate to their beliefs about evolution.

In order to reach such an understanding, the main question and sub-questions were formulated for the study (see also Chapter 1). This methodology chapter describes how those questions were answered, what was done to answer them, as well as why they were answered in that manner. The following are the questions of the study:

Main question

How do the beliefs of teachers and learners influence evolution education in secondary schools in the Vhembe District of Limpopo Province, South Africa?

Sub-questions

1. What do teachers in Vhembe district believe about evolution and what influence do their beliefs have on their teaching of evolution?

2. What do their learners believe about evolution and how do their beliefs influence their learning of evolution?

3. What factors influence the establishment of the beliefs of these teachers and learners about evolution?

4. How do the teachers and learners negotiate potential tensions between their beliefs and the requirements of the curriculum when teaching and learning evolution in Life Sciences classrooms?

The main question gives an overall picture of what was being investigated in this research, i.e. the influence of beliefs about evolution on the learning and teaching of evolution. Teachers and learners were regarded as sources of data, and in this capacity they were to provide the information required to answer the research questions. For instance, the first sub-question could be answered by surveying teachers' beliefs, but because the research focussed on only a few teachers in order to obtain detailed information, talking to them seemed the best way to explore those beliefs. Observing them in action would also provide information about the influence of the beliefs on their teaching. The second sub-question, on the other hand, could be answered by a more quantifiable survey, because there were many Grade 12 learners in the sampled schools. To obtain more information that would provide an in-depth understanding of those beliefs and their influence, it also became necessary to interview them and observe them during lessons. As with sub-questions one and two, the third one could be answered by a survey and interviews with learners as well as interviews with teachers. The fourth research sub-question could be answered by interviewing the teachers about what they do as well as by observing them in action. In order to obtain answers to these questions and to provide the understanding required, it became necessary to use procedures that were rigorous, justifiable and feasible, procedures which would lead to reliable, credible and valid answers as well as to strong conclusions as answers to the research questions.

4.3 THE DESIGN OF THE RESEARCH

In conducting a study of this nature, one needs to consider the position from which the research process is entered into and managed. By engaging in any enquiry, humans are looking not only for knowledge but also for reality or the truth of what is to be known. In

social sciences research, certain parameters are in place to enable researchers to progress in their search for knowledge. How any one researcher goes about their enquiry will be determined by the ideas, beliefs and assumptions that they have about the nature of reality and truth of what is to be studied. Firstly, one may consider the nature of the reality of what is to be known, or *ontology*. The second consideration is on how the researcher, or the knower, relates to the knowledge being sought, how he or she comes to know about the reality, and this is termed *epistemology*. Epistemology is thus the branch of philosophy that deals with the origin, nature and limits of human knowledge (Johnson, 2009). Thirdly considered is *methodology*, which refers to how the researcher "may go about practically studying whatever they believe can be known" (Terre Blanche & Durrheim, 2006, p. 6).

Two opposing perspectives; objectivism and subjectivism, have been used to discuss ontology, epistemology and methodology. Their use depends on whether one considers reality to be objective or subjective. An objective perspective holds that knowledge is absolute, separate from the knower, corresponding to a knowable, external reality. Subjectivism, on the other hand, holds that knowledge is not separate from the knower. Rather, knowledge is shaped by the inner characteristics or structures of the mind, language and culture. Objectivism advances that the purpose of the human mind is to mirror objective reality by way of thought processes and embodies an absolute value, while subjectivism holds that knowledge and reality lack objective or absolute value.

Babbie (2010) defines 'methodology' as a science of finding out, procedures for scientific investigation and a sub-field of epistemology. In the same vein, methodology in this research is defined as the approach used to find out, a sub-field of knowing. In order to find out, certain procedures are necessary. According to Miles and Huberman (1984, p. 20) "to know what you're doing, you need to know how your model of knowing affects what you are doing". Therefore, when developing the design for this study, decisions were taken to ensure that the design would be appropriate for leading to the desired outcomes and for finding out what was to be known. According to Durrheim (2006, p. 37) decisions are usually made along four dimensions, which are: purpose, context, techniques, and paradigm. For this study, the decisions made were about the purpose of the research, research questions that would address the problem, theoretical perspectives and the research paradigm, as well as the methods that would address the research questions.

4.3.1 Choice of research methodology

As part of the design process, two research orientations, qualitative and quantitative, were considered when deciding on the methodology. This involved drawing a comparison between the two, alongside the questions the study wanted to address. Krathwohl (1998, p. 231) states that comparing qualitative and quantitative methods is a bit like contrasting the use of essay questions with multiple-choice ones, or making a choice between the depth and the breadth of data gathering (*ibid.* p. 341). These two have been compared many times, from either a purist or a non-purist perspective.

Current debates revolve around the compatibility or incompatibility of the two approaches, with the purists arguing for incompatibility, while the multiple research movement is debating the best practices and benefits of mixing both approaches in research. These debates continue to affect how knowledge is viewed, what one looks for and expects to find, and how one believes one is to go about finding and justifying that 'knowledge' (Johnson *et al*., 2007). With the purist perspective, the focus is usually on differences and justification of the dominance of one approach over the other, leading to claims that the two are incompatible or irreconcilable, or what is called "incompatibility thesis" (see e.g. Denzin, 2012; Johnson & Onwuegbuzie, 2004; Johnson *et al*., 2007). Quantitative purists, subscribing to the philosophy of positivism, maintain that inquiry should be objective, and that the observer is separate from what has to be observed. In contrast to this, qualitative purists, subscribing to the philosophies of constructivism or poststructuralism, reject positivism and state that the "knower cannot be separated from what is known because the subjective knower is the only source of reality" (Guba, 1990 cited by Johnson & Onwuegbuzie, 2004). However, some researchers argue that epistemological purity does not get research done (Miles & Huberman, 1984), as both neo-positivism and neo-idealism constitute an epistemology continnuum and not a dichotomy (Johnson & Onwuegbuzie, 2004; Miles & Huberman, 1984).

Therefore, it is not necessary to stay with 'either-or', and it could be more productive to shift to 'both-and' formulations (Miles & Huberman, 1984), or to stick to "a strict qualitative-quantitative dichotomy" (Tashakkori, 2009, p. 288), as has been the case in this study. A synergistic approach in which the two approaches interact, so that their combined effect is greater than either approach, alone contributes to a softening of the differences between qualitative and quantitative research (Creswell, 2009). Going beyond the differences and looking at the similarities between the two also curtails claims of superiority. Some of those

similarities are: both utilize empirical observations to address research questions; and both incorporate into their inquiries safeguards which minimize confirmation bias and other sources of invalidity (Johnson & Onwuegbuzie, 2004).

Research in science and in the social sciences has traditionally been restricted to positivism, characterized by quantitative research techniques such as surveys and experimentation where data are presented numerically (Durrheim, 2006). Qualitative approaches, on the other hand, use methods like interviews and observations, and data are mainly given as words or narrative. As stated by Johnson and Onwuegbuzie (2004, p. 18), the major characteristics of traditional qualitative research are induction, discovery, exploration and theory or hypothesis generation; while quantitative research focuses on deduction, confirmation, theory or hypothesis testing, explanation, prediction, standardized data collection and statistical analysis.

Dealing with people, one cannot avoid subjectivity, especially when in-depth information is pursued; hence the inclusion of qualitative approach in this research. Qualitative data are a source of well-grounded, rich descriptions and explanations of processes occurring in a local context (Miles & Huberman, 1984, p. 21). Qualitative approaches therefore, are useful when the researcher wants to add richness to his or her findings (Farber, 2006). The qualitative approach is informed by a constructivist paradigm, based on an interpretive framework where the interaction between researcher and the subject matter is crucial for understanding the situation from the point of view of those inside it (Engelhart, 2001, p. 375). My role in this research was to observe phenomena and describe what I saw in detail rich enough so as "to understand the phenomena in context" (Terre Blanche *et al.*, 2006, p. 276). This involved looking at the teaching and learning about evolution in the "natural setting, attempting to make sense of, or interpret, those phenomena in terms of the meanings" (Denzin & Lincoln, 1998, p. 3) brought to the classroom by teachers and learners. Observing teachers and learners during the teaching and learning of evolution in a natural setting was thus crucial to arrive at an in-depth understanding and knowledge of the influence of the beliefs of both teachers and learners.

Knowledge-building in this regard was based on observational and interactional ways of knowing (Hesse-Biber & Leavy, 2006). This study provides teachers' perceptions of a situation that permits an understanding of their behaviour in the classroom. Understanding or

'knowledge', as Krathwohl (1998, p. 236) notes, is a social construct of behaviour, a joint product of the culture and the meanings assigned by the individual.

To strengthen the research design, in "an attempt to secure an in-depth understanding of phenomena" (Denzin & Lincoln, 1998, p. 4), and "capture the complex, multifaceted aspects of teaching and learning" (Kagan, 1990, p. 459), collection strategies for multiple data were used. Essentially, both qualitative and quantitative approaches were considered important and useful in gathering data for this study. This study therefore used a multiple method design.

In this research, the design adopted borrows from 'mixed methods research' which has been strongly linked to Dewey's philosophy of pragmatism. This is because it offers an epistemological justification and logic for mixing approaches and methods, and is able to integrate perspectives and approaches (Johnson & Onwuegbuzie, 2004; Johnson *et al*., 2007). Pragmatism is a "paradigm that debunks concepts such as 'truth' and 'reality' and focuses instead on 'what works' as the truth regarding the research questions under investigation" (Teddlie & Tashakkori, 2009, pp. 7-8). Therefore, as argued by Johnson and Onwuegbuzie (2004), pragmatism is an important theoretical position for researchers who hold certain assumptions about the construction of knowledge. These assumptions, as articulated by Luft *et al.* (2011), include recognizing that there is a natural world we can describe, and an emergent social world that we can explore; that both subjective and objective viewpoints are important when exploring phenomena, and that knowledge and truth will change over time.

What seems to be at the core of mixed methods research is enquiry that focuses on collecting, analyzing and mixing both quantitative and qualitative empirical material – i.e. techniques, methods, approaches, concepts – in a single study or a series of studies (Denzin, 2012; Johnson & Onwuegbuzie, 2004). Although the methodology in this study may not be defined as mixed methods research, it relies on qualitative and quantitative viewpoints, data collection and analysis to address the research questions. The mixing of methods enabled better description and exploration of phenomena, as the two approaches responded to both the objective and subjective entities of the study, and offered a methodology that was both confirmatory and exploratory. In this study, data about teachers' beliefs were obtained mainly qualitatively and data about learners both quantitatively and qualitatively. Combining both qualitative and quantitative approaches was therefore deemed essential in, not only addressing the research questions, but also to triangulate the findings of the research. In this study, triangulation is achieved by use of different methods to collect the data. This type of

triangulation, referred to as method triangulation (see Krathwohl, 1998), assesses the same aspect of a phenomenon. In this research, the use of both the qualitative and quantitative methods "reflects an attempt to secure an in-depth understanding of the phenomenon" (Denzin, 2012, p. 82), in particular, to assess learners' beliefs about evolution and their effect on learning. Triangulation also involves comparing data to see if there is agreement among different sets.

Mixing methods in this way was meant to provide a wider and deeper picture from different perspectives and angles. The teachers and learners were interviewed and classrooms observed to gather qualitative data. If this is done with a single methodology, generalizability would be limited. Therefore, to have a more general picture of learners' beliefs in the schools sampled, a more descriptive and confirmatory approach was added by use of questionnaires in order to allow for measurement and analysis of relationships between variables regarding beliefs and perceptions of learners. Since the study sought to understand the influence of learners' beliefs concerning their learning about evolution, "the quantitative data" provided a "fuller understanding" (Hesse-Biber & Leavy, 2006, p. 319) of this situation in a complementary manner, so as to capitalize on the strengths of the methods used.

Classroom observations were conducted first, followed by learner questionnaires and then interviews with both teachers and learners. Follow-up interviews were conducted with the teachers to clarify some issues that emerged from earlier data. They formed the last part of data collected, and were informed by data from other sources including learners. The use of both qualitative and quantitative approaches could capitalize on the strengths of these two techniques and perhaps even offset the weaknesses of each. Figure 4.1 on the next page is a pictorial representation of the processes involved, starting with the research questions and leading to data collection. The broken line indicates a possible link between the teachers' final interviews and learners' interviews, where information from the learners' interviews would, if necessary be used in teachers' interview.

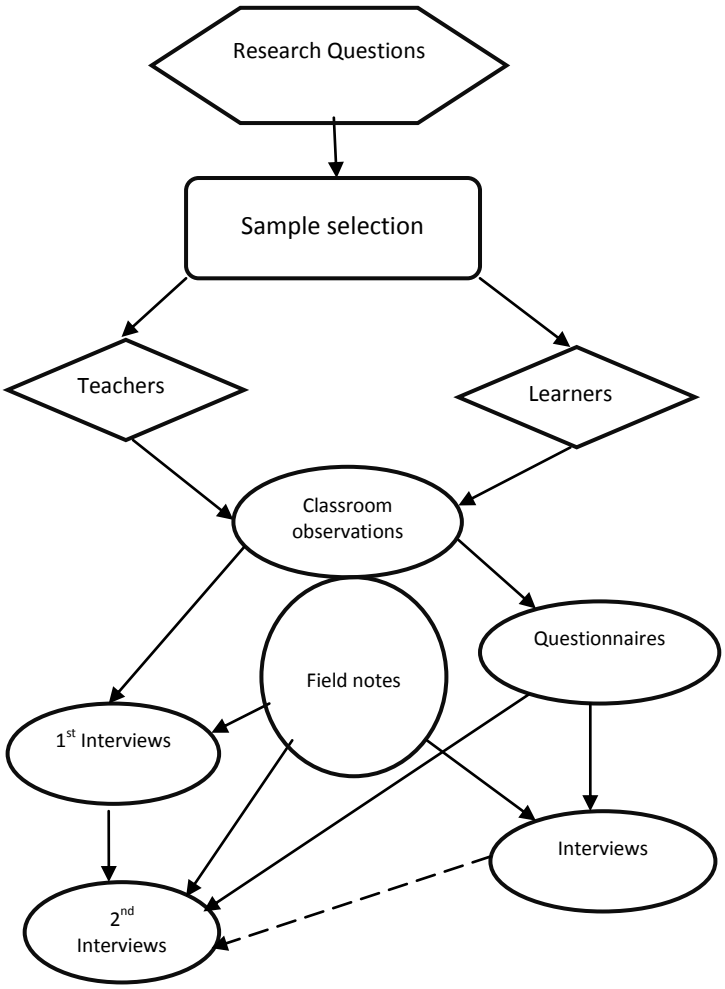

Figure 4.1: Outline of research methodology including data collection procedures

4.3.2 Design of research instruments

This study aimed to explore people's beliefs about evolution, this being a model that incorporates theories that attempt to explain the origins of species or of life and the current variations among life forms on earth. Multiple data sources were used to answer the questions of the study. Instruments were designed to enable the research to uncover numerous perspectives while elaborating on the complex realities of each participant with respect to the situations they faced (Griffith & Brem, 2004). This would provide rich data and attempt, to some extent, to draw general conclusions from the analyses.

Some of the questions in the interviews were designed qualitatively to explore the beliefs of teachers and learners in relation to the logico-structural notions of "Other", "Self" and "Causality". Other questions explored teaching and learning strategies.

4.3.2.1 Quantitative data collecting instruments

(a) Questionnaire for learners

A questionnaire (see Appendix 2) was used to survey the beliefs of learners, adding the quantitative dimension to the study. Having a larger sample of learners meant that the findings would not be confined to "a very vocal few", and enabled the collection of "enormous amounts of information efficiently and quickly" (Krathwohl, 1998, p. 425). The questionnaire was designed with the support and assistance of two statisticians at the university. It had three parts, which covered: biographical information, acceptance of evolution, and beliefs about evolution and attitudes towards learning it. The questionnaire was administered in order to allow for measurement and analysis of associations between variables regarding beliefs and perceptions of learners related to evolution.

The first section of the questionnaire canvassed biographical information about the learners, covering aspects such as gender, age, ethnic group, religious affiliation and participation in religious matters, parents' highest level of education, and learners' willingness to learn about evolution. Spaces were provided on the questionnaire for filling in the information required. In some cases, respondents had to choose from a given list of possible answers, and tick an appropriate box. This section ended with an open-ended question, in response to which learners were to give one single comment about evolution. Even though the questionnaire was administered after classwork was completed, this question was intended to provoke personal responses, as it did not ask learners for their understanding. However, having learned about evolution would give the responding learners information to reflect upon as they gave their comments. The expectation was that the comments would reflect presuppositions about evolution and give an insight into worldviews.

The second section of the questionnaire was of a closed-ended multiple-choice type which investigated learners' acceptance of the notion of evolution. Learners were to decide whether they agreed strongly, agreed, disagreed or strongly disagreed with the statements given, and tick the appropriate boxes. The measure of learners' acceptance was seen as giving an indication of how they evaluate the substantive and syntactical elements of evolution, its fundamental concepts, and of the nature of science (Rutledge & Sadler, 2007). As a body of scientific theory, the knowledge in evolution has been established by a methodology that has been validated. Decisions to accept or to reject it, therefore, may be based on how learners evaluate the methodology applied in coming up with the substance making up the concept of

evolution. In other words, such decisions should consider if evolution is the best valid explanation for the phenomena it is trying to explain, based on available evidence.

To design the part of instrument measuring learners' acceptance of evolution, an adaptation of a 20-item 5-point Likert-scaled Measure of Acceptance of the Theory of Evolution (MATE) instrument, developed and validated by Rutledge and Warden (1999) was done. The reliability of Rutledge and Warden's instrument was found to be .98. It was later evaluated for its reliability in measuring university student acceptance of evolution by Rutledge and Sadler (2007) where it achieved a Cronbach alpha of .94. The slight difference in the two figures may be attributed to the contexts under which the MATE was used. This instrument has been developed to assess overall acceptance of evolution among high (secondary) school biology teachers (Rutledge & Warden, 1999). It has been used at college level to assess the acceptance of evolution by Biology students (Hokayem & BouJaoude, 2008) and by pre-service teachers (Deniz *et al*., 2008).

The instrument has been adapted for use in this study to measure learners' acceptance of evolution. Items added to MATE by Cavallo and McCall (2008) were added to this questionnaire to "evaluate overall [learner] perceptions of evolutionary theory" (Cavallo & McCall, 2008, p. 526).

To adapt it for use in this study, where the subjects were secondary-level learners, the instrument was subjected to reviews by experts in Biology education and in research methods. This was followed by changes to the instrument, by which some items were re-worded to make them easy to understand and respond to by a Grade 12 learner. The changes included converting the scale from 5-point to 4–point in this study by not including the variable 'undecided'. Also, two of the items were split into two items each, and one item into three items, to make them simpler. An example is the item which read "*Current evolutionary theory is the result of sound scientific research and methodology*", which was split for the purposes of this study into "*Current evolutionary theory is the result of sound scientific research*" and "*Current evolutionary theory is the result of sound scientific methodology"*. One item was not included in this study because, in the original Rutledge and Sadler's (2007) MATE, there were two items with the same content where one was stated positively and the other stated negatively. The two items were "*Evolution is not a scientifically valid theory*" and "*Evolution is a scientifically valid theory*". In this study, the former negatively stated item was left out, while the latter positively stated was retained. The reason for the exclusion

was to avoid any confusion that might arise as learners in this study, who were mainly second-language readers, dealt with a negatively-phrased question. Furthermore, the two items adapted from Cavallo and McCall (2008) also generated an extra item because of re-wording. The result of these changes was a 4-point Likert-scale instrument with twenty-seven (27) items.

To validate the MATE used in this study, its internal consistency was determined using Cronbach's coefficient alpha. "Internal consistency describes the extent to which all the items in a test measure the same concept or construct" (Tavakol & Dennick, 2011, p.53). It is estimated by determining the degree to which each item in a scale correlates with every other item in the scale (Durrheim & Painter, 2006, p. 154), or what Cohen *et al*. (2011, p. 640) refer to as "a coefficient of inter-item correlations". According to Tavakol & Dennick (2011), alpha is affected by test length and dimensionality where a low value may be due to "a low number of questions, poor interrelatedness between items or heterogeneous constructs" (*ibid*. p. 54). Cronbach's alpha is a number ranging from 0 when there is no correlation, to 1 when the correlation is at maximum. According to Durrheim and Painter (2006), questionnaire-type scales with an alpha value greater than 0.75 are considered reliable in terms of internal consistency. Cohen *et al*. (2011, p. 640) give guidelines some of which are that anything higher than 0.90 is 'very highly reliable', 0.80-0.90 'highly reliable', 0.70-0.79 'reliable', 0.60-0.69 'marginally reliable' and <0.60 unacceptably low. A Cronbach's alpha of 0.85 was obtained for the MATE instrument used in this research, indicating high reliability. This is an indication that the MATE instrument was reliable, meaning that the items of the instrument were related and that they measured the same psychological construct, the acceptance of evolutionary theory.

As the name of the MATE implies, its main purpose is to measure learners' acceptance of evolution. A distinction between learners' beliefs in a construct such as evolution and acceptance of that construct has been drawn (Nadelson, 2009; Nadelson & Southerland, 2010; Sinatra *et al*., 2003). Unlike beliefs which are based on personal convictions, acceptance of knowledge is based on an evaluation of persuasiveness, plausibility and fruitfulness of the evidence for the construct (Nadelson & Southerland, 2010; Rutledge & Sadler, 2007).

While the MATE was used to evaluate learners' acceptance of evolution, there was still need to explore their beliefs about evolution. A third section with open-ended questions was added

to the questionnaire for this purpose. This section investigated learners' beliefs about evolution and attitudes towards learning about it, also the strategies they used in their learning, including sources they used to enrich their understanding. As discussed more fully in Chapter 3 of this dissertation, beliefs are understood as a subjective way of knowing and are considered as personal truths that learners have about the world (Sinatra *et al.*, 2003; Deniz *et al*., 2008). It was important in this study to investigate the beliefs of learners *after* learning about evolution, when it would be expected that they had acquired some knowledge about evolution, and hence establish their beliefs concerning the substance of evolutionary theory. This section did not therefore look for learners' understanding of evolution, but for the personal and subjective meanings learners give to evolutionary theory. Investigating their attitudes would provide an insight into their epistemological commitment to learning about evolution. They were also asked to provide suggestions for the teaching of evolution, if they had any. This section of the questionnaire was open-ended so as to enable the learners to express their personal views about and related to evolution. Learners were to answer the questions openly and freely and in their own words in the spaces provided in the questionnaire.

In designing the questionnaire, which included adapting some parts such as the MATE section, I worked backward or from what the report should contain to the needed questions (Krathwohl, 1998, p. 362) – that is, with the end in mind. The questionnaire was shared with two experts in questionnaire design, one in Life Sciences education, and two Life Sciences teachers. This enabled the face validation of the instrument as well as assuring of content validity. Validating the instrument was important to check that it measured what it was supposed to measure. It was also piloted in one secondary school, and further improvements were made. The improvements included change in the wording of the instructions and the questions themselves. The main purpose of the changes was to make the questionnaire understandable to Grade 12 learners. Five hundred questionnaires were then prepared to cover the Grade 12 learners in the five schools.

(b) Questionnaire for teachers

The teacher questionnaire (see Appendix 3) was used for gathering teachers' biographical data and some perceptions they had about evolution. It was structured in such a way that teachers had to fill in spaces. The biographical information included teacher's age, gender, religion, teaching experience in general and for Life Sciences and evolution in particular.

4.3.2.2 Qualitative data collection instruments

The data collection involved talking and listening to participants during interviews, as well as observing teachers and learners in action. These two methods, including the notes taken, were sources of verbal data, hence the qualitative approach to the analysis. According to Miles and Huberman (1994, p. 10), "qualitative data focus on naturally occurring, ordinary events in natural settings" and gives the researcher "a strong handle on what real life" is. This study thus used classroom observations to gather 'real life' classroom experience about the teaching and learning of evolution. The interviews were used to obtain in-depth information about the beliefs of teachers and learners and experiences regarding evolution and its education.

(a) Interview schedules for learners

The interview schedule for learners (see Appendix 1) comprised of a list of questions that learners were required to respond to. Learners' responses to the questions sometimes generated further discussions where clarification was necessary. The interviews were not intended to be used with all the learners in the study, but only a selected few. The small number of learners would enable gathering of data with depth and richness as a result of more time thus being available, both for interview and for analysis.

The information supplied by respondents would enable the accumulation of rich data concerning the beliefs of learners about evolution, and what they perceived as the influence of those beliefs on their learning. No question was aimed directly at assessing their content knowledge, even though they had already concluded the learning about evolution at the time of interviews. Instead, the questions checked their views about the origin of species prior to learning about evolution, and how they thought those views affected their learning about evolution. They were also asked if they still held the same views, or if there was a change in the views after instruction. During the discussions in the course of the interviews, learners would consider their understanding of evolution prior to and after instruction, so as to offer a rich explanation of their views and beliefs. In addition, learners would indicate whether or not they were in favour of learning about evolution. To further establish how deeply they felt about evolution, learners were asked to give their opinion concerning the inclusion of evolution in the National Curriculum Statement. In the course of expressing such opinions, they would indicate how strongly they felt, either positively or negatively, about learning evolution. They were also asked how they thought they would perform in a question about evolution in the final examination, so as to establish their confidence regarding their

understanding of evolution. These questions were asked of them in a face-to-face verbal interview. The interviews were recorded on audio tape.

(b) Interview schedules for teachers

The interview schedule for teachers (see Appendix 4) comprised a set of questions which were asked to the teachers. The responses given by the interviewees allowed new ideas that could be discussed further in the interview, thus making the interviews open. The interview elicited verbal responses which were recorded on audio tape, covered their knowledge and understanding of evolution, their views about it and whether those views affected the way they taught evolution. There was also a second interview conducted with all the teachers. Since the purpose was to clarify issues emerging from other data and close any gaps, there was no schedule for these interviews. The questions asked to the teachers aimed at addressing specific issues with each teacher and were thus tailor-made for that purpose.

(c) Classroom observation schedule

According to Marshall and Rossman (2006, p. 98), observation entails the systematic noting and recording of events, behaviours, and artifacts in the social setting chosen for the study. In this study, observation were done to enable the researcher to document and describe the actions and interactions taking place in the classroom. The classroom observation schedule (see Appendix 5) was designed to incorporate a checklist component and some blank spaces to allow for information to be supplied by the observer. The checklist mainly covered the pedagogical practices used in the classroom, as found in the three parts of the lessons: introduction, body of the lesson, and conclusion. Observations are useful when one wants to understand how people behave in a particular setting (Esterberg, 2002). Specific teacher and learner activities, such as question-and-answer or discussions and involvement of learners, were looked for. Strategies, including the grouping of learners and how the grouping methods were used, as well as whether or not the strategies were learner-centred, also formed part of the information canvassed by the instrument. The instrument included spaces that allowed for comments, note-taking and observer reflections. Such notes were formed from observations not catered for in the checklist, such as behaviour, and some comments from learners and teachers in and out of class. The assumption was that "behaviour is purposeful and expressive of deeper values and beliefs" (Marshall & Rossman, 2006). Data from the observations would therefore give an insight into the beliefs of teachers and learners as well as how the teaching and learning processes went on. The instrument was shared with research specialists

and peers for improvement. Besides the checklist, there was space left for writing notes and any emerging insights about actions and behaviour.

4.3.3 Choice of participants for the study

Given the information required to answer the questions, teachers and learners were the main sources of data for this study. Teachers were conceptualized as the major actors and mediators (Van Rooy, 1997) between the National Curriculum Statement (Grades 10-12) and the learners. Learners were, on the other hand, conceptualized as recipients of the content of the curriculum. It was found, in the course of browsing through the National Curriculum Statement (DoE, 2003a), that the foundational concepts of evolution were covered in Grade 10 and in Grade 11 Life Sciences, but the term evolution appeared for the first time in the Grade 12 Life Sciences curriculum under the knowledge area 'Diversity, Change and Continuity' as shown for Grades 10-12 (General) for Life Sciences (see DoE, 2003a, p. 40). Evolution was part of Grade 12 Life Sciences, and a learner studying Life Sciences at this level was bound to encounter the concept of evolution. Considering the purpose of the research and the research questions which needed to be addressed, therefore, it was judged that Life Sciences teachers at Grade 12 and any Grade 12 learners who studied Life Sciences would be the most suitable as participants in this study.

4.3.3.1 Identifying the population for the study

Since the study was to be set up in Vhembe District in the Limpopo Province, all of the Life Sciences teachers and Life Sciences learners in the district formed the largest pool of individuals, the population, from which a representative sample would be selected to take part in the research. As stated by Durrheim and Painter (2006, p. 133), a population encompasses all the elements that make up the unit of analysis. Because there was need for information from classroom teaching and learning, where such information had to be obtained directly from schools and not only individuals, the secondary schools where Life Sciences was taught at Grade 12 provided the teacher and learner population.

4.3.3.2 Selecting samples for the study

The purpose of sampling was to select individuals from the population that could address the research questions (Teddlie & Yu, 2007). To select a sample, consideration was given as to individual members who would be the best sources of the information required. As already indicated, any Life Sciences teacher and any Grade 12 Life Sciences learner would be

suitable as an informant. The 283 secondary schools in the Vhembe District were regarded as population units which would be used to provide the samples of teachers and learners to be respondents in the study. Considering its design, which included qualitative methods to collect rich information from schools, not all of the schools could take part in the study at any one time. A few schools were then selected, so the sample consisted only of those teachers and learners who belonged to the selected schools.

(a) Selection of schools

Any secondary school in the district where Life Sciences was taught at Grade 12 could have been selected for the study. The population for the study was divisible into sub-groups, defined by the areas in which the various schools were found, such as urban, semi-urban, and rural. As stated by Gardiner (2008, p. 8), among others, the terms 'urban' and 'rural' have a complicated history in South Africa, and there is still no agreement about what constitute urban and rural areas. However, Statistics South Africa (Statistics SA) (2010, p. 119) defines an urban area as "formal cities and towns characterised by higher population densities, high levels of economic activities and high levels of infrastructure". It also defines a rural area as "farms and traditional areas characterised by low population densities, low levels of economic activity and low levels of infrastructure" (*ibid.*, p. 113). In this research, 'urban' was used to refer to those areas classified as 'cities or towns' while 'semi-urban' areas are those areas found close to towns, and 'rural' refers to places outside of towns (see Statistics SA, 2010). The purpose was not to insinuate any competitive relationship among these classifications; rather, it became important to establish some degree of representativeness (Durrheim & Painter, 2006). A decision was made to select schools from all three types of area; urban, semi-urban and rural parts of the district, thus forming three population descriptions. Also, those schools that would be easily accessible during the research were preferred, so to this extent convenience selection was employed.

A number of schools fitting the three criteria were thus identified and approached to request permission from principals to conduct the study. The schools whose principals granted permission were selected. Because the number of schools was not the same in all groups, and even the number of learners from the schools was different, this sampling was disporportionate (see Durrheim & Painter, 2006). However, considering that the Vhembe District is described as rural, few schools in the District would actually qualify as urban. The

disproportionate sampling could therefore be seen as representative of the actual distribution of the population in the District.

The schools selected were those which agreed to participate. There were five such schools at the onset of the research. However, during the initial data collection procedures, one more school was added, giving a total of six. During the process of collecting data, one school was dropped as a result of the challenges encountered with it. In what turned out to be the last visit to the school, the principal expressed concern about the research, stating that it could not continue because it was disrupting learning. The concern was that the researcher's visits were distracting learners, especially the lesson observations which had to take place during normal teaching time. Furthermore, because the Grade 12 class would be writing external examinations, they needed to focus on studying and not on the research. When these concerns were raised, the data collection had already started. It was felt, therefore, that changing the procedures would jeopardize the validity and trustworthiness of the findings. Already it had been difficult to meet the teacher and learners in this school. Some visits had to be cancelled because the teacher was not available, or not taking phone calls, or because learners were doing tests and not having normal lessons. Therefore the decision was made to exclude this school, remaining with the other five. The final sample was therefore as follows: two rural (Schools A and B), two semi-urban (Schools D and E), and one urban (School C). Attempts to include a second urban school were not successful.

(b) Selection of learners

There was need to survey the beliefs of Grade 12 learners from the participating schools. The purpose of the survey was to generate more representative and generalizable data, if not for the district, then for the schools where the research was conducted. All the Grade 12 Life Sciences learners in the selected schools therefore automatically became the sample for the survey. Since participation in the study was voluntary, the questionnaires were administered to all the learners who consented to participate in the study.

There was also a need for richer in-depth information from the learners. This required a smaller sample of learners to be selected for individual interviews as opposed to the number responding to the questionnaires. This small sample was selected from those learners who responded to the questionnaire, so that the latter group formed the sampling frame for the subsequent qualitative strand of interview responses (Durrheim & Painter, 2006; Teddlie & Yu, 2007). These small samples from the five schools would also allow for saturation of data

(Teddlie & Yu, 2007). Initially, five learners were intended to form a school sample for interviews. The sample was self-selecting, in that the learners, being aware of the purpose of the research and having completed the questionnaire, volunteered to be interviewed. The assumption was that the learners who would volunteer would be giving an indication that they still wanted to share more views about evolution, beyond what they had already expressed in the questionnaires. However, in all the schools more than five learners indicated that they were willing to be interviewed. In two schools where there were six volunteers, I decided to interview them all, though in one of these schools only five turned up for the interview. In the other three schools where there were more volunteers, smaller samples were selected randomly by just picking their questionnaires. In two schools seven were selected, and in one school eight. Table 4.1 shows the number of learners interviewed at each of the five schools.

Table 4.1: Samples of learners interviewed per school

School	Number of learners interviewed	Percentage
A	7	21.21
B	6	18.18
C	5	15.15
D	8	24.24
E	7	21.21
TOTAL	33	99.99

(c) Selection of teachers

No questionnaire survey was conducted among the teachers, but rather information was obtained by means of biographical data questionnaire, interviews and from being observed in action in the classroom. This was because depth of data was required from this group, including not only their beliefs but also an understanding of their teaching strategies. Therefore only a small sample of those teachers teaching Life Sciences was required in the participating schools. In four of the schools in the study, there was only one teacher who taught Life Sciences at Grade 12 level. In the fifth school, the teaching of Grade 12 Life Sciences was shared with other teachers, but the participating teacher was the only one who taught the sections of the syllabus that included evolution. The participating teachers were the only ones from the selected schools who could provide any information about teaching

evolution at the time of the research. Thus the sample of teachers was selected by virtue of teaching evolution in Grade 12 Life Sciences at the time of the study.

4.3.4 Pilot-testing of the instruments

The instruments were all pilot-tested in the year before full data collection. The learners' questionnaire was tried out with ten learners, and the interview was piloted with two learners in one of the schools, where the observation schedule was also tested. The teachers' questionnaire and interview were pilot-tested at a different school because at the first school the teacher was unavailable at the time of testing the instruments. The main purpose of the pilot-test was to check if the questions were understandable, contextualize the content to South African situation and improve accordingly. Improvements resulting from these trials included change in design and presentation of instruments, in some cases simplifying the language. Some questions in both the learner interview schedule and the teacher interview schedule were removed; others were rephrased, and new ones added. Also, the order was changed so that there was a better flow in the matter being discussed. The overall result was a shorter learner interview schedule – from ten to eight questions – and the teacher interview schedule increased by one question.

4.4 DATA COLLECTION PROCEDURES

Data were collected for both quantitative and qualitative analysis as part of the multiple methods design employed in this study. Table 4.2 gives a summary of the data collection and data analysis procedures employed in the research.

Table 4.2: Summary of data collection and data analysis procedures against research questions

Research sub-questions	Data collection methods	Data Sources	Data captured	Data analysis
1. What do teachers in Vhembe district believe about evolution and what influence do their beliefs have on their teaching of evolution?	Questionnaires Interviews Classroom observations Field notes	Teachers (5) Schools (5)	**Biographical**: gender, age, religion, service length, qualification, evolution education **Social upbringing**: beliefs **Teaching evolution**: Content, beliefs, experiences, concerns, pressures	Seven-step model
2. What do their learners believe about evolution and how do their beliefs influence their learning of evolution?	Questionnaires Interviews Classroom observations Field notes	Learners (348) Learners (33) Learners (342) Schools (5)	**Biographical**: gender, age, race/ethnic group, religion, **Acceptance of evolution** **Learning about evolution**: beliefs, concerns, experiences, strategies, reflection	Frequency analysis Seven-step model
3. What factors influence the establishment of the beliefs of these teachers and learners about evolution?	Questionnaires Interviews Field notes	Learners (348) Teachers (5) and Learners (33) Schools (5)	**Social upbringing**: religion, religious beliefs, education	Seven-step model
4. How do the teachers and learners negotiate potential tensions between their beliefs and the requirements of the curriculum when teaching and learning evolution in the Life Sciences classrooms?	Classroom observations Interviews Field notes	Teachers (5) Learners (33) Schools (5)	Teaching and learning strategies Communication strategies; questions and answers; comments	Seven-step model

This research was content-specific in that it investigated the teaching and learning about evolution as a topic in Life Sciences. For this reason, data collection could only take place at the time when this topic was being taught in schools. The teachers in the sampled schools followed the schedule outlined in the *Pacesetter for Life Sciences Grade 12 - 2012*, provided by the Provincial Office of Education (see Appendix 6). This meant that the teaching of this topic took place at about the same time – during the months of February and March, 2012 – in these schools. Qualitative data were collected by interviewing the five teachers and thirty-three learners from the five schools as well as by observing lessons given on evolution. The field notes taken during the school visits also formed part of the qualitative data.

4.4.1 Quantitative data collection

The questionnaires were administered after the classroom observations had been completed and soon after instruction about evolution was also completed in the schools. Of the 483 Grade 12 learners in the five schools, 348 (72.50%) responded to the questionnaire. The time it took learners to respond to the questionnaire ranged from 20 minutes to 45 minutes. Specifically, they were administered before the teachers' and the learners' interviews.

So that any damaged questionnaires could be replaced, the number taken to the schools was slightly higher than the number of the learners expected to respond to them. The questionnaire was first explained to the learners, so that they knew in advance how they were expected to respond to each of the three sections. For instance, Section A had both closed-option and open-ended questions, while Section B had only closed-option ones and in Section C only open-ended questions were asked. Learners were made aware that they were free to ask for clarification where necessary. They were also informed that all responses would be considered in the analysis, and that there was no right or wrong answer: whatever they wrote would be accepted. This was intended to put them at ease so that they did not feel pressured to provide 'correct' responses, especially as they had just completed learning the topic. The cover page of the questionnaire, which was removed prior to data capturing for analysis, had a section where the learners were to write their names and indicate, by putting a cross or a tick in a box, whether or not they wanted to be interviewed.

4.4.2 Qualitative data collection

Qualitative data were collected in questionnaire by use of open-ended questions in part of Section A and in Section C. Spaces were left in the questionnaire to enable learners to

respond to these open-ended questions. In addition, more qualitative data were collected by use of interviews with teachers and learners, classroom observations and field notes. The next sections outline how the qualitative information was captured.

4.4.2.1 Conducting interviews for teachers

Interviews are good for finding out what people think or feel about something (Esterberg, 2002, p. 36). According to Marshall and Rossman (2006), interviews are based on an assumption that the participant's perspective on the phenomenon of interest should unfold as the participant views it, the emic perspective. It is not the researcher views (the etic perspective) that is of interest (*ibid*.). The interviews were used in order that I should keep an open mind. I needed to be open to any new ideas that could arise during the interviews as well as to ideas that I did not expect, since one cannot predict what will emerge from participants' responses. According to Hesse-Biber Leavy (2006), in-depth interview is a way of gaining information and undersrtanding from individuals on a focussed topic. In this spirit, teachers were interviewed to elicit their views regarding their beliefs about evolution and how those beliefs influenced their teaching of evolution in Grade 12 Life Sciences classrooms. The interviews also covered their knowledge of evolution, and the pedagogical practices applied in teaching about evolution. Other information gathered included teachers' experiences with teaching evolution as well as how they dealt with conflicts if they arose during lessons.

There was one main interview held with each teacher which lasted from 23 to 31 minutes. This interview was meant to access teachers' beliefs, views and past experiences with the topic, to seek their reactions to various segments of the lesson(s), and their thoughts about the teaching (Van Rooy, 1997, p. 68) of evolution. This interview was also used to encourage and/or allow teachers to explain their understanding of evolution and to provide them with opportunities to raise general views and/or concerns about (Van Rooy, 1999, p. 3) teaching evolution. This first interview was conducted after the lessons had been observed and the questionnaires had been administered to the learners. These interviews took place in March, April and May 2012, and all were audio-taped and transcribed. The second interview was conducted after data from the first interview, the lesson observations, learner questionnaires and interviews and notes had all been studied. The second interviews were also audio-taped and transcribed.

4.4.2.2 Conducting interviews with learners

At least five learners from each school were individually interviewed once each to establish their positions regarding evolution and learning about it, and to access their "intersubjective experience" (Kelly, 2006, p. 304). In total 33 learners were selected from those learners who had earlier indicated willingness to be interviewed. In schools where more than five learners had volunteered, six to eight were randomly selected. The interviews sought in-depth information regarding the beliefs and attitudes of learners towards evolution education. These interviews focussed primarily on learners' beliefs about the origin of species and how those beliefs might have affected or not affected their learning about evolution. Learners were also asked to describe their experiences with regard to learning about evolution. Data from learners' interviews would complement that from questionnaires and observations.

The learners' interviews took place in different places at the different schools, sometimes the deputy principal's office, sometimes in the Life Sciences teachers' preparation room, or in a classroom, a car, or outside in a covered walkway. In all these places, some privacy was maintained by ensuring that there were no people nearby to hear the conversation. Each learner was interviewed individually. The time for the interviews ranged from 6 to 12 minutes. All interviews were audio-recorded.

At the beginning of an interview, the interviewee was greeted warmly, followed by a small chat to establish who they were and how they felt. As Marshall and Rossman (2006) note, interviews involve personal interaction for which cooperation is essential. The small talk was done to make them feel comfortable, build trust and generally establish rapport with them. Then they were thanked for taking part in the research and in the interview. This was followed by communicating the purpose of the research and a statement of appreciation for their valuable contribution to the research. I then assured them that whatever they said would be treated with anonymity as was stated in the consent form they had signed. Next they were made aware that the interview was going to be recorded on audio tape and that this would facilitate the flow of the discussion, but if they had objection, they were to say so. Welcoming the interviewees in this manner ensured that they knew what was expected of them during the interview and why. It was important to treat the participants with respect and to be sensitive to their reactions. That meant giving them information pertaining to the research, giving them time to respond to questions, repeating questions to them if not clear, and also avoiding interrupting them as they spoke. When the interviews were concluded, the

respondents were thanked and wished well with their studies and future aspirations. Some of them thanked me in return for the opportunity to take part in the research, and for the greater awareness they had gained regarding evolution.

4.4.2.3 Conducting classroom observations

Classrooms were visited to observe the teaching and learning strategies used during the teaching of evolution. Before data collection commenced, all the schools were visited, and by this time I had already met the teachers. The purpose was to schedule the visits for observing lessons. Teaching timetables were obtained and discussed with the teachers to find out, among other things, the actual work schedule for teaching about evolution. This information would help me to select which lessons to observe and to avoid assessment or any other activity. When all the timetables were collected, a schedule for visiting schools for lesson observations was drawn up. The teachers concerned were then contacted by telephone to inform them about the programme planned for their school and to secure times for the visits. Just prior to a visit, the teachers were again contacted by telephone to remind them, and also check if there would be any obstacles to the visit. Reminders were made two days beforehand and reconfirmed the day before visits that were on Wednesdays to Fridays. For Monday and Tuesday visits, reminders were made the week before and visits reconfirmed the day before.

Two of the schools were about 2 km (1.2 miles) apart, and two were about 5 km (3.1 miles) from each other. One of the schools was further from the rest, with the nearest of the two being 70 km (43.5miles) away while the furthest was 110 km (68.4 miles) from the nearest other of the sampled schools. Because of the distance between the schools and the varying timetables at each of the schools, it was not possible to visit all the schools on the same day. This also made it impossible to visit all the lessons teaching about evolution. Eventually, two to three lessons per school were observed (see Table 5.59). The topics observed were ‘Evidence for evolution’, ‘Early theories of evolution’, ‘Natural selection’, ‘Speciation’, ‘Human evolution’, and ‘Alternative explanations for the diversity of life’ as they are reflected in the NCS for Life Sciences Grade 10-12 curriculum (see DoE, 2003a). Not all these topics were observed in all the schools (see Table 5.59).

The lesson observations were conducted to enable me to describe the teaching and learning strategies used. The behaviour, actions and comments of teachers and learners were noted as well as the way in which they interacted with each other and with the content of the lessons

about evolution. The observations helped me to be closer to action (Kelly, 2006, p. 308) of teaching and learning in the classrooms, and facilitated making inferences about teachers' beliefs to augment those stated in interviews (Speer, 2005, p. 368). Similarly, the learners' worldviews were inferred from their actions and comments. I was also able to observe the strategies that both teachers and learners used for coping, if and when there was any tension between their beliefs and evolution. The intention was to explore any tensions existing between the beliefs of teachers and learners about evolution and the curriculum requirements of teaching and learning it, and to identify the strategies they used to deal with the tension.

Using an observation schedule, the following information was recorded: the setting within which the lessons take place – including the seating arrangement of learners and the position of the teacher – the number of learners, how the teacher and learners interacted and behaved towards each other, the activities of teachers and learners, the language used – including opinions expressed – the materials used (if any), and any other events that took place. Besides the checklist component, which was objectively presented, there were spaces in the instrument to record events not catered for in the checklist component, such as comments from the teacher and/or the learners, their behaviour and any other matters. I also used these spaces for my own comments and reflections, adding some subjectivity to the data collected.

4.4.2.4 Taking notes during school visits

Notes were made about experiences during the school visits, any data not captured in interviews, interesting things that were discussed when the recorder was switched off – as advised by Kelly (2006, p. 300), information not captured in the checklist component, as well as my interactions with teachers and learners. Notes were taken during visits to capture events in classrooms, and after lessons from interactions with learners and teachers. For instance, after a lesson was observed, some questions were put by teachers for purposes of clarification on what might have been observed. In my turn I asked teachers, for example, their opinions and impressions about the lesson, their choice and use of textbooks and certain teaching and learning strategies observed, and any other comments they had about teaching evolution and about their learners' response to evolution learning. Such responses were captured in the notes which did not refer specifically to the classroom observations, but to the school. These notes included my reflection of what took place and were used to enrich the analysis of the interviews and of the lesson observations. Comments included the inferences I

made from some of the classroom observations as well as the after-class discussions I had with teachers.

4.5 DATA ANALYSIS

A total of 483 Grade 12 learners and 5 Life Sciences teachers from 5 secondary schools participated in the study. The 348 learners responded to the questionnaire, while 33 of them participated in individual interviews. The same five Grade 12 Life Sciences teachers who were observed teaching evolution were also interviewed individually. As already indicated, this ensured that multiple data sources within a multiple-method design were used to answer the questions of the study and to uncover numerous perspectives while respectfully elaborating on the complex realities of each participant.

This study was an investigation into 'evolution education'. Teachers and learners provided information that would be used to assess how their beliefs influenced the learning and teaching of evolution. Interviews and classroom observations were the units of observation, with the data from them being mainly textual, to be categorized. The individual teachers and learners were therefore, units of analysis in this study.

The data in this study were analysed using an adaptation of models suggested by Johnson and Onwuegbuzie (2004), Hesse-Biber and Leavy (2006) and by Miles and Huberman (1984, 1994). The model used in this study caters for both quantitative and qualitative data, as some components resemble those that are found in analyses in the respective approaches. It is a seven-stage model comprising: (a) data exploration, (b) data reduction, (c) data display, (d) data transformation, (e) data correlation, (f) data interpretation and (g) drawing conclusions.

(a) The first step is what Hesse-Biber and Leavy (2006) named *data exploration.* This step involves being more familiar with the data through reading (*ibid*.). In this phase the researcher reads the textual and/or audio data and *thinks about it*. The step involves getting a closer picture of the data in order to potentially draw out some findings. It is usually preceded by data preparation where data are entered into some data base (*ibid*.), such as by transcribing data from audiotapes. Coding, which is part of data reduction, may be begun at this stage. For this study, data exploration was carried out by reading the transcripts and listening to the audiotapes.

Quantitative data preparation is done by assigning codes to different variables, and then entering it in appropriate data base.

(b) *Data reduction* is the second stage in this model but the first of Johnson and Onwuegbuzie's (2004) seven-stage model which involves reducing the dimensionality of the data. Qualitative data reduction involves exploratory thematic analysis and memoing, includes tasks such as coding, and looking for patterns. Coding involves identifying 'chunks' or 'segments' in the textual data and giving this a label (code) (Hesse-Biber & Leavy, 2006). It is the process of selecting, focusing, simplifying, abstracting and transforming the 'raw' data that appear in written-up notes. According to Miles and Huberman (1994), data reduction occurs continually throughout the analysis and includes the earlier stages described by Hesse-Biber and Leavy (2006). It happens through editing, segmenting and summarizing data; coding and memoing; and later through conceptualizing, and developing abstract concepts as a way of reducing the data. Coding schemes are usually developed inductively or also, as is the case in this study, driven by research questions (Miles & Huberman, 1984). According to Cohen *et al*. (2011, p. 599), coding is that process of disassembling and reassembling the data. Data are disassembled when they are broken apart into lines, paragraphs or sections. The fragments are then rearranged, through coding, to produce a new understanding that explores similarities, differences, across a number of cases (*ibid*.). Coding helps researchers locate key themes, patterns, ideas, and concepts that may exist within their data (Hesse-Biber & Leavy, 2006). Coding is done in different levels in this study in order to reach a point where the research questions were addressed.

Quantitative data reduction includes the use of descriptive statistics, factor analysis, and cluster analysis. In this study, descriptive statistics are used to give frequencies and percentages of responses.

(c) *Data display* involves describing the reduced data pictorially (Johnson & Onwuegbuzie, 2004). According to Miles and Huberman (1994), *data displays* organize, compress and assemble information. Some of the ways of displaying data are graphs, charts, and diagrams of different types, and these may be done throughout the analysis. This step was done by organizing data into different forms of display. Displayed data make it easy to compare different data sets and to plan further analyses, permitting direct use of the results in a report (Miles & Huberman, 1984, p. 25). In this study, tables and

matrices are done, from which further analyses are carried out. Charts and graphs are used to present both qualitative data and quantitative data.

(d) In the *data transformation* stage, the quantitative data are converted into a narrative that can be qualitatively analyzed, i.e. 'qualitized'; while qualitative data are converted into numerical codes that can be represented statistically, or 'quantitized' (Johnson & Onwuegbuzie, 2004). In this research, qualitative data are quantitized by assigning numerical values to the codes, and then applying statistical analyses.

(e) *Data correlation* involves correlating quantitative data with the qualitized data, or the qualitative data with the quantitized data (Johnson & Onwuegbuzie, 2004). In this study the qualitative and quantitative data from the learners' questionnaire were correlated to investigate the relationships between the two data types of data. Specifically, associations were investigated between learners' characteristic variables and the measure of acceptance of evolution.

(f) *Data interpretation*. This step includes Hesse-Biber and Leavy's (2006, p. 355) data interpretation step which is about making meaning of data. The interpretation of data happens in earlier stages as well. For that reasons, the step also includes and leads to drawing conclusions. In this research, this step includes consolidating and comparing data from different sources and analyses.

(g) The final stage which follows interpretation is *drawing conclusions*.

The seven steps are followed by the legitimization step, which involves assessing the trustworthiness of both types of data, and any subsequent interpretations (Johnson & Onwuegbuzie, 2004, p. 22). Though the model looks linear, the actual analysis did not follow a linear pattern and sometimes the steps overlap. The process depends on the research questions being answered and data available.

In the next section, analyses of qualitative and quantitative data are presented separately. This reflects what was actually done with each type of data.

4.5.1 The analysis of the learners' questionnaire

The analysis of quantitative data from questionnaires includes data reduction by use of descriptive analysis where scores and percentages are calculated. This applied to all sections,

Section A which gathered biographical data, Section B which investigated the acceptance of evolution by the learners, and Section C which explored learners' views about evolution and the education dealing with it. The qualitative data from the open-ended questions in Section A and in Section C were analyzed qualitatively by categorizing the responses and then coding them. Data were then displayed, quantitized by assigning numbers to the codes. The numbers assigned were then analyzed descriptively.

4.5.1.1 Analysis of quantitative data

The quantitative data were gathered concerning biographical information and concerning the acceptance of evolution. The analysis of these data involved a number of stages.

To be ready for analysis, the raw data from the questionnaires had to be prepared. The numerical codes useful in transforming data into numbers were already assigned when the questionnaires were designed. For example, in anticipation of the variable 'gender' having to incorporate male learners and female learners, males were assigned code '1' and females were code '2'. This meant that the dimensionality of the data was reduced by having only two codes for responses to this question. Next, the data were entered into a computer format by a university statistician assisting in the study. The Statistical package used to process the data was SAS ® Version 9.3 under XP (SP3) on a desk top computer. In this research the unit of analysis was individual learners or respondents, so scores for each learner were recorded in rows (see Durrheim, 2006). When all the data had been entered, as the last stage of preparation, data cleaning was done. This involved looking for errors – such as missing or wrong codes – in the entered data for each questionnaire. For example, wrong codes could mean entering '09' instead of '1' or '2' for the variable 'gender'. To correct such an error in the data set, the questionnaire was checked for the correct code. Data dimensionality was further reduced by breaking data into frequencies and percentages.

The data display stage represents the type of descriptive statistics and its aim was to represent the scores of observations obtained in a summarized fashion (Durrheim, 2006). The reduced data were arranged in tables and matrices, which enabled me to look for patterns. For all the quantitative data, descriptive data analyses were performed by investigating the distribution of scores or frequencies on each variable.

For the nominal data, the mode was determined from the value with the largest occurrence as shown by the highest percentage, the longest bar in the bar graphs or the largest area in the

pie charts. "Nominal measures indicate only that there is a difference between categories of objects, persons or characteristics" (Durrheim & Painter, 2006, p. 155), but "the categories are mutually exclusive" (Cohen *et al*., 2011, p. 605). Assigning specific codes to different categories in a variable makes those categories different from one another. Therefore the category with the highest frequency could be determined.

(a) Analysis of learners' biographical data

The biographical data enabled a description of the participants in the sample so as to give an insight into learners' personal characteristics, such as age and gender, as well as their background, which included their religion, culture and the community in which they lived. The biographical information was measured by means of a nominal scale. For example, to determine the distribution of gender properly a nominal variable '1' was used to represent 'male' and '2' to represent 'female'. Other variables included learners' 'cultural group', 'religion', 'community from which learners came' and 'from whom or where they first heard of evolution', and 'parents' or guardians' highest education level'.

Data in this section were analysed using descriptive statistics, which according to Cohen *et al*. (2011) describe and present data in terms of summary frequencies and percentages. These were presented in tables and also plotted in graphs in the form of bar charts or pie charts in order to give pictorial presentations and show proportions. The measure of central tendency applied in this case was the mode because the data were nominal or categorical, and data were interpreted in terms of size of the frequency. The mode is the score which is given by most people or has the highest frequency (*ibid*.).

(b) Analysis of the MATE scores

The measure of acceptance of the concept of evolution was meant to indicate the extent to which learners found evolution acceptable. The acceptance of evolution by learners was measured using an ordinal scale with their opinions labelled 'strongly agree', 'agree', 'disagree', and 'strongly disagree', with a numerical value on an ordinal continuum given to each. According to Cohen *et al*. (2011) an ordinal scale classifies but also introduces order into the data. For instance, the scale is giving information about the levels of agreement. As already mentioned, there were twenty-seven (27) 4-point Likert-scaled items in the instrument. The highest score indicated acceptance. Possible scores for the measure, therefore, ranged from a high of 108 to a low of 27 which equated to percentages of 100 to 25

respectively. The scores for each respondent were converted to percentages so that they could fit in with the five categories of acceptance found by Rutledge and Sadler (2007): Very High Acceptance = 89-100%; High Acceptance = 77-88%; Moderate Acceptance = 65-76%; Low Acceptance = 53-64%; and Very Low Acceptance = 25-52% (see Rutledge and Sadler, 2007).

The items were categorized into concepts related to evolutionary theory that are addressed by the instrument proposed by Rutledge and Sadler (2007). Rutledge and Sadler had six categories to which Cavallo and McCall (2008) added a seventh. The concepts and related items are shown in Table 4.3 below. The numbers of the items indicate the order in which they appear in the questionnaire.

Table 4.3: Concepts addressed by the Measure of Acceptance of Evolutionary Theory (MATE) – (adapted from Rutledge and Sandler, 2007 and Cavallo and McCall, 2008)

Concepts	Items in the questionnaire
Process of evolution	1; 11; 23; 24; 25;
Scientific validity of evolutionary theory	2; 12; 14; 15; 16; 17
Evolution of Humans	3; 18
Evidence of evolution	4; 5; 6; 8; 10; 19; 20
Scientific community's view of evolution	7; 22
Age of the earth	9; 13
Perceptions of respondents	21; 26; 27

(c) Data correlation

Data correlations were checked among the different variables. For instance, associations between the acceptance of evolutionary theory and variables such as learners' gender, family background and attendance at religious services were investigated. The association of a variable with acceptance of evolutionary theory was estimated from the probability value at a significance level of $p = 0.05$. The level of significance is usually a value which is expressed as a probability. In this research, a probability value of 0.05, represented as alpha (α) was selected, meaning that the probability that an incorrect conclusion would be drawn, calculated as $100 \times \alpha$ (100×0.05), is 5%. Put differently, the chances of obtaining the measured association as a result of sampling error are 5%. To have a proper statistical test of correlation, a null hypothesis was established. A hypothesis is an educated guess or an expectation about differences between groups in the population or about relationships among

variables (Durrheim, 2006, p. 209). In this study we are looking at relationships among the variables. The null hypothesis suggests that in reality, there is no (null) difference between the mean of the sampling distribution from which the sample came and that of the population (Krathwohl, 1998, p. 466). If the level obtained is higher than 0.05 ($p>0.05$), the true null hypothesis will be rejected, that is, we will accept the probability that the results are due to chance only. A lower level ($p<0.05$), on the other hand, indicates the likelihood of accepting a false null hypothesis, or rejecting the null hypothesis that the outcome has been due to chance only, whereas other factors could have contributed.

Because we wanted to draw inferences about the relationships between the variables (Durrheim, 2006), the Chi-square test was used. The null hypothesis being tested was that there was no association between the variables being investigated, in which case a change in one variable would not have an effect on the other variable. The Chi-square test was used to determine if there was a significant association between the learners' characteristics and the MATE variables. This test is designed to analyse categorical non-parametric data, which means the data that has to be divided into categories. According to Cohen *et al*. (2011) the Chi-square test is a test of difference that can be conducted for a univariate analysis when there is one categorical variable, or between two categorical variables. Learners' characteristics captured in the biographical data were nominal i.e. categorical for the characteristics to be investigated. The test "measures the difference between a statistically generated expected result and an actual (observed) result to see if there is a statistically significant difference between them" (*ibid*.). Frequencies are used in the test, and the test determines if the frequencies observed are significant. The null hypothesis (H_o) for the Chi-square test was that the learner characteristics have no association with their acceptance of evolution. For this reason an alternative hypothesis (H_a) was that the learner characteristics have an association with the acceptance of evolution.

To do the test, the data are tabulated in contingency tables. As an example, the table below shows a Chi-square contingency table for investigating association between 'gender' and Item 2 in the MATE (*The theory of evolution is capable of being scientifically tested*). The rows represent the gender variables male and female, while the columns show the Likert scale variables or agreement levels categorised into 'Strongly Agree' = 4; 'Agree' = 3; 'Disagree' = 2 and 'Strongly Disagree' = 1. The table shows the observed frequencies of male and female responses for each of the Likert scale categories. The numbers in the cells

are arranged such that the top number represents the observed frequency while the bottom number represents the expected frequency. For instance, the observed frequency of 'Strongly Agree' for males is 5, while the expected frequency is 4. The column and row for totals show the sums of observed frequency at each scale and the total number of males and females in the sample. These totals are important for determining the expected frequencies. To calculate the expected frequency for each cell, the following formula is used:

$$\text{Expected value of a cell} = \frac{\text{row total x column total}}{\text{Overall total}}$$

So, as an example, for the cell showing 5 as observed frequency, the observed frequency is calculated as 10x130/322 = 4.07 which is then rounded off to 4 to give a whole number.

Table 4.4 Chi-square contingency table for gender and Item 2

	Strongly Disagree	Disagree	Agree	Strongly Agree	Total
Male	5 4	13 19	85 69	27 37	130
Female	5 6	35 29	87 103	65 55	192
Total	10	48	172	92	322

This table is referred to as a 2x4 contingency table because there are two rows of frequencies against four columns of agreement levels. The row and column for totals are into included. This information is useful when determining the 'degrees of freedom' (df) for this table. The formula used for that was: df = (r-1)(c-1),

where 'r' represents number of rows and 'c' represents number of columns in the table. Substituting the figures gives (2-1) (4-1) = 1x3 = 3. So, the 'degrees of freedom' for this table is 3. 'Degrees of freedom' is a "mathematical construct that is related to the number of restrictions that have been placed on the data" (Cohen, *et al*., 2011, p. 653) or "the freedom with which the researcher is able to assign values to the cells, given fixed marginal totals" (*ibid*., p. 655).

The Chi-square test determines the probability of association of a data distribution. It enables one to test how likely it is that gender and levels or agreement are associated. But a chi-square test does not determine cause-and-effect. In other words, it cannot be said that learners' responses were caused by their gender. A typical example would be saying that learners' attendance at religious services causes their agreement to a particular item in the

data. Another feature of the Chi-square statistic is that it assumes that the there are no more than 20 percent of the total number of cells in a contingency table which contain fewer than five cases. In the example given here, none of the cells contain fewer than five cases; therefore, the Chi-square result can be regarded with confidence. For many of the tests done in this study, the validity of the Chi-square results was questionable because more than 20 percent of the cells were empty because of missing data.

In order to decide on whether the frequencies were significant or not, a level of significance had to be decided upon. Usually there are three levels of significance used: 0.01, 0.05 and 0.001. The first two are usually used more commonly than the latter, but the conventionally accepted minimum level of significance is usually 0.05 (Cohen *et al*., 2011). In this study 0.05 was used. Because a null hupothesis was given, which was that there was no association between learners' characterisitics (e.g. gender) and the agreement with or acceptance of Item 14, the task in this case is to show that the hypothesis is not supported for 95% of the population. For a significance level of 0.01 the percentage of the population not supported for would be 99. So, when indicating the statistical significance of the test, it is important to consider the significance level. The results of analysis of the Contingency Table given above were: Chi-square = 14.3982, df = 3 and p = 0.0024. The probability is smaller than the significant level 0.05, therefore the association between gender and acceptance of Item 14 is statistically significant because less than 5% of the population support the null hypothesis that there is no association between gender and acceptance of Item 14. Therefore, an association exists, even though it cannot be said from this test what type of association it is.

Given the dialectical constructivist approach to worldview development (Cobern, 1997), the correlations identified might give an insight into the factors contributing to the worldview development of these learners, and we can then infer similar associations in the populations from which the learners were drawn. But of course a sample may not be as perfect a reflection of the population (Babbie & Mouton, 2001) as it might be, especially when it is a very small one. However, the sample was selected conveniently. Therefore, the associations identified may not be a reflection of population characteristics. The conclusions reached are therefore limited to the sample and not generalizable.

4.5.1.2 Analysis of the qualitative data in the questionnaire

For the qualitative data gathered in Section C and part of Section A, analysis followed a hermeneutical approach. Hermeneutical analysis is an interpretive approach, emphasizing the importance of the views of participants, based on their experiences and their standpoint (Mansour, 2008a). The purpose of this research was mainly descriptive and interpretive, so as part of the interpretive process it was important to read the data and be familiar with them. Analysis also followed the steps as described in Section 4.5 above.

All interviews were audiotaped. It was therefore necessary to transcribe them so as to convert them to text. This step is equivalent to what Hesse-Biber and Leavy (2006) termed *data preparation.* They state that this step involves entering and storing data into a database of some kind. Two research assitants were commissioned to transcribe the audiotapes. Then the researcher checked the transcriptions while also listening to the tapes, made corrections where necessary, and added any missing details such as 'laughs' of 'sighs'. It was important to do this soon after the interviews while the events were still fresh.

Next, more reading was done in order to be more familiar with the data. This is the stage which Hesse-Biber and Leavy (2006) refer to as *data exploration.* The step involves getting a closer picture of the data in order to potentially draw out some findings. Whilst reading through the transcriptions and being familiar with the responses, categories were formed by grouping similar responses. The developed categories were then quantitized by assigning numerical values, which were then analyzed to give descriptive data. Coding, which is part of data reduction, was begun at this stage. The codes were displayed in tables with the categories of responses as rows and the frequencies for each category in the columns. The categories were further analyzed inductively and coded to reveal possible learners' beliefs about evolution and their worldviews. Inductive analysis was done manually.

The numerical data for the codes were then plotted in tables. Crosstabulations (Cohen *et al.*, 2011) were made to present data for two or three variables and cells in the tables interpreted. The displayed data enabled further analyses. The second stage involved coding the categories by making inferences on the descriptive codes. For instance, thematic analysis was done and codes representing themes for specific categories of responses were assigned. This was done inductively in line with the research questions. Participants' possible worldviews were inferred in this manner. For instance, for a worldview to be 'religious', the responses had to

have religion as the view or perspective behind the response. 'Scientific' worldview, on the other hand, reflected views based on modern science. Other worldviews were designated as 'cultural' if they reflected knowledge from the community that was not based on modern science or religion, and 'personal' if they reflected personal opinion not based on culture, religion or science. Also, beliefs were inferred from the responses in relation to whether evolution was regarded as valid or not. These were also subjected to further analysis and inference according to the possible worldviews informing them. To interpret the data, frequencies of responses showing the extent of occurrence, i.e. most or few, were used to indicate the prevalence of beliefs or possible worldviews of participants.

Analyses of the open-ended questions also included checking the correlations among the responses, and this affected mainly the items in Section C and the two open-ended questions from Section A.

4.5.2 Analysis of data from interviews and school visits

The analysis of data from interviews and classroom observations – including field notes – started with early steps such as data preparation phase and data exploration. These steps involved transcribing the data and becoming familiar with them through reading and thinking about them. This familiarization stage was followed by coding, classifying and categorizing the data into broad themes to give them meaning. The transcriptions of the data from interviews, observations and field notes were used in the exploratory thematic analysis and memoing. This involved putting data into categories and then inductively identifying codes for the categories. Inductive analysis, which was manually done, was applied mostly to the open-ended questions. The coding process was also driven by the research questions, as was the case with the interviews with both teachers and learners.

This study assumed that the direction of causality was cyclical or circular, on the premise that teacher behaviour affects learners' behaviour, which in turn affects teacher behaviour and, ultimately, learners' academic performance (Brophy & Good, 1986 cited by Fang, 1996). However, academic performance in this study did not include assessment, but rather, learning experience as perceived by learners. Data from observations facilitated the examination of relationships between teachers' beliefs and their in-class teaching practices. Data from learner responses were analyzed to provide a deeper understanding of the observations.

A summary of the methods which were used to collect and analyze data to answer the research questions is reflected in Table 4.2 above.

4.6 QUALITY ASSURANCE TECHNIQUES

For any research that is conducted, it is important that the data collected are true, authentic and can be believed and trusted. In this study, this assurance was enhanced by employing multiple methods of data collection so as to look for corroboration. Since this study employed a multiple-methods design, data quality was determined by separate standards of quality in both the qualitative and quantitative approaches (Teddlie & Tashakkori, 2009). Teddlie and Tashakkori (2009, p. 209) suggest two basic questions that should be asked concerning the quality of data. The first question, involving measurement validity for quantitative data and credibility for qualitative data, is:

- Am I truly measuring, or recording, or capturing what I intend to, rather than something else? (*ibid.*)

This first question addresses the issue of internal validity, that is, how truthful the findings of the study are.

The second question concerns the measurement reliability for quantitative data, and the dependability of qualitative data, and is stated as:

- Assuming that I am measuring or capturing what I intend to, is my measurement or recording consistent and accurate? (*ibid.*)

This second question addresses the extent to which the findings can be replicated and also be applicable to other contexts, thus an issue of external validity. Regardless of the form taken by a research exercise, it is important to subject it to careful inspection and rigour so as to work towards quality. What is important in multiple-methods research where qualitative and quantitative approaches have been used is to strive for the trustworthiness and credibility of qualitative data as well as the validity and reliability of quantitative data. In the following sections of this discussion, the quality issues related to both quantitative and qualitative data in this study are considered.

4.6.1 Qualitative data validation techniques

The qualitative dimension of the study had data that were a source of "well-grounded, rich description and explanation of processes occurring in local contexts" (Miles & Huberman, 1984, p. 21), where the intention was to "derive fruitful explanations" (p. 22) regarding the teaching and learning of evolution in a sample of South African secondary schools. It was thus important that the results of the study and the conclusions made from them were acceptable and not unreasonable. Ensuring the quality of the data in qualitative research is crucial to indicate that the data are trustworthy, by using ways that are demonstrable and understandable to others (Bradley, 1993). Miles and Huberman (1984) refer to efforts made by Halpern (1983) to develop validation criteria and by Guba and Lincoln (1981) in determining the trustworthiness of qualitative data. Miles and Huberman (1984) propose a flow model to indicate their general conception of qualitative data analysis, as a way to respond to concerns about validity and verifiability. Besides the data concerned, which "appear in words rather than numbers", they consider "concurrent flows of activity: data reduction, data display, and conclusion-drawing [or] verification" (Miles & Huberman, 1984, p. 23).

4.6.1.1 Perspectives on trustworthiness and crystallization

Lincoln and Guba (1985, p. 301-328) propose four criteria for the 'trustworthiness' of data: credibility, transferability, dependability and confirmability. These criteria were applied in this study because of the 'constructivist' or 'interpretive' dimension (Creswell & Miller, 2000, p. 125) of the qualitative strand.

(a) To work toward the *credibility* of the data, 'member checking' and 'peer-debriefing' were applied during data collection and analysis. The participants were requested to go over the transcripts of their interviews, and later the themes and categories of the data to check "whether the overall account is realistic and accurate" (Creswell & Miller, 2000, p. 127). This added credibility by giving participants a chance to react to both the data and the final narrative (Creswell & Miller, 2000) as they checked the interpretation.

(b) Secondly, peers were consulted to obtain feedback and ideas at different stages of data collection and analysis. To achieve the *confirmability* criterion, some of the participants were given the notes and transcripts to read and review, and they were

invited to reject or modify any information, so as to strive for validation from their side and give them confidence that they were represented correctly and accurately.

(c) My role was to provide rich and ample description of the data so that those who wished to extend the working assumptions to another context could do so, thus meeting the criterion of *transferability*. To define the context in this case, Keppie's (2006, p. 242) definition that it is "the setting or circumstances in which an event or behaviour or interest occurs" is borrowed. The rich descriptions provide readers with detailed accounts of the structures of meaning which develop in a specific context, and the understanding thereof can be transferred to new contexts in other studies (Van der Riet & Durrheim, 2006, p. 92). For instance, this research was conducted in one district of Limpopo Province. If similar understandings can be obtained with a different set of learners in the same district, or a sample from another district, then transferability will have occurred. This research was conducted once for this group, but included learners from different areas of Vhembe District participating under different conditions.

(d) Dependability refers to the extent to which the reader can be convinced that the findings did occur as the researcher says that they did (Van der Riet & Durrheim, 2006, p. 93). To work toward dependability, rich and detailed descriptions that show how certain actions and opinions are rooted in and develop out of contextual interaction are provided (*ibid*., p. 93-94). Furthermore, an account of any changing conditions in the phenomena should be provided, so that there is coherence in the internal processes (Bradley, 1993). Accordingly, there was no assumption in this study that the beliefs being investigated were a stable and unchanging reality (Van der Riet & Durrheim, 2006). Therefore, rather than aiming for repeatability of the results, the aim was to convince the reader that the findings did occur as reported, and to provide frank statements of the methods used to collect and analyze the data (*ibid.*). Rich descriptions of the changing circumstances and how they affected the events in the research should therefore be convincing.

Multiple sources of data were used so that the findings were not dependent on the peculiar characteristics of a single method of measurement (Krathwohl, 1998, p. 143). To see that this process, or 'triangulation' (Kelly, 2006; Krathwohl, 1998; Mathison, 1988) was not limited to one method (within-methods triangulation) but occurs across the different methods (between-

methods triangulation), qualitative and quantitative methods were used. Combining multiple sources may also "complete a picture that would be incomplete without them" as "the information from one source helps in interpreting the meaning of another" (Krathwohl, 1998, p. 276).

Mathison (1988) states that the predominant assumption is that "triangulation will result in a single valid proposition … [as researchers] ... look for the convergence of evidence ..." but will miss out on other outcomes, which she terms *inconsistency* and *contradiction* (p. 15). She further notes that all three types of outcome – the convergent, inconsistent and contradictory findings – are valuable when utilized to understand the social phenomena under study. Thus, triangulation is viewed as a "technique which provides more and better evidence from which researchers can *construct meaningful propositions* about the social world" (Mathison, 1988, p. 15), and enables comparison of data to see if there is agreement.

As one source of data was classroom observation, to give meaning to these observations, interviews were essential, as together these sources of data gave a more complete picture of the teaching and learning of evolution, while theories from the literature enabled me to interpret the data and give plausible explanations. Within the interpretivist paradigm, multiple sources lead to *crystallization*, when what emerges from the data is both confirmed and enriched. When 'saturation point' is reached, information repeats itself and nothing new is being learned, and one knows intuitively that it is time to leave the field (Krathwohl, 1998). My role was to report all data collection procedures used in the study in order to make "the processes employed in the research … more public" (Anfara *et al.*, 2002, p. 35). This enabled me to substantiate interpretations and findings with a reflexive account of the processes of research (Altheide & Johnson, 1998, p. 292).

4.6.2 Quantitative data validation techniques

For using measurement in research it is important that the instruments used do actually measure what they are supposed to measure and that they are consistent in carrying out the measurement. In order to assure this about research, researchers must check on the validity and reliability of the instruments they use.

4.6.2.1 Reliability

Reliability refers to the consistency of an instrument in measuring whatever it measures (Krathwohl, 1998, p. 435), or the stability of methods and findings (Altheide & Johnson, 1998, p. 287). As stated by Babbie and Mouton (2001, p. 119), it "is a matter of whether a particular technique, applied repeatedly to the same object, would yield the same result each time". The consistency makes the instrument dependable to the extent that it yields the same results on repeated trials (Durrheim & Painter, 2006, p. 252) and provides a similar score for similar amount of evidence. Repeatability, as a vital element of reliability, suggests that replication of the testing procedures does not alter the results. Furthermore, consistency in quantitative research is based on the assumption of a single reality, that there is something out there to be studied that is unchanging (Lincoln & Guba, 1985). As stated by Van der Riet and Durrheim (2006, p. 93), positivists believe that they are studying a stable and unchanging realitiy, therefore, reliability is a highly valued criterion that indicates the accuracy and conclusiveness of the findings in quantitative research. However, qualitative researchers "do not assume that they are investigating a stable and unchanging reality", and "do not expect to find the same results repeatedly" (*ibid.*). In this way, reliability differs from trustworthiness discussed above, since the former emphasises consistency and the latter, dependability.

The instruments used in collecting quantitative data acquired biographical data and measured the level of acceptance of the notion of evolution. The latter, obtained by the MATE instrument which was adapted in this research, had already been validated to ensure its reliability (see Rutledge & Warden, 1999; Rutledge & Sadler, 2007) because using an established measure is another way to striving for reliability (Babbie & Mouton, 2001, p. 122). The questionnaire, including the two measures, was also pilot-tested. Each responding learner received the same questionnaire so as to strive for consistency. As outlined earlier, internal consistency was measured for the MATE.

4.6.2.2 Validity

Validation in research is important and necessary. Validity has been commonly referred to as "a measure that accurately reflects the concept it is intended to measure" (Babbie, 2010; Babbie & Mouton, 2001). This refers particularly to validity of the measure where the instrument actually measures what it is intended to assess (Durrheim & Painter, 2006; Teddlie & Tashakkori, 2009). However, Cohen *et al.*, (2011, p. 179) state that "more recently validity has taken many forms" and is "a requirement for both qualitative and quantitative

research". Cohen *et al*. (2011) further state that validity is never perfect but that researchers should "strive to minimize invalidity and maximize validity" (*ibid*.) instead. Validity is discussed here in relation to the quantitative approach.

Part of the questionnaire used in this study was intended to measure the acceptance of evolution by the learners. This was done by using the Measure of Acceptance of the Theory of Evolution (MATE), an instrument which had already been developed and validated (see Rutledge & Warden, 1999; Rutledge & Sadler, 2007). MATE was adapted for this study and was further validated by subjecting it to reviews by experienced researchers and Life Sciences educationists who assessed its suitability for the South African context, as well as whether or not it measured what it was supposed to measure. As stated by Durrheim and Painter (2006, p. 152), validity does not relate "only to the properties of the measure but also to the purposes to which the measure is put and the context in which the measure is used". This measure was used and validated in a different context, so it was necessary for it to be suitable for use in South Africa. The reviews by experts established the face validity, or "appearance of validity" (Krathwohl, 1998, p. 428), and content validity by assessing that the content was indeed related to evolution.

Validation during data collection was done by checking the "the accuracy and truthfulness of the findings" (Altheide & Johnson, 1998, p. 287). This was done by administering the questionnaire to the learners after they had all undergone instruction about evolution, so that they were at the same level regarding exposure to evolution content. This happened after the lesson observations had been conducted and instruction about evolution was completed. It was assumed that, at this stage learners would have enough information about evolution from which to draw in order to decide about their beliefs about the topic. Categories of the initial twenty MATE items, that indicate what the items measure, have been developed (see Rutledge & Sadler, 2007). The additional items resulted from splitting some original MATE items, and therefore fitted into these same categories.

4.7 ETHICAL CONSIDERATIONS

According to Hesse-Biber and Leavy (2006), the term *ethics* derives from the Greek word *ethos* which means *character*. Ethics are about right or wrong. They are about doing what is right, treating people fairly and not hurting anyone (Lichtman, 2013). They represent the code of conduct to be followed when conducting an activity. Ethical behaviour represents a set of

moral principles, rules, or standards governing a person, or a profession (*ibid*., p. 51) or an activity. In research, ethical issues may stem from the kinds of problems investigated and the methods used to obtain data such as the nature of participants, the type of data to be collected or what is to be done with the data (Cohen *et al*., 2011). This study was about beliefs of people. Since it was dealing with human subjects, it was essential to consider ethics when soliciting their personal information and reporting that in this study. According to Cohen *et al*. (2011), "[a] major ethical dilemma is that which requires researchers to strike a balance between the demand placed on them as professional scientists in pursuit of truth, and their subjects' rights and values potentially threatened by the research". Some of the major principles associated with ethical conduct include: doing no harm to those participating in the research, guaranteeing privacy and anonymity to the individuals participating in the research, treating information from them with confidentiality, and informing participants of the nature of the study and expecting that they may choose to or not to participate (Lichtman, 2013). Ethics do not only prevent harm to the participants, but also preserve their rights (Horwood & Graham, 2003, p. 107). During the planning phase, I had to indicate how the research was going to be conducted and how ethics were going to be considered in order not to harm the participants or settings of the study. An application was made to the Ethics Committee of the University of Pretoria to review the ethics relevant to this study. The review included determining whether the methods were appropriate and that they would not cause harm to the participants. This research was therefore approved by the Ethics Committee of the university. Data collection only commenced after the ethical clearance was granted on 21 April 2011. Generally, the research was conducted according to the ethical guidelines stipulated by the university. When at one point assistance was required to transcribe some of the interviews, an amendment to this effect was requested of the Ethics Committee. The clearance certificate was issued on 29 May 2013 after completion of the research.

In this research, no potential harm or risk to the participants was envisaged since no form of treatment would be based on the results. However, since the information required from participants could be regarded as being of a personal or even of a private nature, participants could still be wronged in the obtaining of that information, violating the philosophical principle of "non-maleficence" (Wassenaar, 2006). It was necessary to avoid and minimize potential wrongs in this research (*ibid.*). Of utmost importance, therefore, was maintaining autonomy and respect for the dignity of persons (*ibid.*), by ensuring confidentiality and

privacy of the participants, and obtaining their informed consent (Esterberg, 2002). To ensure that the ethics were adhered to, the measures outlined below were followed.

4.7.1 Full disclosure

Since this research sought information from human subjects, it was necessary and important that relevant gate-keepers and prospective participants were given sufficient and truthful information about the research. It was important to inform participants effectively about the nature of the study so that they understood the intent of the investigation before participating in it. Letters were written to people for this purpose. The information given included my own particulars, the nature, purpose and procedures of the research, as well as the nature of the participants and their role(s) in the study. It also indicated that data collection would include visits to schools, observation of Life Sciences lessons on evolution, interviews with teachers and learners, and questionnaires for the learners.

4.7.2 Permission to conduct research

Gaining access to a research setting is an important part of the research which requires approval by gate-keepers. According to Farber (2006), gate-keepers are the people who allow a researcher access to what he or she wants to study. The gate-keepers in this case included the authorities such as the Provincial and District Departments of Education as well as the principals of the schools. Prior to the research, letters were written to request permission from these persons of authority. Permission was requested from the Limpopo Provincial Education Department and from the District Education office for Vhembe to conduct research in schools in Vhembe District (see Appendix 7 and Appendix 8). Once permission was granted by the Provincial and District Departments of Education, the schools were approached and permission was sought from the principals of the schools (see Appendix 9) where the study would be conducted.

4.7.3 Informed consent

It became necessary to obtain voluntary informed consent from participants which according to Krathwohl (1998), is a key part of working with human subjects. Informed consent is received after the subject or participant in a study has been carefully and truthfully informed about the research (Fontana & Frey, 1998). Consent was sought from the potential participants, that is, the teachers and learners. Life Sciences teachers who were to participate

in the research were given letters (see Appendix 10) informing them of the intentions behind the study and the role they would play, so that if they agreed to participate in the research, they could give their informed consent. A letter (see Appendix 11) informing the parents and/or guardians of the learners about the research accompanied a consent form that parents were requested to complete if they agreed to their children taking part in the study. Learners also received their own letters (see Appendix 12) whereby they were to give consent if they wished to participate in the study. Furthermore, participants were assured that the study would result in no harm to them as individuals and no damage to the school setting as a result of their taking part in the research. This was all the more possible because the research was conducted in a normal school setting where participants were not subjected to any harmful objects or chemicals. For the learners who were below 18 years of age at the time of the research, parental consent was necessary. Only those learners whose parents and/or guardians approved, and who themselves gave consent, took part in the study. In all cases consent was formalized (Wassenaar, 2006) by participants signing the form provided to all whose consent was required.

4.7.4 Voluntary participation

Participants were notified that participation was voluntary, that a participant was free to decline or withdraw even after the study had commenced, and that there would be no consequences in case one withdrew from the study before its completion. As stated by Cohen et al. (2011), "subjects should have the option to refuse to take part and know this, and they should have the right to terminate their involvement at any time and know this also". Thus, participants have a right to free participation. Voluntary participation means that a person has the right not to take part in the research, not to answer questions, and not to be interviewed, not to have their home (school) intruded into, not to answer telephones or emails. Therefore, the researcher should ensure that participant have the right to withdraw at any time (*ibid*.).

4.7.5 Right to privacy and confidentiality

Cohen *et al*. (2011) consider privacy to be of primordial value, and regard anonymity, confidentiality and informed consent as corollaries to privacy. It is therefore an individual's right to keep their privacy. Safeguards to protect the privacy of participants are necessary especially when sensitive information such as religious preferences is sought from participants (*ibid*.). According to Fontana and Frey (1998, p. 70) 'right to privacy' involves

protecting the identity of the subject. In this study, the right to privacy was recognized for the individual participants and their schools. The principals, teachers and learners were informed of this right. With regards to confidentiality and anonymity the principals were informed that the identity of their schools would be protected. Similarly, participating teachers and learners were assured that confidentiality and anonymity would be maintained by not exposing their identity in the dissemination of the results of the study. To strive for anonymity and confidentiality as well as maintain their right to privacy, all interviews were conducted in a private place where no other persons could hear the conversation, thus protecting the information provided by the interviewees. In the analysis of the questionnaires, numbers have been used for individual informants. The top page with their particulars was removed prior to analysis, so that a questionnaire is anonymous. In the report, pseudonyms have been used for schools and participants.

4.8 CONCLUSION

The methodology a researcher employs in a study is guided by a number of decisions made which include the purpose of the research, the problem being addressed, the questions formulated to address the problem, theoretical underpinnings, research paradigm and the methods that would address the research questions. It is important to consider elements of quality and ethics so that the research findings are acceptable to the research communities and other stakeholders. Measures employed to achieve quality are determined by the type of sources a researcher uses in a study, as well as the research methodology the researcher adopts for the study. In this study, a multiple methods approach has been employed where both qualitative and quantitative approaches have been used to collect and analyse data. The measures employed to achieve quality, and consider ethics, therefore, are commensurate with the use of humans as sources of information, and with the methods of the study. Because of using human subjects, it was essential to avoid practices that would harm them in any way when conducting the research and when reporting the results. Issues of anonymity and informed consent were, therefore, some of those considered. Since the method of the study involved the use of both qualitative and quantitative approaches, quality measures to achieve validity and reliability in the quantitative approaches, as well as to strive for trustworthiness for the qualitative ones were employed. The next chapter discusses the results of the research from the quantitative strand.

CHAPTER 5
FINDINGS OF THE QUANTITATIVE APPLICATION OF THE STUDY

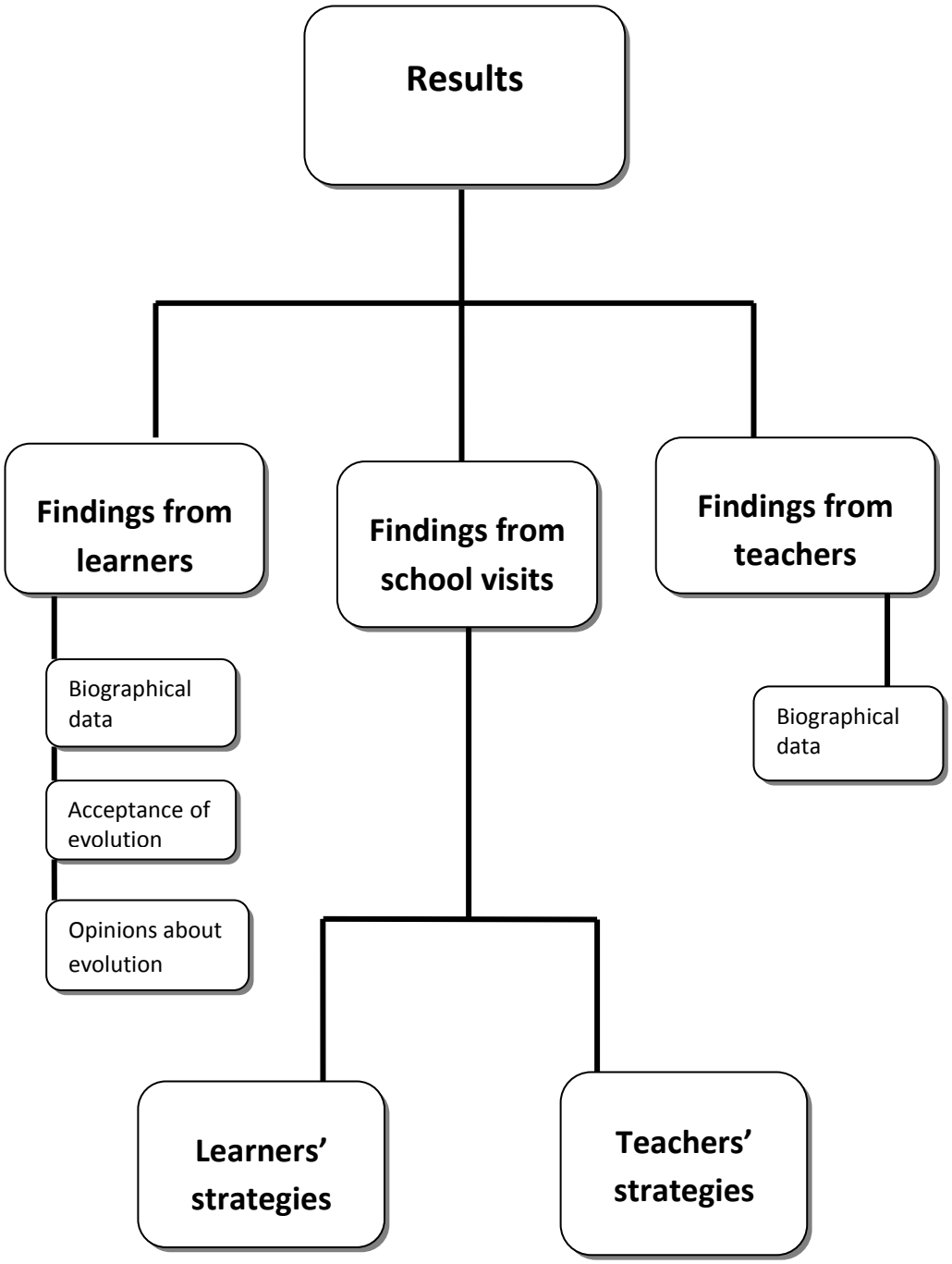

Figure 5.1: Overview of Chapter 5

I did accept that Christianity is all about God and when it comes to evolution it's all about scientific things. So I have taken my mind off Christianity out and let the science deal with evolution so that I can learn more, so that it cannot affect me as I am a Christian (A learner in School A).

5. 1 CHAPTER OVERVIEW

This chapter discusses the findings from the quantitative data obtained in the research. There are five main sections. The first section presents results from the learners, collected on the questionnaires. The second section addresses findings from teachers' biographical data. This is followed by the third section, presenting findings from the school visits which cover classroom observations during the visits. At the beginning of the discussion for each data source, the purpose of the method of collection used and any issues pertaining to data collection and analysis are looked at. The fourth section discusses the relationships among the findings from the different sources. The chapter ends with conclusions about the results obtained.

The results from learners' open-ended questions are also presented in this chapter, even though the data were qualitative in nature. This is because analyses of the data involved both qualitative and quantitative approaches, but mainly the latter with the application of descriptive statistics. Also, these results were correlated with the quantitative aspects of the questionnaire, hence the decision to report them together.

The quantitative values were computed descriptively to determine the totals and the percentages. However, not all the 348 learners responded to the various questions asked, and for most variables the number of respondents was less than 348. The 'n' value represents the number of learners who responded in Section A of the questionnaire, which elicited the learners' biographical information. Percentages in this section represent the number of learners with a particular response as a proportion of the total number of learners who responded in that question. However, for Section B which had open-ended questions, 'N' simply represents the number of responses. Since some of the responses were given by more than one learner, 'N' is sometimes found to be more than 348 in this section. The percentage values are therefore the number of responses which are similar or in a category, as a proportion of the total number of responses given to that question.

5. 2 FINDINGS FROM LEARNERS

Data were obtained from learners by means of questionnaires (see Appendix 2), interviews (see Appendix 1) and classroom observations (see Appendix 5) conducted during school visits. Results from the questionnaires are presented first, followed by those obtained during school visits. Findings from the interviews are presented in Chapter 6.

5.2.1 Learners' questionnaires

The learners' questionnaire had three main sections: Section A to gather biographical information about learners, Section B to canvass their acceptance of evolution, and Section C to obtain information pertaining to their beliefs about evolution and learning it. Results reported in this chapter include learners' biographical information and the measure of acceptance of evolution theory.

5.2.1.1 Learners' biographical data

This section reports on the characteristic variables found for the learners, captured from their biographical data. Tables and graphs are used to represent the information, which is given in raw scores and percentages. All the percentages for the individual scores have been rounded off to two decimal places, and then added up to give the total percentage for each variable, which should be 100. In some instances, this total is not achieved as expected, but is either 99.99 or 100.01. This is caused by the rounding off of percentages calculated for the individual scores, where some percentage points are close to a half and cause an error. Graphs and pie charts have been derived from the results in order to give a pictorial presentation of the data. Pie charts and bar charts are also useful in showing proportions (Cohen *et al*., 2011). In addition to the tables and graphs, some discussion is given in order to explain the data.

(a) Gender and age of learners

There were altogether 348 learners who responded to the questionnaire, 209 (60.06%) of these were female while 139 (39.94%) were male. As would be expected for learners at this level of education in South Africa, at the time of the research most were aged at 17 years (n = 162; 46.55%), followed closely by 18 years (n = 115; 33.05%), with a few below and above (see Table 5.1 below).

Table 5.1: Age of learners at last birthday in years

Age at last birthday (years)	Number of learners (n = 348)	Percentage (%)
17	162	46.55
18	115	33.05
19	26	7.47
16	21	6.03
20	9	2.59
21	4	1.15
22	4	1.15
26	1	0.29
No response	6	1.72
TOTALS	348	100.00

The age range for the group was 10 years (from 16 years to 26 years), indicating some degree of variability. Figure 5.2 is a histogram showing that the majority (79.60%) of the learners were aged between 17 and 18 at their last birthday, with the mode at age 17. Data using questionnaires were collected in March to April 2012. For some learners, their birthday fell in the previous year (2011), while for others it was in a month of 2012 before the data were collected. This suggests that the majority of the learners started Grade 1 when they were 7 years old.

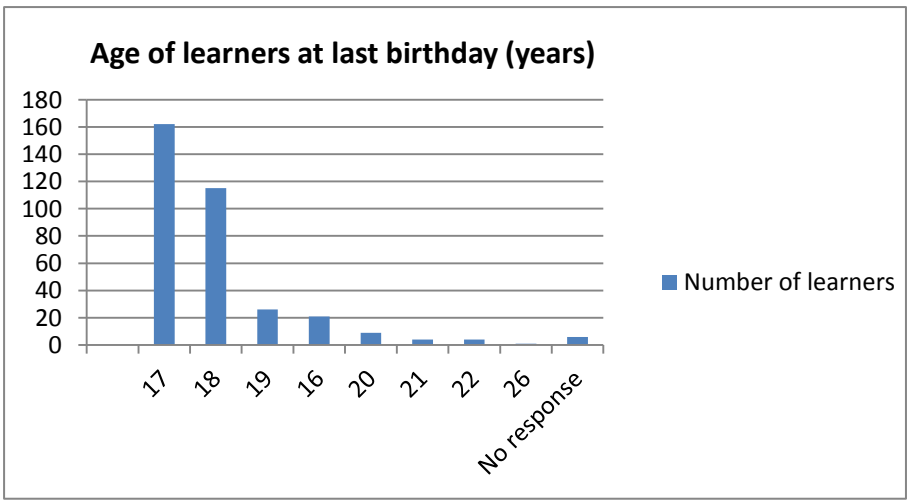

Figure 5.2: Ages of learners at the last birthday

(b) Religion of learners and attendance of religious services

The majority (94.83%) of the learners in this study stated that they belong to some religion and (93.68%) belong to a Christian faith within seven denominations: Pentecostal (34.48%), Zionist (19.83%), Catholic (18.68%), Christian denomination not known (13.22%), Protestant (6.61%), AME (African Methodist Episcopal) (0.29%), Seventh-Day Adventist

(0.57%). While four of these denominations (Catholic, Pentecostal, Protestant, and Zionist) were listed in the questionnaire, AME, Seventh-Day Adventist and 'Christian' emerged from the responses of the learners who responded with the code for 'Other'. For this code, respondents were to name their religion. For the respondents who put 'Christian', this could indicate that they do not know the denomination, or that they do not align themselves with any particular one. Other religions mentioned for this code are shown in Table 5.2. There were four (1.16%) learners who belonged to non-Christian religions, one (0.29%) to an African religion, and two (0.58%) who did not belong to any religion.

Table 5.2: Religions of learners

Religion	Number of learners (n = 348)	Percentage (%)
Christian, Pentecostal	120	34.48
Christian, Zionist	69	19.83
Christian, Catholic	65	18.68
Other – Christian Denomination not known	46	13.22
Christian, Protestant	23	6.61
Other - Seventh Day Adventist	2	0.57
No religion	2	0.57
Muslim	1	0.29
Jewish	1	0.29
Other - African Traditional Religion	1	0.29
Other – AME	1	0.29
Other – Rastafarian	1	0.29
Hindu	0	0.00
No response	*16*	*4.60*
TOTALS	348	100.01

Table 5.3 shows the frequency of attendance at religious services by learners. Most learners indicated attending religious services more than once a week (46.84%) or once a week (45.11%), with a few attending once a month (4.02%), once a year (2.01%) or never (1.44%).

Table 5.3: The frequency with which learners attend religious services

Frequency of attendance at religious services	Number of learners (n = 348)	Percentage (%)
More than once a week	163	46.84
Once a week	157	45.11
Once a month	14	4.02
Once a year	7	2.01
Never	5	1.44
No response	*2*	*0.57*
TOTALS	348	99.99

As shown in Table 5.4, the majority (76.72%) of the learners attended religious services with their family, while fewer attended alone (7.76%) or with friends (12.93%). The frequency of attendance at religious services can be taken as an indication of a person's commitment to their religion. It may also be a tradition of the family and not necessarily an individual matter.

Table 5.4: People with whom learners attend religious services

People with whom learners attend religious services	Number of learners (n = 339)	Percentage (%)
With family	267	76.72
With friends	45	12.93
Alone	27	7.76
No response	*9*	*2.59*
TOTALS	339	100.00

(c) Cultural groups of learners

Altogether there were 11 cultural groups listed in the questionnaire, but there were only 8 groups represented in the study. The largest (95.69%) proportion of respondents belonged to the Venda cultural group. The other groups were North Sotho (0.57%), South Sotho (0.29%), Swazi (1.44%), Tswana (0.29%), Xhosa (0.29%) and non-South African (0.29%), with the group consisting mostly of the Venda. This information is presented in Table 5.5 and Figure 5.3, with the latter showing the proportions of the cultural groups.

Table 5.5: The cultural groups to which learners belong

Learners' cultural groups	Number of learners (n = 348)	Percentage (%)
Venda	333	95.69
Tsonga	5	1.44
North-Sotho	2	0.57
South-Sotho	1	0.29
Swazi	1	0.29
Tswana	1	0.29
Xhosa	1	0.29
Other (specify)	1	0.29
No response	3	0.86
TOTALS	348	100.01

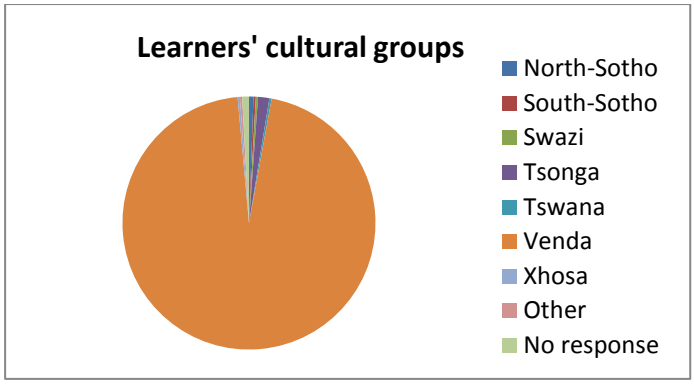

Figure 5.3: Cultural groups of respondents

(d) Home communities of learners

As can be seen in Table 5.6 and Figure 5.4, the majority (79.89%) of the learners described the community they came from as rural, fewer saw their communities as urban (11.49%) and as suburban (6.03%).

Table 5.6: Home communities of learners

Learners' cultural groups	Number of learners (n = 348)	Percentage (%)
Rural	278	79.89
Urban	40	11.49
Suburban	21	6.03
No response	*9*	*2.59*
TOTALS	348	100.00

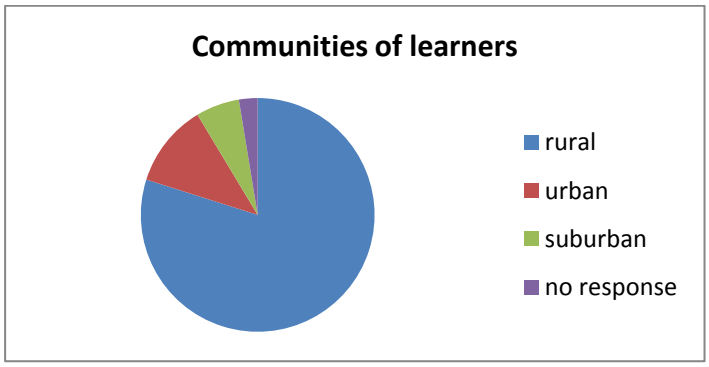

Figure 5.4: Communities of learners

(e) Education level of parents or guardians

As can be seen from Table 5.7 and Figure 5.5, for the majority (65.23%) of learners, the highest educational level of their parents and/or guardians is tertiary; fewer had parents and/or guardians who had not gone further than high school (26.15%) or primary school

(2.30%). Considering that the majority (79.89%) of these learners consider themselves as coming from rural communities, it is interesting that so many parents have achieved the tertiary level of education. But the finding could also indicate that these learners belong to parents who, being educated themselves, ensure that their children receive education as well. It is also possible that parents or guardians who gave consent for their children to take part in the research were mostly those with high levels of academic achievement. Also, since this variable represented parents and/or guardian, it is possible that some are not 'parents' but are actually 'guardians'. These 'guardians' could have been a relative such as an older sibling, aunt or uncle, or any relative with whom a learner lives. One of the reasons for living with guardians could have been to enable the learner to be closer to school. Guardians may also be a family friend or some other acquaintance of the family.

Table 5.7: Highest education level of the learners' parents and/or guardians

Highest academic level of the parents/guardians	Number of learners (n = 348)	Percentage (%)
Tertiary	227	65.23
High school	91	26.15
Primary	8	2.30
Other	1	0.29
No response	*21*	*6.03*
TOTALS	348	100.00

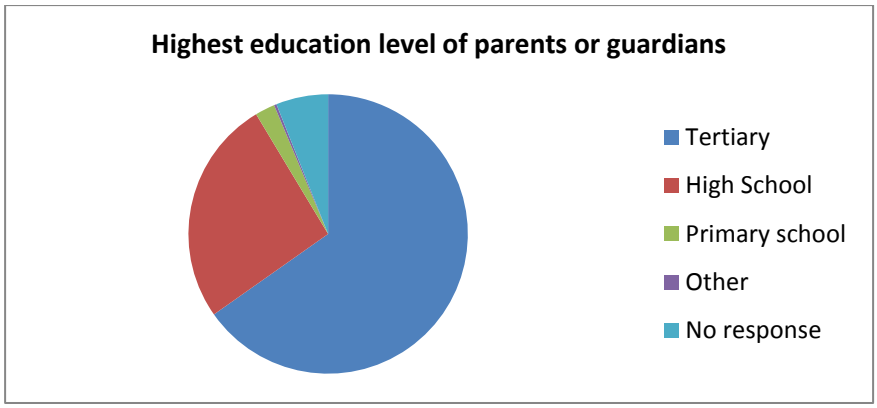

Figure 5.5: Highest education level of learners' parents and/or guardians

(f) Sources from whom or where learners first heard of evolution

Given that the aim of this study was to understand how the beliefs about evolution held by teachers and learners influence the teaching and learning of evolution, some of the questions in this section were related to knowledge about evolution. When asked from whom or where they first heard about evolution, learners revealed several sources as shown in Table 5.8. The

sources included humans (70.42%) and print media (14.08%) and internet and television (14.36%). For the greater proportion (47.13%), the school teacher was the first source of information regarding evolution followed by books (13.79%) and television (12.64%). Put together, parents, siblings and other relatives were sources for 13.23% of the learners, while 6.90% heard about evolution from friends.

Table 5.8: Sources from where learners first heard of evolution

Sources from whom or where learners first heard of evolution	Number of learners (n = 348)	Percentage (%)
School teacher	164	47.13
Books	48	13.79
Television	44	12.64
Friends	24	6.90
Sister	17	4.89
Brother	12	3.45
Religious leader	11	3.16
Parents	9	2.59
Other relatives	8	2.30
Internet	6	1.72
Magazines	1	0.29
No response	4	1.15
TOTALS	348	100.01

This information, which includes other sources of knowledge about evolution, is shown in Figure 5.6 below.

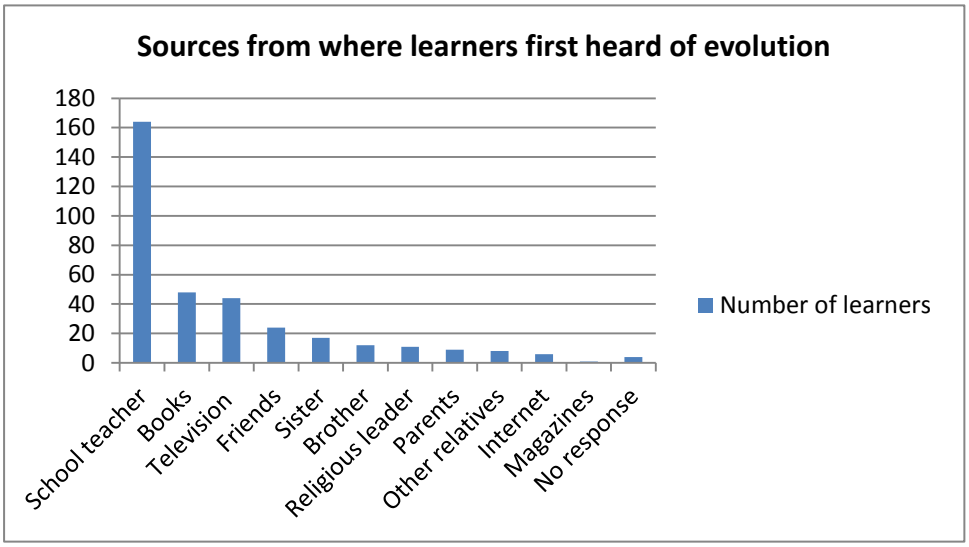

Figure 5.6: Sources from where learners first heard of evolution

Most of these learners (47.13%) stated they had heard about it first from their teacher. That teacher could include those who taught in the lower grades in the GET band or Grades 10-11 where evolution related concepts are covered. Perhaps evolution is not necessarily a household topic, hence the reason for few learners hearing about it from family. Only 3.16% respondents reported hearing about evolution for the first time from their religious leader. This could imply that evolution is not an issue that is discussed much in religious circles for this group of learners.

(g) Time since learners first heard about evolution

As can be seen in Table 5.9, although the time elapsed since they first heard of evolution varied from 1 to 2 years to more than 10 years, most (42.82%) learners had heard of it between 1 to 2 years before, which coincides with the time they were in Grade 10. This therefore could suggest that many of these learners first heard of evolution from their teacher in Grade 10. Although evolution is not mentioned as a topic at this level, related concepts like biodiversity are taught where teachers are likely to mention evolution. The other learners heard of evolution about 3 to 4 years before (25%), from 5 to 6 years before (17.82%), from 7 to 8 years before (5.75%), from 9 to 10 years before (3.74%) and 2.87% had heard about it more than years before the study.

Table 5.9: Number of years ago when learners first heard of evolution

Number of years since learners heard of evolution	Number of learners (n = 348)	Percentage (%)
1 to 2 years ago	149	42.82
3 to 4 years ago	87	25.00
5 to 6 years ago	62	17.82
7 to 8 years ago	20	5.75
9 to 10 years ago	13	3.74
More than 10 years ago	10	2.87
No response	7	2.01
TOTALS	348	100.01

For the learners who heard about evolution three or more years before the study, there are possible explanations to account for that. For instance, it is possible that some of the learners had already learned of evolution in grades lower than Grade 10, or even in lessons outside of Life Sciences. As one of the learners revealed in an interview, she first learned of evolution in Grade 7 – which was in primary school and therefore five to six years before this study. This learner had also first heard of evolution from her teacher, just as those who first heard of it in Grade 10 and Grade 12 Life Sciences lessons. Besides this learner, others revealed during

interviews hearing about evolution first from their relatives: one from a father, another from older brothers and sisters, and two from grandparents. Considering that 33 out of the 348 respondents, fewer than 10%, were interviewed and some of those interviewees revealed hearing about evolution from people other than teachers, it is possible that other learners had heard of evolution in grades lower than Grade 10 or outside of the school setting.

(h) Summary of learners' biographical data

The biographical data of learners presented above shows there were more females (60.06%) than males (39.94%) and most learners reached their seventeenth (47.37%) and eighteenth (33.63%) years at their last birthday before the study, showing that they could have started primary school at the ages of six or seven. The majority (93.68%) of the learners were Christian, and 47.11% attended religious services more than once a week while 45.38% attended at least once a week. This implies a high level of commitment among learners in this group, or devotion to their religious beliefs. Learners also attend religious services with their families more than they do alone or with friends, an indication of a strong family influence or involvement in the belief system of learners that is inclined towards religion, particularly Christianity.

Learners were mostly from the Venda cultural or ethnic group (95.69%) with the majority (79.89%) coming from rural communities. The parents of most learners (65.23%) in the study had undergone tertiary education. Since this variable represented parents and/or guardians, it is possible that some learners' 'parents' are actually 'guardians'. This may be a relative such as an older sibling, aunt or uncle, or any who is educated at tertiary level. Guardians may also be a family friend who may be educated. Regarding knowledge about evolution, the commonest response (47.67%) was 'first heard of it from the school teacher', mostly in the preceding one to five schooling years. This implies that the school plays a significant role in disseminating scientific knowledge to this group of learners.

The last question in this section of the questionnaire required learners to state their most important single comment about evolution. Results are presented in Section 5.2.1.4 (a) with other open-ended questions. The next consideration here is results concerning the acceptance of evolution, obtained in Section B of the questionnaire.

5.2.1.2 Results from the measure of acceptance of the theory of evolution (MATE)

The analyses of data from questionnaires included descriptive analysis, where frequencies and percentages were calculated. As described in Chapter 4, the Measure of Acceptance of the Theory of Evolution (MATE) had twenty-seven 4-point Likert scale questions. The Likert points were Strongly Agree (score 4), Agree (score 3), Disagree (score 2) and Strongly Disagree (score 1). Thus possible scores for the MATE used in the study ranged from a high of 108 to a low of 27, representing 100% and 25% respectively. The totals depended on whether a respondent attended to all the items where the minimum and maximum scores for each item were 1 and 4 respectively.

The results show that not all the 348 participants responded to all the items. This can be deduced from the n-values given in Table 5.10, which shows the number of respondents for each of the 27 items. Table 5.10 also shows the percentage responses for each of the four Likert points.

Table 5.10: Learners' responses to items relating to acceptance of evolutionary theory

Item	Percentage Responses				
	n	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.	340	29.71	41.47	14.12	14.71
2. The theory of evolution is capable of being scientifically tested.	322	28.57	53.42	14.91	3.11
3. Modern humans are the product of evolutionary processes that have occurred over millions of years.	323	23.22	31.58	20.74	24.46
4. The theory of evolution is based on speculation.	307	12.05	25.41	44.30	18.24
5. The theory of evolution is based on valid scientific observation.	317	24.61	51.10	18.93	5.36
6. The theory of evolution is based on valid scientific testing.	315	20.95	49.52	21.59	7.94
7. Most scientists accept evolutionary theory to be a scientifically valid theory.	327	32.42	52.60	12.23	2.75
8. The available data are clear as to whether evolution actually occurs.	321	11.84	46.11	25.86	16.20
9. The age of the earth is less than 20,000 years.	322	54.66	27.95	10.56	6.83
10. There is a significant body of data that supports evolutionary theory.	322	18.63	52.80	19.57	9.01
11. Organisms exist today in essentially the same form in which they always have.	327	23.55	36.39	25.08	14.98
12. Evolution is a scientifically valid theory.	316	21.20	51.58	18.04	9.18
13. The age of the earth is at least 4 billion years.	322	19.25	32.92	26.71	21.12
14. Current evolutionary theory is the result of sound scientific research.	302	12.25	40.73	35.43	11.59
15. Current evolutionary theory is the result of sound scientific methodology.	220	10.45	43.64	38.18	7.73
16. Evolutionary theory generates testable predictions with respect to the characteristics of life.	323	21.05	48.30	19.81	10.84
17. The theory of evolution can be correct since it agrees with the Biblical account of creation.	334	29.64	22.16	25.75	22.46
18. Humans exist today in essentially the same form in which they always have.	321	24.92	27.41	23.99	23.68
19. Evolutionary theory is supported by factual historical data.	323	28.79	50.15	16.41	4.64
20. Evolutionary theory is supported by laboratory data.	321	17.45	45.79	26.79	9.97
21. I believe that evolution is the best explanation for the way the world has come to exist in its present form.	325	18.77	27.38	22.77	31.08
22. Much of the scientific community accepts that evolution occurs.	324	24.07	49.69	17.90	8.33
23. The theory of evolution brings meaning to the diverse characteristics observed in living forms.	312	18.59	51.28	23.40	6.73
24. The theory of evolution brings meaning to the diverse behaviours observed in living forms.	323	18.89	43.65	26.93	10.53
25. Organisms on earth came into existence at about the same time.	324	29.94	38.58	21,30	10.19
26. Evolution is the best explanation for how the world of today has come to exist as we experience it.	320	19.69	31.56	26.25	22.50
27. Evolution is the best explanation for how the organisms of today have come to exist in their current form.	324	24.07	37.65	18.83	19.44

Table 5.11 shows the statistical output for the acceptance of evolution by learners when sums per respondent are used. Although 348 respondents answered the questionnaire, 347 completed the MATE as shown in Table 5.11.

Table 5.11: Statistical output for learners' acceptance of evolution using sum values for respondents

n	$\bar{X}$	SD	$\sum$	Min	Max	Std Error	Median	Mode
347	67.78	14.18	23521	5	100	0.76	69.00	71.00

The expectation would have been that the minimum score would be 27, provided a participant answered 'strongly disagree' to each of the 27 items, giving a total score of 27 for this learner. Similarly, a maximum of 108 would be achieved if at least one participant answered 'strongly agree' to all the 27 items. However, the minimum shown in Table 5.11 is 5 and the maximum score is 100. The reason for this observation is that some candidates did not respond to all the 27 items. The respondent who had the score of 5 had responded to only 2 items answering agree (3) to one and disagree (2) to the other.

Rutledge and Sadler (2007) used five categories of acceptance and the relative percentages as: Very High Acceptance: 89-100%; High Acceptance: 77-88%; Moderate Acceptance: 65-76%; Low Acceptance: 53-64%; and Very Low Acceptance: 20-52%. In this research the scores for each respondent were determined, and the average score was 67.78 (SD = 14.18). Since there were twenty-seven items, the highest score possible for each respondent was 108, therefore, an average score of 67.78 is equivalent to 62.76% which, following Rutledge and Sadler's categories, falls within the range of Low Acceptance (53-64%). Therefore, according to the results when using sum values, this group of learners shows a low acceptance of the evolutionary theory if I use the categories of Rutledge and Sadler (2007).

Table 5.12 shows the statistical output for the acceptance of evolution by the learners when mean scores out of four possible per item, per respondent are used instead of sums for the sample of 347 learners. The means were calculated only on items responded to by learners.

Table 5.12: Statistical output for learners' acceptance of evolution using means for 347 respondents

n	$\bar{X}$	SD	Std Error	Median	Min	Max
347	2.74	0.39	0.02	2.75	1.48	3.70

Using the statistics output shown in Table 5.12, we find that the percentage acceptance calculated using the mean acceptance (2.74) and expected acceptance (4) gives 68.50%. This

percentage falls within the range of moderate acceptance (65-76%) suggested by Rutledge and Warden (2000). The difference between using sums and means could have arisen through the fact that some respondents did not respond to all the items, with a possible result of a bigger standard error, i.e. 0.76, than would result from using means, which is 0.02. Taking the results from the means therefore gives a better picture because only scores from items with responses were used. So, we can conclude that, overall, learners in this group moderately accepted the theory of evolution.

However, there were some variables which had missing data as emerged from the raw data presented. To offset the effect of the missing data, the affected variables were deleted, and only those data with all the items responded to were considered. The sample size (n-value) for those with complete data was 117. The mean ($\overline{x}$) values for this sample were computed where for all the variables, the possible minimum-value was 1 and the possible maximum-value was 4. Table 5.13 shows the results after deletion of variables with missing data including the standard deviation (SD).

Table 5.13: Learners' responses pertaining to acceptance of evolutionary theory by means

Item	n	∑	$\bar{X}$	SD
1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.	117	334.00	2.85	0.96
2. The theory of evolution is capable of being scientifically tested.	117	369.00	3.15	0.66
3. Modern humans are the product of evolutionary processes that have occurred over millions of years.	117	318.00	2.72	1.05
4. The theory of evolution is based on speculation.	117	271.00	2.32	0.90
5. The theory of evolution is based on valid scientific observation.	117	357.00	3.05	0.80
6. The theory of evolution is based on valid scientific testing.	117	349.00	2.98	0.82
7. Most scientists accept evolutionary theory to be a scientifically valid theory.	117	373.00	3.19	0.72
8. The available data are clear as to whether evolution actually occurs.	117	306.00	2.62	0.86
9. The age of the earth is less than 20,000 years.	117	386.00	3.30	0.94
10. There is a significant body of data that supports evolutionary theory.	117	337.00	2.88	0.83
11. Organisms exist today in essentially the same form in which they always have.	117	324.00	2.77	0.98
12. Evolution is a scientifically valid theory.	117	342.00	2.92	0.82
13. The age of the earth is at least 4 billion years.	117	294.00	2.51	1.08
14. Current evolutionary theory is the result of sound scientific research.	117	295.00	2.52	0.84
15. Current evolutionary theory is the result of sound scientific methodology.	117	297.00	2.54	0.79
16. Evolutionary theory generates testable predictions with respect to the characteristics of life.	117	326.00	2.79	0.86
17. The theory of evolution can be correct since it agrees with the Biblical account of creation.	117	317.00	2.71	1.14
18. Humans exist today in essentially the same form in which they always have.	117	297.00	2.54	1.09
19. Evolutionary theory is supported by factual historical data.	117	355.00	3.03	0.76
20. Evolutionary theory is supported by laboratory data.	117	319.00	2.73	0.88
21. I believe that evolution is the best explanation for the way the world has come to exist in its present form.	117	280.00	2.39	1.11
22. Much of the scientific community accepts that evolution occurs.	117	348.00	2.97	0.89
23. The theory of evolution brings meaning to the diverse characteristics observed in living forms.	117	334.00	2.85	0.83
24. The theory of evolution brings meaning to the diverse behaviours observed in living forms.	117	313.00	2.68	0.91
25. Organisms on earth came into existence at about the same time.	117	359.00	3.07	0.93
26. Evolution is the best explanation for how the world of today has come to exist as we experience it.	117	309.00	2.64	1.01
27. Evolution is the best explanation for how the organisms of today have come to exist in their current form.	117	318.00	2.72	1.02

Statistical output using means from data with deleted variables is shown in Table 5.14. The n-value (number of respondents) is 117 as a result of the deletion, and the mean and standard deviation are also affected. The mean goes up to 2.79 and, since this is out of a possible maximum of 4, gives a percentage value of 69.75%. Although this is higher than the percentage before some variables were deleted, it still falls within the moderate acceptance range of 65-76%.

Table 5.14: Statistical output for learners' acceptance of evolution using means for 117 respondents

N	$\bar{x}$	SD	Median	Min	Max
117	2.79	0.91	2.77	2.32	3.30

The statistical output shown in Table 5.14 gives yet another acceptance level from the one calculated when means were used for 347 learners. From Table 5.14, the mean is 2.79 with a possible maximum of 4. The percentage is therefore 69.75% and falls within the moderate acceptance range of (65-76%) suggested by Rutledge and Warden (2000). So, the results of Tables 5.12 and 5.14 for 347 and for 117 learners respectively show moderate acceptance of evolution by the learners.

As discussed in Chapter 4, the items in the MATE were categorized into concepts (see Rutledge & Sadler, 2007). Table 5.15 shows seven concepts, the first six of which were in Rutledge and Sadler's (2007) instrument. The seventh category, perceptions about evolution, was adapted from Cavallo and McCall (2008). These categories were used to assess the acceptance of related concepts of evolution by the sample of 117 learners.

Table 5.15: Means for concepts addressed by the Measure of Acceptance of Evolutionary Theory (adapted from Rutledge and Sandler, 2007 and Cavallo and McCall, 2008) based on the sample of 117

Concepts	Items in the questionnaire	$\bar{x}$
Process of evolution	1; 11; 23; 24; 25;	2.84
Scientific validity of evolutionary theory	2; 12; 14; 15; 16; 17	2.77
Evolution of Humans	3; 18	2.63
Evidence of evolution	4; 5; 6; 8; 10; 19; 20	2.81
Scientific community's view of evolution	7; 22	3.08
Age of the earth	9; 13	2.91
Perceptions of respondents	21; 26; 27	2.58

Looking at the individual items in Table 5.13, we find that the item most accepted was 9 with a mean of 3.30 (SD = 0.94). Item 9 (*The age of the earth is less than 20,000 years*) addressed the concept 'Age of the earth'. An item addressing the same concept, item 13 (*The age of the earth is at least 4 billion years*), is the third least accepted ($\bar{x}$ = 2.51; SD = 1.08). Item 4 (*The theory of evolution is based on speculation*) is the least accepted, with a mean of 2.32 (SD = 0.90). This item falls within the concept, 'Evidence of evolution', and other items addressing the same concept, i.e. 10 (*There is a significant body of data that supports evolutionary theory*), 19 (*Evolutionary theory is supported by factual historical data*) and 20 (*Evolutionary*

theory is supported by laboratory data), are not so lowly-rated, with the exception of item 8 (*The available data are clear as to whether evolution actually occurs*) which is in the bottom quartile of acceptance.

Table 5.15 shows the concepts together with the means of the grouped item means per concept. Looking at these means, the concept most agreed to was 'Scientific community's view of evolution' in items 7 and 22, followed by 'Age of the earth' in items 9 and 13 with means of 3.08 and 2.91 respectively. On the other hand, the learners showed least agreement with the concepts of 'Perceptions of respondents' – represented by items 21, 26 and 27 – followed by the 'Human evolution' – with items 3 and 18 where the means were 2.58 and 2.63 respectively.

(a) Investigating the correlations within the variables measuring evolution acceptance

Inter-correlations were checked among the variables in the MATE itself. While twenty-six MATE items gave positive inter-item correlation values, item VV29, stated as "*The theory of evolution can be correct since it agrees with the Biblical account of creation*", gave a negative value in both raw (-0.239) and standardized (-0.244) variables, indicating a negative correlation between this item and others. The factors which can lead one to agree with this statement include lack of understanding of evolution, the Biblical account of creation. On the other hand it could also mean that some learners accepted evolution because it was said to agree with the notion of creation, implying an evaluation of evolution based on their personal convictions and opinions as well as congruence between evolution and their beliefs system. In that sense the one agreeing to the statement could be a 'theistic creationist'. The statement could also be agreed to by theistic evolutionists, or those who view evolution and creation as being compatible. Alternatively, the results could also imply that the learners failed to read the statement properly. Because it shows a negative correlation, this item could have reduced the reliability of the measure, such that if it was removed from the test, the reliability might have increased.

(b) Associations between learner characteristics and acceptance of evolution

Investigations were carried out to measure associations between some of the learner characteristics – such as gender, age, frequency of attendance at religious services, parent's highest education level, and time since hearing about evolution – and the acceptance of evolutionary theory. The inter-correlations identified were expected to give an insight into the

factors contributing to the worldview development and establishment of beliefs of these learners as well as to the effect of these beliefs and worldviews on learning about evolution.

Investigating associations between MATE and learners' characteristic variables using four-way data

The findings reported here are from investigations of correlations when using data from the four-point Likert scale, which is termed four-way data. Even though variation was observed within this group of learners in terms of all the variables investigated, the variant samples were of very different sizes. For instance, a variable such as cultural or ethnic group had 96.52% of the respondents (n = 333) belonging to the Venda group. The remaining 3.48% were distributed among the other eleven cultural groups. Using the culture variable in the analysis would therefore not provide a conclusive comparison among the culture variants.

However, for all the variables, with the exception of gender, analysis yielded Chi-square (χ^2) values which could not be treated as valid because many of the cells in the analyses had expected counts of less than five (5). We could not, therefore, make any inferences about the association between these variables.

The gender variable yielded Chi-square results within 3 degrees of freedom (df = 3) when the data used were from the 4–point scale. However, for all but three of the items, the p-value was larger than 0.05 ($p>0.05$) indicating high probabilities of chance occurrence, so that we could not reject the null hypothesis that any association between gender and acceptance of evolution was due to chance. One of the items, Item 4: *The theory of evolution is based on speculation*, had a p-value slightly higher at 0.0563 and a Chi-square value of 7.5495. This suggests that most of the observed results were likely to have occurred by chance only and no other factors are likely to have had an association with the observed results. Results for the items which showed lower and more significant p-values are shown in Table 5.16. For these items, the null hypothesis can be rejected and we may infer that there is an association of some sort, and not by chance, between the variables being investigated and acceptance of evolution even though the type of association is not known.

Specifically, the results show that there is a significant association between gender and items 2, 15 and 25, as shown in Table 5.16 when using four-way data.

Table 5.16: Items with low and significant p-values by gender using 2-way data

Item	df	χ^2	p
2: The theory of evolution is capable of being scientifically tested.	3	14.3982	0.0024
15: Current evolutionary theory is the result of sound scientific methodology.	3	8.3062	0.0401
25: Organisms on earth came into existence at about the same time.	3	14.1177	0.0027

Investigating associations between MATE and learners' characteristic variables using two-way data

The initial investigations on MATE and other data presented in the foregoing discussions were based on the four levels (four-point scale). These analyses yielded sparse results about which not much could be said. The four points in the Likert scale were then grouped to give two levels in order to carry out further analyses on the data. This was done by combining the response categories; 'Strongly Agree' with 'Agree' to give only 'Agree', and 'Disagree' with 'Strongly Disagree' to give only 'Disagree'. Basically the 'Strongly Agree/Agree' point became 'Agree' while the 'Disagree/Strongly Disagree' became 'Disagree' and these two were the new variables for a 2-point scale and data we refer to as two-way data. The findings presented in the following discussion therefore, were based on the resulting 2-point scale data. Table 5.17 gives the statistics output for 2-point data in the MATE.

Table 5.17: Statistics output for the MEANS procedure for two-point data with sample of 347

Scale	N	$\overline{X}$	SD	Std Error	Median	Min	Max
2-pt	347	1.64	0.18	0.01	1.67	1.13	2.00

The associations investigated included those between learners' characteristics and the acceptance of evolution. Table 5.17 shows selected characteristic variables of learners whose effect on the acceptance of the theory of evolution was investigated. Collapsing response categories in the MATE from four to two led to the number of degrees of freedom (df) going down as there were fewer cells. The investigated variables were gender, age, religion, frequency of attendance at religious services, from whom a respondent first heard of evolution, and the number of years since first hearing about evolution. Table 5.18 shows some of the statistic outcomes of these investigations. In the column for '***Item***' the number represents the chronological appearance of the items in the questionnaire. For instance, item 1 was the first to appear while item 27 was the last.

Table 5.18: Associations between acceptance of the theory of evolution and gender, religion, frequency of attendance at religious services, from whom first heard of evolution and years since first heard of evolution

	Gender (V2) and 2-way (VV2)]			Age (2-way) (VV3)			Religion (2-way) (V4)			5 Christian denominations (2-way) (VV4)			Frequency of attendance (2-pt) (VV5)			From whom first heard (2-pt) (VV10)			Years since heard of evolution (2-pt) (VV11)		
Item	Df	χ^2	p	df	χ^2	p	df	χ^2	P	df	χ^2	p	df	χ^2	p	df	χ^2	p	df	χ^2	p
1.	1	0.9333	0.8174	1	0.5020	0.4786	11	11.1472	0.4310	4	5.8016	0.2145	1	0.5439	0.4608	3	9.8593	0.0198	2	2.9122	0.2331
2.	1	2.5625	0.1094	1	3.0122	0.0804	11	17.2524	0.1006	4	5.6282	0.2287	1	0.0165	0.8979	3	2.1523	0.5414	2	1.5836	0.4530
3.	1	0.7354	0.3911	1	0.1753	0.6755	10	19.3306	0.0363	4	12.7259	0.0127	1	0.1698	0.6803	3	6.7198	0.0814	2	0.0163	0.9919
4.	1	2.7768	0.0956	1	0.5728	0.4492	11	13.2355	0.2782	4	4.7310	0.3160	1	0.4701	0.4930	3	9.3921	0.0245	2	8.3525	0.0154
5.	1	0.1764	0.6745	1	0.5254	0.4685	11	19.7388	0.0491	4	11.2479	0.0239	1	0.0389	0.8437	3	14.3335	0.0025	2	1.8243	0.4017
6.	1	0.0028	0.9580	1	1.7617	0.1844	11	7.8349	0.7280	4	2.4719	0.6497	1	0.1678	0.6820	3	4.5000	0.2123	2	0.0116	0.9942
7.	1	0.0397	0.8421	1	1.7536	0.1854	11	7.0540	0.7947	4	5.2492	0.2627	1	0.0944	0.7586	3	3.3595	0.3394	2	3.6380	0.1622
8.	1	0.1624	0.6869	1	0.1954	0.6584	11	12.2162	0.3476	4	2.8202	0.5884	1	0.0187	0.8911	3	0.1982	0.9779	2	2.0126	0.3656
9.	1	0.1853	0.6668	1	2.6741	0.1020	11	25.6532	0.0073	4	6.5748	0.1601	1	0.0545	0.8154	3	2.1439	0.5431	2	10.0441	0.0066
10.	1	0.1849	0.6672	1	3.7568	0.0526	11	11.7130	0.3856	4	2.1672	0.7059	1	0.0158	0.9001	3	1.9172	0.5898	2	0.9291	0.6284
11.	1	3.6196	0.0571	1	3.9104	0.0480	11	13.3403	0.2717	4	8.6379	0.0708	1	1.6677	0.1966	3	1.9760	0.5774	2	3.0867	0.2137
12.	1	0.2938	0.5878	1	0.2009	0.6540	11	6.7918	0.8157	4	3.3037	0.5084	1	0.0039	0.9503	3	1.2928	0.7308	2	0.2450	0.8847
13.	1	0.0712	0.7895	1	1.2007	0.2732	10	8.7234	0.5585	4	4.3085	0.3659	1	0.4504	0.5021	3	4.0633	0.2547	2	3.3254	0.1896
14.	1	0.6248	0.4293	1	0.2852	0.5933	10	6.3201	0.7877	4	0.4714	0.9762	1	0.6035	0.4373	3	4.4354	0.2181	2	0.8644	0.6491
15.	1	1.7224	0.1894	1	0.3239	0.5693	9	5.9443	0.7455	4	1.8932	0.7554	1	1.1050	0.2932	3	0.3478	0.9508	2	0.5506	0.7593
16.	1	0.4664	0.4947	1	0.2712	0.6026	11	10.5333	0.4831	4	5.2336	0.2642	1	0.0172	0.8957	3	1.1460	0.7660	2	3.6290	0.1629
17.	1	2.5302	0.1117	1	0.3797	0.5378	11	14.4228	0.2105	4	9.3162	0.0537	1	0.0117	0.9138	3	1.4355	0.6972	2	0.2216	0.8952
18.	1	2.2289	0.1354	1	0.6388	0.4241	11	11.9230	0.3695	4	6.0358	0.1965	1	1.1022	0.2938	3	4.9507	0.1754	2	13.7435	0.0010
19.	1	0.0309	0.8605	1	0.2987	0.5847	11	9.0631	0.6161	4	3.3935	0.4943	1	0.4618	0.4968	3	7.8167	0.0500	2	2.3433	0.3099
20.	1	0.0345	0.8526	1	3.9537	0.0468	11	13.1013	0.2868	4	6.0566	0.1950	1	2.3736	0.1234	3	4.1731	0.2434	2	1.5783	0.4542
21.	1	0.4643	0.4956	1	0.5875	0.4434	11	11.8243	0.3770	4	3.4017	0.4930	1	0.4709	0.4926	3	5.5084	0.1381	2	0.8600	0.6505
22.	1	0.0262	0.8714	1	1.7609	0.1845	11	7.1579	0.7862	4	4.3454	0.3613	1	0.0509	0.8215	3	1.6098	0.6572	2	0.0236	0.9883
23.	1	1.7087	0.1912	1	0.2026	0.6526	9	11.5252	0.2414	4	5.2128	0.2662	1	0.3270	0.5674	3	5.6248	0.1314	2	0.2906	0.8648
24.	1	0.7082	0.4000	1	0.8251	0.3637	11	5.9847	0.8744	4	1.1694	0.8831	1	2.7087	0.0998	3	3.3670	0.3384	2	1.5972	0.4500
25.	1	3.5532	0.0594	1	0.0825	0.7740	11	3.5203	0.9819	4	0.4694	0.9764	1	0.9071	0.3409	3	6.1196	0.1059	2	1.0635	0.5876
26.	1	0.6754	0.4112	1	0.8417	0.3589	11	11.8708	0.3734	4	5.7436	0.2191	1	0.0032	0.5548	3	1.8118	0.6124	2	2.9802	0.2254
27.	1	0.3720	0.5419	1	3.5592	0.0592	11	10.1500	0.5169	4	2.2541	0.6891	1	1.2966	0.2548	3	3.9026	0,2722	2	3.1667	0.2053

- ***Variables not showing significant outcomes***

The results showed no significant results for the 'gender' variable when 2-way data were used which is different from the results from 4-way data. One other variable which showed no significance was the 'frequency of attendance at religious services'. As shown in Table 5.15, the probability of a significant result in all the items is higher than 0.05; therefore it can be accepted that the observed association for these variables is due mainly to chance.

- ***Variables showing significant outcomes***

The other four variables showed significant outcomes for some of the items. For instance, with 'Age', items 11 and 20 had probability values (p-values) lower than 0.05 ($p<0.05$) while all the other items had larger than 0.05 p-values. The variable 'From who first heard of evolution' gave significant probability values with items 1, 4, 5, and 19. Except for item 1 which belonged to the category describing the 'process or evolution', the other three items generally described the 'Evidence of evolution'. The variable 'Years since heard of evolution' showed a significance association with three items: 4, 9 and 18; with item 4 describing 'Evidence of evolution', item 9 'Age of the earth', while item 18 describes 'Evolution of humans'.

The investigation on the religion variable using 2-way data involved two levels. In one level the test involved all religions mentioned by the respondents in the study. In further analyses, this variable was reduced so that only Christian religions were investigated. The reason was that there were five Christian religions to which the majority of the learners (92.82%) belonged (two of the Christian faiths with only one respondent each were left out), and the investigation was meant to find out if the type of Christian faith to which a learner belonged had an association with their acceptance of evolution. The assumption was that some or one of the Christian faiths would show association with acceptance of evolution than others. However, the probabilities did not indicate any change in the association between religion and acceptance when only the more represented Christian faiths were investigated compared to when all the religions were investigated together. Interestingly, the MATE items which gave a significant probability ($p<0.05$) were the same in both investigations.

These were item 3, '*Modern humans are the product of evolutionary processes that have occurred over millions of years*', and item 5, '*The theory of evolution is based on valid observation*'. For item 3, $p = 0.0363$ for all religions and $p = 0.0127$ for only Christian faiths.

For item 5, p = 0.0491 for all religions and p = 0.0239 for only Christian faiths. For item 9, the probability was significant (p = 0.0073) for all religions and not significant (p>0.05) for only Christian faiths at p = 0.1601. From these it can be concluded that there seems to be a significant association between religion and some items, notably items 3, 5 and 9 which, respectively, describe 'Evolution of humans', 'Evidence of evolution' and 'Age of the earth'. Therefore the observed results are not only due to chance but other alternative factors could possibly have had an association.

From these investigations we can conclude that there are some characteristic variables of learners that show some association with their acceptance of the theory of evolution and these are religion, age, the person from whom the learner first heard of evolution, and the number of years since the learner had heard of evolution.

5.2.1.3 Results from open-ended questions

The open-ended questions in both Section A and Section C of the questionnaire were analysed qualitatively to identify the categories and themes and come up with codes to represent those themes. The data were then 'quantified' by counting the occurrences of different responses represented as codes, and then computing totals and percentages. Findings from different questions are presented in the next sections in tables and charts accompanied by a discussion to explain the presentation. In the tables and charts presenting the information gathered for the open-ended questions, 'n' is used to represent the number of occurrences, or frequency, of a category of responses. The categories shown in the tables were all formed during the initial analysis of the open-ended questions from the questionnaires. In Section C, an allowance was made for up to five variables per question per respondent. In some responses only one variable was identified for analysis while in others more than one variable was identified. This explains why, in some cases, 'n' is greater than 348 which was the total number of respondents who responded to the questionnaire. The tables presenting these data have two columns for percentages – the first column showing percentage of the total number of responses and an overall percentage, and the second column showing the percentage of learners out of 348 who gave the response. This last percentage is more than 100 because there were more responses than one for a respondent in some of the cases.

Following the initial analysis, the categories were analyzed further and new themes emerged to which codes were assigned. It was not always easy to know if the phrases applied in the

codes were sufficient in communicating the meaning of the theme. For instance, deciding between 'science', 'scientific', 'science-related' or 'modern science' for a code indicating a science-related category was not easy, as well as choosing the right phrase for a theme defining a motivated attitude. The other difficulty was setting the parameters clearly to distinguish the different codes and themes. In some questions there were two stages of setting up codes, while in other questions three stages were required. With the richness of data in the responses to these questions and depending on the type of question and responses, it was possible to analyse the data from various perspectives. It is still possible that more or different codes and themes could have been generated from the data. In presenting the findings, the questions are rephrased into statements used as headings. After a heading, a discussion is provided for every question on how the different codes were arrived at, including the number of stages involved in the analysis as well as how the tables and figures that have been used to present the results were formed.

(a) Learners' single most important comment about evolution

The first of these open-ended questions, which appeared as Question 11 at the end of Section A, was, "*What is your single most important comment about evolution?*" This question required learners to give their most important comment about evolution and it was expected that the information from the learners would give an insight into their perception of truth concerning the existence of species, and hence an insight into their worldview. Since only one comment was expected from the respondents, where more than one comment was given, only the first one was considered for analysis. For this question, only one response from a learner was used in the analysis, therefore 'n' which represents the frequency of responses, is also equivalent to the number of learners giving that response.

Responses to this question were expected to reveal the views of learners about the theory of evolution. Since this questionnaire was administered after learners had received instruction in evolution, it was expected that the basis for their responses would include the knowledge they had acquired at school. The question was open-ended and general, and learners could give their responses from any perspective. In the analysis, responses were first categorized to bring similar responses together. For instance, comments such as 'best description of origin of species arising from those that existed in the past', 'very convincing' and 'real' were put together in one category. The second step involved assigning codes to the categories. Because responses varied and ranged from those learners who found evolution 'valid', 'valid but not

for humans', to those who stated that evolution 'does not exist' or 'does not occur at all', two possibilities were considered in coming up with the required codes.

The analysis for this question generated nine categories from the responses. These categories were later coded, firstly to reveal the views of learners regarding validity of evolution as a scientific theory or as real, and secondly to infer, from the responses and the first codes, the learners' view of reality regarding evolution or the worldviews of learners. The first set of codes, or stage 1 codes ['Codes (1)'], was meant to reveal whether the learners found evolution to be a valid scientific theory or not. The codes in the second stage ['Codes (2)'] were based on the worldview inferences. In other words, they were based on whether the responses could have been influenced by *scientific* or *religious* thinking or both, or it was everyday thinking which was coded as '*personal*'? If both scientific and religious occurred in one response, the code was stated as '*mixed*'. 'Scientific' in this sense referred to modern science. This analysis does not mean that an individual cannot be both religious and scientific. Rather, the analysis looks at the comments and the possible thinking behind them. Table 5.19 shows the categories of the responses, the number of responses (n) and percentages, and corresponding codes identified as fitting for the categories.

Table 5.19: Learners' comments about evolution

Categories elicited from learners' comments	n	%	Comments about validity	Possible worldviews
1. Best description of origin of species arising from those that existed in the past; sharing common ancestor; and variation; very convincing; real; interesting	95	29.60	Valid and convincing	Scientific
2. Evolution is valid scientific theory; based on facts and strong evidence of changes in populations over time; based on natural selection; means survival of the fittest	57	17.76	Valid	Scientific
3. Humans have not evolved from another species; needs more research	23	7.17	Not valid for humans	Mixed
4. Do not understand it; confused; does not occur now; make some to lose faith	12	3.74	Not valid	Religious
5. Explanation of how things happen / any unclear definition	19	5.92	Unclear	Unclassifiable
6. Evolution is based on speculation; just a theory; not a fact; I do not accept it; it does not have enough evidence	12	3.74	Not valid	Personal
7. It is another religion or belief; and plays God	5	1.56	Evolution as religion	Religious
8. Anti-God; anti-Christianity; devilish; anti-Christ; anti-religion; against my beliefs	35	10.90	Against religion	Religious
9. Evolution does not exist; unreal; no proof; does not occur at all	66	19.63	Unreal, not valid	Personal
TOTALS	324	99.99		

The first set of codes was meant to indicate whether the comments from the respondents found evolution to be valid, real, true, or the opposite of these. Also, some respondents brought in comments that related evolution to their religion, as can be seen in categories 7 and 8. Categories 1 and 2 both refer to the validity of evolution, but they differ in how that validity was qualified in the comments. For instance, in category 1, respondents brought in the element of "best description" or "strong evidence" instead of just 'description' or 'evidence', which is the case in category 2. These two categories were coded as '*scientific*', since they were based on scientific understanding.

The three categories which were first coded as '*not valid*', i.e. categories 3, 4 and 6, were taken as indicating that respondents did not accept evolution as valid, since their comments refuted some of the claims of evolutionary theory. For category 3, where evolution was accepted except in the case of humans, the code was given as '*mixed*'. The 'mixed' code meant that the comments reflected an acceptance of the scientific explanation of evolution, but only in part as respondents wouldn't accept human evolution. Learners' personal beliefs, religious beliefs or any views alternative to those of Science could therefore have prevented learners from accepting human evolution, thus showing mixed views or perspectives. The other '*not valid*' categories were coded differently, based on whether the comment was religious or not. Where no religion was referred to, as in category 6, the code applied was '*personal*', meaning that the comment could have been based on any personal knowledge system which was not religious but was still an alternative to scientific thinking.

The difference between categories 7 and 8 in 'Codes (1)' is that in category 7 evolution was specifically said to be "playing God" or that it was playing the role of religion itself, while in category 8 evolution was said to be "against religion" or "against God", without an indication that it was playing God or was a religion itself. However, in the second coding, these two categories were both coded as '*religious*' meaning that they were likely to be based on religious predispositions or on people's worldview. The responses which were not clear in meaning and could not fit in the identified codes were coded as '*unclassifiable*'.

Table 5.20 shows the numbers of learners accepting evolution as valid or not accepting it, and the worldviews they might be holding related to their comments.

Table 5.20: Learners' comments about evolution and possible worldviews

VIEWS	Scientific	Personal	Religious	Mixed	Unclassifiable	Totals	%
Valid	152					152	46.91
Mixed				23		23	7.10
Unclear					19	19	5.86
Not Valid		78	12			90	27.78
Against religion			35			35	10.80
Another religion			5			5	1.54
TOTALS	152	78	52	23	19	324	
Percentage	46.91	24.07	16.05	7.10	5.86		99. 99

The information in Table 5.19 was condensed to form Table 5.20. Information about the validity of evolution was extracted from Table 5.19, and Table 5.20 gave the results shown in Table 5.21. The occurrences first coded as 'against religion' and 'another religion' were added to the 'not valid' code. This was because what was being inferred from the statements in the categories concerned were not attitudes about religious beliefs but attitudes about the validity of evolution. So, whether it was for religious or any other reason, it was evolution that was being regarded as not being valid.

Table 5.21: Views of learners regarding the validity of evolution when asked to give a single comment about evolution

Views	Number of learners (n = 324)	Percentage (%)
Valid	152	46.91
Not valid	130	40.12
Mixed	23	7.10
Unclear	19	5.86
TOTALS	324	99.99

Similarly, information about learners' possible worldviews was extracted from Table 5.19 and Table 5.20. The results obtained from that extraction are shown in Table 5.22.

Table 5.22: Worldviews of learners when asked to give a single comment about evolution

Codes	Number of learners (n = 324)	Percentage (%)
Scientific	152	46.91
Personal	78	24.07
Religious	52	16.05
Mixed	23	7.10
Unclassifiable	19	5.86
TOTALS	324	99.99

To summarize the results for this question, Table 5.23 was drawn to combine the views on validity and the worldviews of learners. Figure 5.7 presents the information from Table 5.23.

Table 5.23: Views of learners about evolution in terms of the validity of evolution and learners' possible worldviews

	Scientific	Personal	Religious	Mixed	Unclassifiable	Totals	%
Valid	152					152	46.91
Not Valid		78	52			130	40.12
Mixed				23		23	7.10
Unclear					19	19	5.86
TOTALS	152	78	52	23	19	324	
Percentage	46.91	24.07	16.05	7.10	5.86		99.99

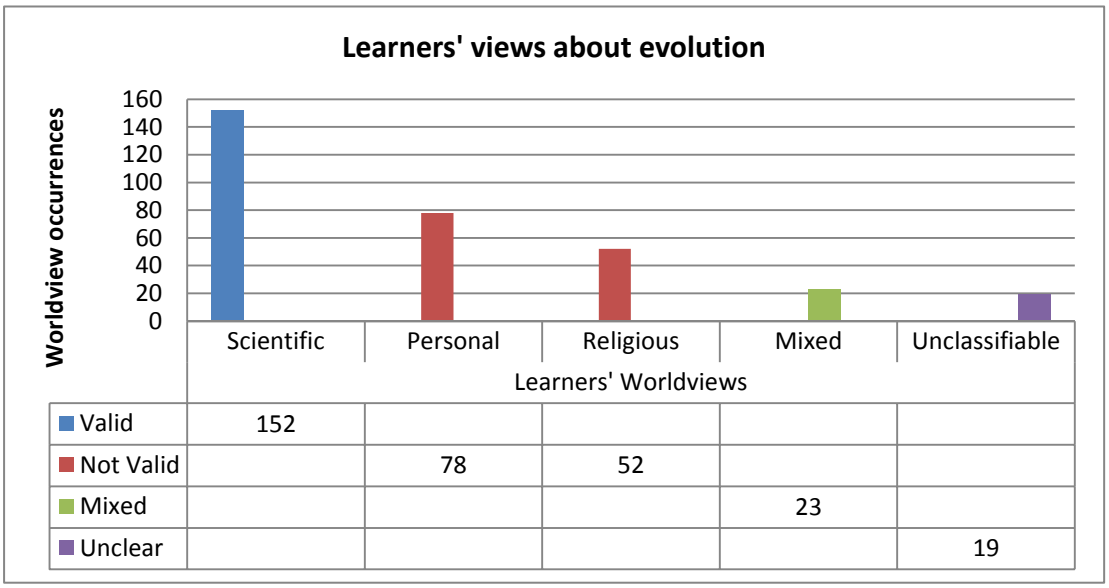

Figure 5.7: Views of learners about evolution in terms of the validity of evolution and learners' possible worldviews

As would have been expected, the results for this question show that some learners found evolution not to be valid while others do find it valid. There were also learners who hold certain views which seem to determine their opinions about validity of evolution. '*Religious*' comments were those that mentioned God or religion or both, while those that refuted evolution with no reference to God or religion were coded '*personal*'. Scientific comments were those that gave a 'scientifically correct' comment, that is, comments reflecting modern science thinking. The results therefore indicate that 46.91% of the participants gave scientifically-inclined responses, as opposed to 24.07% (n = 78) who used every day personal

notions and 16.05% who gave religious comments. This information is presented in Table 5.23 and Figure 5.7.

As acknowledged earlier, there could be different ways of building the categories as well as assigning themes to the categories. For instance, in all the themes identified, i.e. *scientific*, *religious* or *personal*, there are responses which show misconceptions. For instance, responses such as 'evolution does not have evidence', 'has no proof', and 'it is another religion' which have been coded as *personal* or *religious* show lack of understanding and misconceptions about evolution. Similarly, some responses categorised as *scientific*, such as 'means survival of the fittest' also do not indicate correct conception about evolution, even though there is some scientific idea in the response.

It would appear from these results that learners with a scientific worldview find evolution valid as a scientific theory while those who have a religious worldview find evolution not to be valid. However, we cannot conclude that this is the case, nor can we extrapolate this finding to the rest of the population or even to other samples.

(b) Learners' beliefs about evolution

The second question, the first in Section C, "*What is your belief about evolution*?" was meant to find out how learners described their own beliefs in relation to evolutionary theory. The expectation was that the responses would also provide insights into learners' acceptance of evolutionary theory. Results are shown in Table 5.24, where 'n' represents the frequency of responses for each category. Columns labelled Codes (1), Codes (2) and Codes (3) represent codes from the first, second and third stages of coding.

The first stage codes relate to whether the response indicated acceptance of evolution by the learners. By stating that they "strongly believe in evolution" or make a comment that evolution is "true", "real" or "taking place"; learners show that they accept the theory of evolution and the code given was '*accept*'. In cases where learners stated that they believed in it "but not completely" or showed some confusion or lack of understanding, such as "believe in Lamarckian theory only" the code was '*partially accept'*, indicating that there was some acceptance. The degree of acceptance, however, could differ in terms of how well the theory seemed to be understood. Two other codes were combined as '*neutral*' for responses showing a detached stance, such as "it is scientists' theory" or "study for examinations", and the fourth code was '*not accept*' for responses that stated that evolution was a "myth",

"guess", or that it was "not occurring presently". This level was termed 'acceptance' which shows whether responses were inclined to accepting or not accepting evolution.

The second stage of coding looked at how the learners perceived evolution in terms of its validity. The theme emerged as 'views about evolution'. One of the codes was '*valid*', for responses that said evolution was valid, real and true such as a belief that stated that "evolution is still taking place", that "I strongly believe in evolution" and could give a correct scientific definition such as that evolution is a "valid scientific theory explaining changes in species and earth over time". The responses coded as '*not valid*' include statements such as "evolution is not occurring presently", "it does not exist", "it is not true" as well as "I believe in creation". Some responses indicated mixed beliefs, where a respondent would say that "I believe in both evolution and creation" or "I believe in evolution but not completely" or "I believe in evolution of other species but not in humans". The '*mixed*' code was used for those who indicated two positions right away and those who seemed confused. The code indicates that the confusion was brought about by mixed views.

The third stage codes ('Codes (3)') looked at whether the responses were inclined towards scientific explanations or alternatives, and possible worldviews thereof. For instance, in categories 1, 2 and 4 responses, where explanations were scientifically inclined and correct, or reflected a scientific explanation of evolution, the '*scientific*' code was used. Where explanations reflected a religious inclination such as in categories 7 and 8, the code used was '*religious*'. The code '*mixed*' was given for responses which had both religious and scientific inclinations and '*personal*' for responses that were not scientific but did not accept evolution for reasons silent about religion. Results from these three coding stages are presented in Table 5.24.

Table 5.24: Learners' beliefs about evolution

Categories elicited from learners' responses	n	%	Acceptance	Views about validity	Possible worldviews
1. Strongly believe evolution; descent from common ancestor; it is real; true; and is still taking place	100	19.53	Accept	Real and valid	Scientific
2. Valid scientific theory explaining change in species and earth over time; millions of years; shared characteristics	112	21.88	Accept	Valid	Scientific
3. Believe it but not completely; not in humans but only in other species	30	5.86	Partially accept	Unsure	Mixed
4. Takes place due to environmental changes, natural selection and competition	29	5.66	Accept	Valid	Scientific
5. Neutral; non-committal; scientists' theory; speculation; not religious; study for examinations	38	7.42	Neutral	Neutral	Personal
6, Confused; historical evidence hard to believe; believe in Lamarckian theory only,	37	7.23	Partially accept	Unsure	Personal
7. Evidence insufficient; has gaps and conflicts; myth; guess; not occurring presently; contradicts religion; confuses Christians	14	2.73	Not accept	Not valid	Religious
8. Believe in evolution and creation	23	4.49	Partially accept	Unsure	Mixed
9. Strongly opposed to evolution; it does not exist; not true; opposes God; believe in creation	129	25.20	Not accept	Unreal; Not true	Religious

Combining similar codes form stages 1 and 2, codings in Table 5.24 give the four codes shown in Table 5.25, while the codings from stage 3 give the four codes shown in Table 5.26. Table 5.25 has the codes from stages 1 ('Codes (1)') and 2 ('Codes (2)') together, because these codes related well, such that all '*accept*' codes from stage 1 ('Codes (1)') related with '*valid*' in stage 2 ('Codes (2)'), and that was the same for the other codes as well. Because such a one-to-one relationship was not found with stage 3 ('Codes (3)') and the others, a separate table, Table 5.26, was drawn up to present the results of Codes (3).

Table 5.25: Learners' beliefs regarding the validity of evolution

Learners' beliefs about evolution	Learners' acceptance of evolution	Responses		Percentage of learners (%)
		N	Percentage (%)	
Valid	Accept	241	47.07	69.25
Not valid	Not accept	143	27.93	41.09
Unsure	Partially accept	90	17.58	25.86
Neutral	Neutral	38	7.42	10.92
TOTALS		512	100.00	147.22

Table 5.26: Possible worldviews affecting learners' beliefs about of evolution

Learners' beliefs about evolution	Responses		Percentage of learners (%)
	N	Percentage (%)	
Scientific	241	47.07	69.25
Religious	143	27.93	41.09
Personal	75	14.65	21.55
Mixed	53	10.35	15.23
TOTALS	512	100.00	147.12

Cross-tabulating the information from Table 5.25 and Table 5.26 gave rise to Table 5.27 and Figure 5.8.

Table 5.27: Learners' possible worldviews and their beliefs about evolution

Views about validity Acceptance	Worldviews	Scientific view	Religious view	Personal view	Mixed view	Totals	%
Valid and real	Accept	241				241	47.07
Not Valid and Unreal	Not accept		143			143	27.93
Unsure	Partially accept			37	53	90	17.58
Neutral	Neutral			38		38	7.42
TOTALS		241	143	75	53	512	
Percentage		47.07	27.93	14.65	10.35		100.00

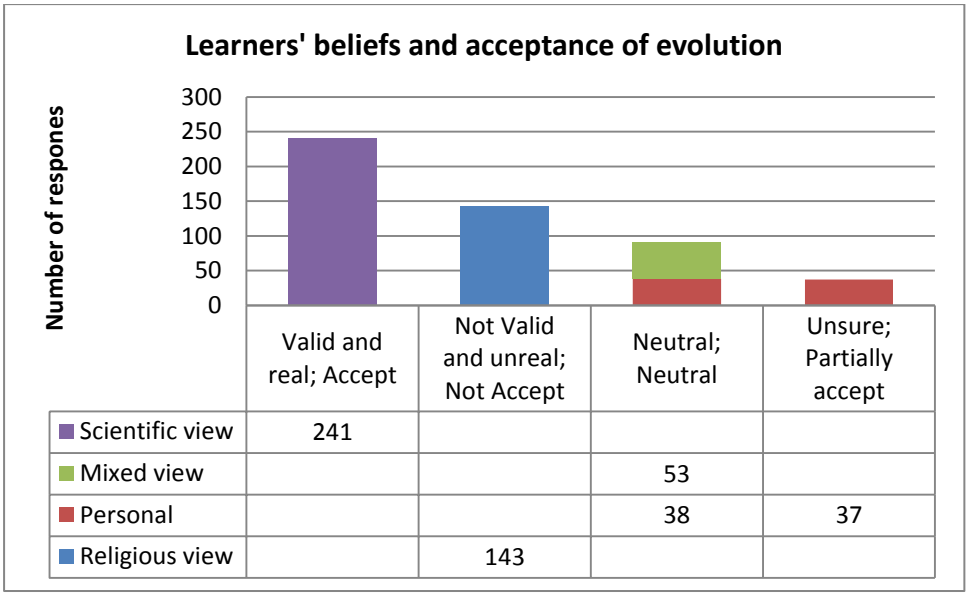

Figure 5.8: Learners' beliefs about evolution and acceptance of evolution

The results indicate that there is a relationship between worldview and perception about the validity of evolution and acceptance of the concept. We see from the results that learners who respond from a scientific perspective are more likely to find evolution valid and accept it, as was indicated by the scientifically-inclined responses they gave. Such scientific responses were likely to be informed by scientific worldviews. However, learners who responded from a religious perspective tended to regard evolution as not true or not valid, and did not accept it. These learners could be operating from a religious worldview, which influences their judgement about the validity of evolution and their acceptance of it.

As it is shown in the corresponding categories, scientific views were those that indicated that evolution was valid, real, true, still taking place, and that it explained change in species over time. On the other hand, religious views were those that did not accept evolution as valid because the respondents believed in God or in creation instead of evolution. Some (27.93%) of responses which were classified as '*religious*' found the evidence of evolution not enough, evolution contradicting their religion, or evolution not true and not valid. A smaller proportion (10.35%) of responses indicated beliefs in (or acceptance of) both creation and evolution, and these responses were coded as '*mixed*'. Furthermore, there was some indication that more learners (47.07% of responses) had a scientific worldview as they found evolution real, true and valid and accepted it.

(c) Learners' beliefs about the origin of species on earth

The third question was "*Describe what you believe regarding the origin of species on earth*". It was expected that learners, having learned about evolution and who accepted evolution, would give responses that related evolution to the origin of species. However, the question asked about learners' beliefs, not so much their understanding or knowledge of evolution from the classroom, but more to gain an insight into learners' perceptions of causality. The results in Table 5.28 show the first stage and second stage codes. The first stage codes – Code (1) – indicate whether respondents thought species were created or if they evolved. Learners' views of causality, and hence worldviews, were then inferred from the categories to generate the second stage codes – which were '*religious*', '*scientific*' and '*mixed*' – to indicate learners' perspectives. As in earlier analyses, '*scientific*' refers to explanations inclined towards modern scientific thinking, while '*religious*' refers to religious attitudes towards causality when respondents either mention that species were created, as in category 1. '*Mixed*' views are those that reflect both the religious and scientific predispositions, while for

the 'not sure' responses, the worldview was inferred as '*unsure*', since the responses were not aligned to religious or scientific thinking. The results of the analyses are shown in Table 5.28 and Table 5.29 where 'n' represents the number of response occurrences.

Table 5.28: Learners' beliefs regarding the origin of species on earth

Categories elicited from learners' responses	n	%	Beliefs about origins	Worldviews
1. All species created by God's word; at the beginning; Origin of all species best known by God; humans created in His image	214	54.73	Created	Religious
2. All species created by God; then all underwent natural evolution	19	4.86	Created, then evolved	Mixed
3. Humans created by God as they are and have not evolved from anything; other species have evolved	0	0	Humans created; other species evolved	Mixed
4. Sometimes not sure; confused	27	6.91	Not sure	Unsure
5. All species except humans originated from others	2	0.51	Humans created; other species evolved	Mixed
6. All species have evolved from one single organism; species	47	12.02	Evolved	Scientific
7. Species originated due to environmental changes such as continental drifts; and as they try to adapt in new places; big bang	30	7.67	Evolution	Scientific
8. Humans and apes originate from same ancestor	14	3.58	Evolution	Scientific
9. All species have evolved from pre-existing species; by natural selection	38	9.72	All species evolved	Scientific
TOTALS	391	100.00		

Combining similar codes from stage 2 coding yielded four codes, '*scientific*', '*religious*', '*mixed*' and '*confused/unsure*'.

Table 5.29: Learners' possible worldviews in relation to origin of species on earth

Learners' worldviews	Responses (n = 391)		Percentage of learners (%)
	N	Percentage (%)	
Religious	214	54.73	69.25
Scientific	129	32.99	37.07
Unsure	27	5.37	7.76
Mixed	21	6.91	6.03
TOTALS	391	100.00	120.11

The results for this question show that '*religious*' views dominate (54.73%) when learners are asked about what they believe regarding the origin of species. This is a different result from that observed for the previous question, where learners were asked to give their beliefs about evolution. This could imply that learners do not relate evolution to the origin of species, and

mostly believe that species came about through creation. There are even responses that were classified as '*mixed*' worldview because they indicated acceptance of evolution for all species but not for humans.

(d) Learners' perceptions about the influence of their beliefs on learning evolution

This question, "*Describe how your beliefs influence your learning of evolution*" required learners to reflect on their learning experiences and describe how their beliefs influenced their learning about evolution. The responses of learners ranged from those where learning was completely impeded or mildly impeded, to those of learners who felt that their beliefs actually enhanced their learning about evolution and were happy about learning it. The first codes therefore looked at whether the influence was negative or positive, or if there was any effect. In cases where learners indicated an emotion such as 'hate' or 'happy', the categories were separated from those in which such emotions were not reflected, by qualifying 'negative' or 'positive' codes with 'very'. For instance, comments such as "hate learning evolution" or "scared of learning evolution" were regarded as '*very negative*' since they indicated a depth of emotion felt by the respondent. Comments such as "make learning difficult" or "felt bored" do not indicate any depth of emotion and were coded as merely '*negative*'. At the other end of the scale, the learners felt their beliefs "enhanced learning" and such responses were coded '*positive*' whereas comments such as "very happy" and "challenged me to think hard and participate in class" were coded as '*very positive*' because the learners were actively involved in class and emotionally elated to learn evolution.

The second stage codes looked into the kind of relationship that existed between learners' beliefs and evolution. The codes therefore indicated whether there was a conflict between the two, whether the beliefs were separated from evolution, or whether the learners' beliefs supported or complemented learning about evolution. In a way these codes could give an insight into learners' perceptions of the relationship between religion and science. The relationships inferred from these responses were '*conflict'*, '*complementarity*' and '*separate*'. The term 'strongly' was added to differentiate the 'conflicted' from 'strongly conflicted', and 'complementary' from 'strongly complementary' influence, depending on how the learners had expressed themselves. While in some instances learners made comments such as evolution "insults God", which shows a religious predisposition, in some cases the comments did not imply any religious views. But since learners had to indicate how their beliefs

influenced their learning, the understanding was that all the responses were based on the respondents' beliefs, whether they were religious, personal or scientific.

Between the negative and the positive influences were found responses where learners indicated that there was no influence and those who were confused during the learning of evolution. The understanding here is that the beliefs were there, but learners either ignored them during learning, or separated them from the learning process. This category was given the code '*separate*' to indicate that learners were able to separate their beliefs from the concept of evolution. There were some learners who reported being confused and not understanding evolution as it is shown in category 5 of Table 5.30. It did not seem that the confusion was brought about by their beliefs, as it was for the responses in category 4. The responses in the latter category did show that the confusion was brought by learners' beliefs, as they even stated that they did not "know what to believe". The responses in category 5 give an impression of confusion caused by lack of understanding and, since the learners were describing the influence of their beliefs, it shows that the confusion was brought about by those beliefs. Therefore the code given was '*conflicted*'.

The third stage codings related the influence of beliefs to border crossings that could have existed for the different categories. The typology provided by (Phelan *et al*., 1991) was adapted to determine the border crossings for learners. Four crossings were identified: '*smooth*' for situations where learning was enhanced and enjoyed; '*managed*' for learners who managed to learn even though they were still experiencing some discomfort or conflict; and '*hazardous*' for cases where learning did not take place because there was a strong conflict. The fourth border crossing from the typology, '*impossible*' was included for category 1, where learning was completely impeded, meaning that the border was impervious and impossible to cross. The results of this stage are presented in the 'Codes (3)' column.

At this stage we can neither infer whether strongly conflicted views relate to strongly-held religious or personal views, or whether strongly complementary views relate to no or weak religious views, nor can we infer relationships with scientific views. This is because, as some of the learners indicated, they were happy to learn about evolution. Being strongly religious does not, therefore, necessarily lead one to being strongly opposed to learning about evolution; instead, the opposite can happen where a strongly religious person can be highly motivated to learn. But with regard to crossing the borders between one's beliefs and evolution, then positive influences are taken to imply smooth crossings while difficulty in

learning suggests hazardous crossings. Nevertheless, having a strong scientific worldview may not be a source of motivation for one to learn about evolution, as other factors may be involved. The results for the three coding stages are shown in Table 5.30, Table 5.31 and Table 5.32, where 'n' represents the number of occurrences of the responses, and Codes (1) showing the type of influence, Codes (2) perception of conflict, and Codes (3) giving type of possible border crossing, represent the results of stages 1, 2 and 3 codes respectively.

Table 5.30: Learners' responses indicating the influence and effect of beliefs on learning evolution

Categories elicited from learners' responses	n	%	Type of influence	Perception of conflict	Border-crossings
1. Very negatively; completely impede learning; hate and scared to learn it; insult to God	23	4.41	Very negatively	Strongly conflicted	Impossible
2. negatively; make learning difficult; lose interest; bored; contradict beliefs; disagree with evolution	124	23.80	Negatively	Conflicted	Hazardous
3. Learn because it is in syllabus; not believe; would leave it if had a choice	31	5.95	Negatively but learn	Conflicted but learn	Managed
4. Confusing – do not know what to believe and learning sometimes difficult because of my religious beliefs; don't want to believe God anymore; all life from God	64	12.28	Confused	Conflicted / learning difficult	Hazardous
5. Confusion; don't understand	16	3.07	Confused / not understand	Conflicted	Hazardous
6. No influence; no effect. Evolution and my beliefs separate. I put my beliefs aside; my beliefs strong; teacher helped me to settle	40	7.68	No influence	Separate	Managed
7. Enhance learning somewhat; want to know more; compare evolution and religion; find fault with evolution	101	19.39	Positive	Complementary/ integration	Smooth
8. Enhance learning; make me understand evolution more; my beliefs and evolution complement each other; agree	63	12.09	Positive	Complementary/ integration	Smooth
9. Enjoy; very happy challenge me to think hard; participate in class; research	59	11.32	Very positive	Strongly complementary	Smooth

Table 5.31: Influence of learners' beliefs on learning evolution

Learners' beliefs' influence on learning evolution	Responses (n = 521)		Percentage of learners (%)
	N	Percentage (%)	
Very positive/Positive	223	42.80	64.08
Very negative/Negative	147	28.22	42.24
Negative/Confused/Learn	95	18.23	27.30
No influence	40	7.68	11.49
Confused/Lack understanding	16	3.07	4.60
TOTALS	521	99.99	149.71

Table 5.32: Border crossings experienced by learners during learning

Learners' border-crossings	Responses (n = 521)		Percentage of learners (%)
	N	Percentage (%)	
Smooth	223	42.80	64.08
Hazardous	204	39.16	58.62
Managed	71	13.63	20.40
Impossible	23	4.41	6.61
TOTALS	521	100.00	149.71

Table 5.33: Relationships of learners' beliefs to evolution

Learners' border-crossings	Responses (n = 521)		Percentage of learners (%)
	N	Percentage (%)	
Conflicted	258	49.52	74.14
Complementarity	223	42.80	64.08
Separated	40	7.68	11.49
TOTALS	521	100.00	149.71

Combining Table 5.31 and Table 5.33 gives the relationship between beliefs and evolution compared to the effect of beliefs on learning about evolution. This information is presented in Table 5.33. Table 5.33 was also combined with Table 5.32 to compare the relationship of beliefs to evolution with possible border crossings. This information is represented in Table 5.34. Table 5.28 was again combined with Table 5.32 to relate border crossings to the effect on learning. This resulted in Table 5.35.

Table 5.34: The relationship between learners' beliefs and evolution and their effect on learning evolution

Relationships / Effect on learning	Conflicted	Complementary	Separated	Totals	%
Very positive /Positive		223		223	42.80
Very negative/ Negative	147			147	28.22
Confused/Negative/ Learning	95			95	18.23
No influence			40	40	7.68
Confused, lack understanding	16			16	3.07
TOTALS	258	223	40	521	
Percentage	49.52	42.80	7.68		100.00

Table 5.34 shows the way in which the learners' beliefs relate to evolution and the influence of that relationship on learning about evolution. In the conflicted state, the beliefs clash with evolution and do not reconcile. This has a negative influence on learning about evolution because the learner cannot cross the border between science and his or her personal beliefs. In a state where the personal beliefs are separated from science during the learning process, there is no direct influence of beliefs on learning evolution. When personal beliefs and evolution complement each other, the influence on learning is positive and learning is enhanced.

Table 5.35: The relationship between learners' beliefs and evolution and border crossings when learning evolution

Border crossings / Learner beliefs	Smooth	Hazardous	Managed	Impossible	Totals	%
Conflicted		204	31	23	258	49.52
Complementarity	223				223	42.80
Separated			40		40	7.68
TOTALS	223	204	71	23	521	
Percentage	42.80	39.16	13.63	4.41		100.00

The results in Table 5.35 show learners who are conflicted and the different cultural border-crossing experiences they may undergo. A few (4.41%) responses showed conflicted learners might have found the borders completely impervious and it was possible for them to learn, while many more responses (39.16%) indicated hazardous border crossing and some (13.63%) managed to learn despite the conflict. Of those who had managed border crossing experience, some (7.68%) were able to manage, as they had separated their beliefs from learning, which indicates a 'separated' relationship for evolution and their beliefs. The

majority of responses (42.80%), that indicated beliefs which were complementary to evolution, also indicated that the respondents experienced smooth border crossings.

Table 5.36: The relationship between border crossings and the effect of leaners' beliefs on learning evolution

Effect on learning \ Border crossings	Smooth	Hazardous	Managed	Impossible	Totals	%
Very positive /Positive	223				223	42.80
Very negative/ Negative		124		23	147	28.22
Confused, lack understanding		80			80	15.35
No influence			40		40	7.68
Confused/Negative/Learning			31		31	5.95
TOTALS	223	204	71	23	521	
Percentage	42.80	39.61	13.63	4.41		100.00

Table 5.36 shows that, learning is hazardous (39.61%) to impossible (4.41%) for very negatively affected learners, while some of the negatively affected (5.95%) and those not influenced (7.68%) experienced 'managed' border crossings, and for those whose learning was positively affected (42.80%), the crossing of the learning borders was smooth.

In summary, the results show that the occurrences of responses indicating a conflict between learners' beliefs and learning evolution (49.52%) is more than the responses indicating that beliefs and evolution complement one another (42.80%) and the border crossings were smooth. This implies that more learners experience a conflict between their beliefs and learning evolution than those who find their beliefs and evolution complementary. The number of responses showing conflict is also more than that indicating separation of beliefs from evolution (7.68%), implying fewer learners who were able to separate their beliefs from evolution in order to learn. The responses indicating learners who experienced a conflict include those which indicate learners who were negatively influenced and their learning strongly impeded (28.22%), those who are negative and confused but still manage to learn (18.23%) and those who are confused and do not understand what they are learning (3.07%). These results further reveal that, irrespective of whether learners were experiencing a conflict or not, learning still took place, except in the small group (4.41%) who were strongly negative, strongly conflicted and felt they could not learn, with impervious border crossings. Of all the responses (521) to this question, only 7.68% indicated beliefs which had no

influence on learning because learners were able to separate their beliefs from evolution and, although conflicted, the border crossings were managed.

(e) Learners' attitude towards learning evolution at school

The purpose of this question, "*What is your attitude towards learning evolution in school?*", was to find out what attitudes learners have towards learning about evolution. Since the question was asked after learning had occurred, it was expected that learners would be able to recall their experiences and that they would describe their attitude based on that experience. The learners' responses were first put into categories where nine such categories were generated. The attitudes so categorized included those of learners who hated learning about evolution to those who found the concept of evolution good enough to be applied in their lives. In between these two extremes were those that were impartial about learning about evolution, while some were confused and did not know what to believe.

The first stage in which codes were assigned to the categories looked at whether the attitudes were positive or negative. The attitudes which indicated hating learning about evolution or found it to be a waste of time were assigned the code '*negative*', while those that found evolution good to learn about were assigned the '*positive*' code. For those that did not show either positive or negative attitudes, the code given was 'neutral'. The fourth code was 'compromise', and this was for those who said they were positive yet did not believe in or accept evolution. The codes for this stage are shown in the column labelled 'Codes (1)' in Table 5.37.

Upon further analysis, the categories and the first stage codes were examined to find out if the responses indicated any willingness to learn as a result of the various attitudes. Codes indicating lack of willingness were given the code '*lack motivation*', while those which showed willingness were given the code '*motivated*'. One category – category 3 – was given the code '*examination motivated*', as learners indicated learning because they have to pass, so it seemed as if examinations were the main motivator for learning. Category 4 was given the code '*impartial*' because there was an indication that evolution was seen to have nothing to do with one's beliefs, suggesting that there was neither hindrance to learning nor enhancement thereof resulting from one's predisposition. This analysis generated the second stage codes in the column named 'Codes (2)'.

Categories were analysed a third time to find out if the learners' beliefs or worldviews could have resulted in the attitudes observed, to understand the kind of relationship that existed between the learners' beliefs and attitude towards evolution that could have given rise to the attitude. If the attitude was negative, there was an implication of conflict and, if so, the worldview responsible was also inferred from the responses. The categories of attitude were examined and, if there was mention of faith or religion and the attitude was negative, the code assigned was '*conflict/religious*' to indicate the presence of conflict and the worldview attached to that conflict, as in categories 1 and 2. Category 3 does not include any mention of religion, so the code given was '*conflict/personal*' indicating that personal beliefs other than religious ones were responsible for the conflict. For categories where learners indicated that evolution had nothing to do with their beliefs, as in category 4, or that they participated in class despite not believing, as in category 5, the code assigned was '*separate/personal*', indicating a detached relationship from a personal perspective – personal because it is not clear whether or not it was religious beliefs which affected the learners' responses. This means learners were able to separate their religious or personal beliefs from evolution while learning. The rest of the categories, 6 through 9, indicated willingness to learn and mentioned aspects of science in that learning. These categories also indicated a complementary attitude where the learners' beliefs were in harmony with the concept of evolution. These were therefore assigned the code '*complement/scientific*' at this stage of analysis, indicating a modern scientific worldview. The '*separate/personal*' and the '*complement/scientific*' codes do not imply that learners experienced any conflict. Results of these analyses are presented in Tables 5.37, 5.38, 5.39, 5.40 and 5.41, with 'n' representing the frequency of the responses in the categories.

Table 5.37: Percieved attitudes of learners towards learning evolution in school

Categories elicited from learners' responses (n = 427)	n	%	Attitudes	Motivation	Beliefs /worldview
1. Strongly negative; hate learning about evolution; reduces my faith; do not want to participate and do not listen in class	44	10.30	Negative	Lack motivation	Conflict and Religious
2. Negative; bad attitude; my beliefs contradict; not enough evidence; lose interest in class; not understand; waste of time	56	13.11	Negative	Lack motivation	Conflict and Religious
3. Confused / mixed– not sure if I should learn it; should have a choice to learn it; force myself to learn; various views confuse me; have to pass	45	10.54	Negative	Examination motivated	Conflict and Personal
4. Impartial: Evolution is just another scientific content to learn and pass Life Science. It has nothing to do with my life; won't change my beliefs.	21	4.92	Neutral	Impartial	Separate and Personal
5. Positive though not believe; participated and cooperated in class	21	4.92	Compromise	Motivated	Separate and Personal
6. Positive: learn about species origins; evolution; understand world better or differently	119	27.67	Positive	Motivated	Complement and Scientific
7. Good; like to learn other people's views; more about world	35	8.20	Positive	Motivated	Complement and Scientific
8. Good: understand how scientists work; enough evidence; challenging; enjoyed debates	18	4.22	Positive	Motivated	Complement and Scientific
9. Very good; participate fully; want to learn more; argue and debate; will apply it	68	15.93	Very positive	Very motivated	Complement and Scientific

Three tables were generated from the information in Table 5.37 and Table 5.38 to present the attitudes of learners; Table 5.39 to present their motivation or lack of motivation; and Table 5.40 to reflect their worldviews plus the relationship with evolution. This was done by adding together all the occurrences for similar codes and calculating percentages.

Table 5.38: Learners' attitudes towards learning about evolution

Learners' attitudes	Responses (n = 427)		Percentage of learners (%)
	N	Percentage (%)	
Positive	240	56.20	68.97
Negative	145	33.96	41.67
Neutral	21	4.92	6.03
Compromise	21	4.92	6.03
TOTALS	427	100.00	122.70

The results shown in Table 5.38 indicate that the majority of the learners had a positive attitude towards learning about evolution as shown by 56.20% of all the responses, with fewer (41.67%) showing a negative attitude and some (6.03%), a neutral position towards learning about evolution.

Table 5.39: Learners' motivation as a result of their attitudes toward learning evolution

Learners' motivation	Responses (n = 427)		Percentage of learners (%)
	N	Percentage (%)	
Motivated	261	61.12	75.00
Lack motivation	100	23.42	28.74
Examination motivated	45	10.54	12.93
Impartial	21	4.92	6.03
TOTALS	427	100.00	122.70

The results presented in Table 5.39 indicate that most learners (61.12%) were willing to learn about evolution, while some were slightly motivated and others were not motivated (23.42%).

Table 5.40: Learners' perspectives and worldviews contributing towards learners' attitudes

Learners' worldviews	Responses (n = 427)		Percentage of learners (%)
	N	Percentage (%)	
Complement / Scientific	240	56.21	68.97
Conflict / Religious	100	23.42	28.74
Conflict / Personal	45	10.54	12.93
Separate / Personal	42	9.84	12.06
TOTALS	427	100.01	122.70

The results presented in Table 5.40 show that learners' attitudes reflect more harmony or complementarity, which could be a result of scientific worldviews (56.21%) more than religious (23.42%) and personal (10.54%) worldviews, both of which indicate conflict. A few responses reflected a detached or separate (9.84%) relationship.

Table 5.41: Learners' attitudes, motivation to learn and possible worldviews influencing attitudes towards learning evolution

Motivation / Attitudes	Motivated	Lack motivation	Examination motivated	Slightly motivated	Motivation / Relationship and Worldviews
Positive	240				Complement and Scientific
Compromise				21	Separate and Personal
Neutral				21	
Negative			45		Conflict and Personal
		100			Conflict and Religious
TOTALS	240	100	45	42	

Generally, the results from this question show learners with a positive attitude towards learning about evolution (61.12%). The same group of learners were also motivated to learn about evolution (61.12%). Some (56.21%) of these learners showed scientific worldviews which could have been responsible for such attitudes, with other learners (9.84%) able to separate their beliefs from evolution in order to learn. A small proportion (4.92%) of the motivated learners did so by separating their beliefs, while others (another 4.92%) were only slightly motivated. If headings in Table 5.41 are taken to represent learning, the cells at the lowest left and highest right ends of the diagonal indicate, respectively, the weakest likelihood of learning and the highest likelihood of learning for this group of learners. The cell at the bottom left indicates the lowest learning point, affecting 23.42% of the learners, while the cell at the top right hand corner indicates the highest learning points, affecting 56.21% of learners. The headings are arranged to indicate that learners who had a positive attitude, were motivated to learn and had a scientific worldview would learn evolution best. On the other hand, learners who had negative attitudes, lacked motivation towards learning evolution and were highly religious would most likely benefit less from evolution instruction.

(f) Learners' experiences with regard to learning evolution

In this question, "*Describe your experiences with regards to learning evolution*", learners were expected to describe the experiences they had undergone while learning about evolution. Because the question was open-ended, learners could come up with responses from any perspective. Ten categories were generated from their responses. After the numbers of responses for each category were determined, the categories were further analysed, whereby three different codes were generated. The first stage of coding examined learners' experiences in terms of how learners felt about themselves as well as whether any learning

had occurred. These generated the 'Codes (1)' results. There were two subsequent codings which generated 'Codes (2)' and 'Codes (3)'.

'Codes (1)' covered a range of experiences from 'very frustrated' to 'enjoyed learning'. Together with the categories, the first stage codes were then used to determine whether the experiences were positive or negative, which generated 'Codes (2)'. In cases where learners experienced frustration, confusion and the weakening of beliefs a '*negative*' code was assigned. On the other hand, when learners expressed enthusiasm about learning and related what they had learned during evolution classes, this was regarded as a positive experience and the code '*positive*' was assigned. Thirdly, the categories were examined to find out if the experience could have resulted from religious views, scientific views or personal views. This coding generated the results in the column headed 'Codes (3)'. There were four responses which indicated that those learners had no experience and their responses were therefore coded as 'not given' in the column for 'Codes (1)' which reported actual experiences, and were found to be unclassifiable in the second and third stages of coding.

Tables 5.42, 5.43 and 5.44 present the results from these analyses. Table 5.42 shows the overall results, while the other tables show the results from the three different analyses. To distinguish between 'Codes (1)' and 'Codes (2)', the former highlights experiences as felt by the learners, therefore referred to as 'Feelings', while the latter shows the type of experience in terms of whether it was e positive or negative; for this reason they are referred to as 'Experiences' in the ensuing discussions.

Table 5.42: Experiences and feelings of learners with regard to learning evolution

Categories elicited from learners' responses	N	%	Experiences	Feelings	Worldviews
1. Very frustrated; want to leave class; my beliefs undermined; against Bible	7	1.81	Very frustrated	Very negative	Religious
2. Frustrated; difficult to understand and to believe because of my religion; performance low	18	4.66	Frustrated	Negative	Religious
3. Confused; because of my beliefs; may lose focus/faith; conflicting theories	20	5.18	Confused	Negative	Religious
4. Not interested; evidence not enough; makes little sense; theories conflicting; not sure	9	2.33	Confused	Negative	Personal
5. My faith was weakened or decreased or changed because of evolution	5	1.30	Beliefs weakened	Negative	Religious
6. Learned about origins and evolution	83	21.50	Learning occurred	Positive	Scientific
7. Opened my eyes to other views; understanding the world differently; how scientists work;	207	53.63	Learning occurred	Positive	Scientific
8. Enjoyed debates and classroom discussions about evolution; learning from one another	11	2.85	Enjoyed learning	Positive	Scientific
9. Enjoyed it; learned a lot ; evolution gave me an opportunity to think critically	22	5.70	Enjoyed learning	Very positive	Scientific
10. No experience	4	1.04	Not given	Unclassifiable	Unclassifiable
TOTALS	386	100.00			

Table 5.43: Learners' feelings with regard to learning about evolution

Learners' feelings	Responses (n = 386)		Percentage of learners (%)
	N	Percentage (%)	
Learning occurred	290	75.13	83.33
Enjoyed learning	33	8.55	9.48
Confused	29	7.51	8.33
Frustrated	25	6.48	7.18
Beliefs weakened	5	1.30	1.44
Feelings not given	4	1.04	1.15
TOTALS	386	100.01	110.91

The results show that learners had various experiences, in which some were frustrated (6.48% of responses) by learning about evolution. Some of those who were frustrated had such a bad

experience that they wanted to leave class, and some in the same category felt that their beliefs were being undermined. However, the majority of learners had positive experiences, with some enjoying learning about evolution. Generally, most learners experienced learning and learned new things and other views about understanding the world, such as how scientists work. To arrive at the information presented in Table 5.44, the occurrences for the categories with similar codes in stage 2 were added together and percentages calculated for each code. Inferences were made from the learners' feelings as to whether those feelings were negative or positive. The results show that the majority of the learners (83.68%) had positive experiences regarding learning about evolution. This group includes learners who enjoyed learning about evolution (8.55%) and who stated that they were able to learn about evolution (75.13%), as shown in Table 5.43.

Table 5.44: Learners' experiences with regard to learning about evolution

Learners' experiences	Responses (n = 386)		Percentage of learners (%)
	N	Percentage (%)	
Positive	323	83.68	92.82
Negative	59	15.28	16.95
Unclassifiable	4	1.04	1.15
TOTALS	386	100.00	101.92

The information presented in Table 5.45 was obtained by adding up numbers of occurrences for categories with similar codes in stage 3, and then working out percentages for each code. The results show that the learners' responses which were inclined to modern scientific thinking (83.68%) were more than those indicating religious reasoning (12.95%) or reasoning from any other personal perspective (2.33%).

Table 5.45: Learners' worldviews inferred from learners' feelings and experiences

Learners' worldviews	Responses (n = 386)		Percentage of learners (%)
	N	Percentage (%)	
Scientific	323	83.68	92.82
Religious	50	12.95	14.37
Personal	9	2.33	2.57
Unclassifiable	4	1.04	1.15
TOTALS	386	100.00	101.91

The results in Table 5.45 show the possible worldviews from which learners could have described their experiences about learning about evolution. The modern scientific worldview occurs more times than the religious and personal worldviews. Most of the learners were able to learn despite their personal views. To summarize the results from question 17, Table 5.46 was constructed.

Table 5.46: Learners' experiences and their effect on learning against worldviews inferred from those experiences

Feelings / Experiences	Learning occurred	Enjoyed learning	Confused	Frustrated	Beliefs weakened	Feelings not given	Feelings / Worldviews
Positive	290	33					Scientific
Negative			20	25	5		Religious
			9				Personal
Unclassifiable						4	Unclassifiable
TOTALS	290	33	29	25	5		386
%	75.13	8.55	7.51	6.48	1.30	1.04	100.01

Results for this question showed the majority (83.68%) of responses were positive about learning about evolution, and the same proportion exhibited the modern scientific worldview and also all learned new things. They are learning a new thing I was still while 8.55% enjoyed learning. On the other hand, some learners experienced frustration and this could have been influenced by learners' religious beliefs which caused them to have negative learning experiences.

(g) Sources used by learners to enrich their knowledge about evolution

As the question requires, "*Indicate the sources you use to enrich your knowledge about evolution*", respondents were expected to give the source(s) they used so as to give insight into the sources they preferred and those that were available to them. The categories were formed by putting similar sources together in terms of their physical attributes and the kind of information they provided. Books, magazines and other sources that could be read were all coded as '*print*', while television and internet were coded as '*video*'. The internet was also regarded as offering print material when text is the main source of information. Humans were coded as '*humans*' and '*audio*', since they mostly communicate by speech. 'Land' sites such as the Cradle of Humankind, models and doing experiments were coded firstly as '*artefacts*', as they would provide direct first-hand information and they were tangible. Considering that one of the factors that respondents mentioned as the cause for not accepting evolution was

lack of evidence, the second stage of coding considered the type of evidence that the sources mentioned could provide. For instance, the print media were considered as providing secondary evidence, since they mainly give an account of such evidence. Similarly, audio and video media would provide secondary evidence, while live specimens and sites would provide primary evidence. The responses and analyses for sources used by learners are presented in Table 5.47.

Table 5.47: Sources learners use to enrich understanding of evolution by name

Categories elicited from learners' responses	N	%	Type of source	Type of evidence
1. Prescribed textbooks; examination papers	186	23.66	Print	Secondary evidence
2. Other books; magazines; articles; library	155	19.72	Print	Secondary evidence
3. Documentaries: TV and radio channels: National Geographic, Animal Planet, CDs and DVDs on evolution	65	8.27	Video	Secondary evidence
4. Internet	186	23.66	Video – print	Secondary evidence
5. Land sites: Cradle of Humankind; evidence	9	1.15	Artefacts (historical)	Primary evidence
6. Life specimens; models; experiments	5	0.64	Artefacts (current)	Primary evidence
7. My teacher (primary & high school); scientists	106	13.49	Humans – audio	Secondary evidence
8. My school mates and friends	12	1.53	Humans – audio	Secondary evidence
9. Relatives: parents, grandparents, sister or brother, cousins; other people	45	5.73	Humans – audio	Secondary evidence
10. Pastor or religious leader	8	1.02	Humans – audio	Secondary evidence
11. None	4	0.51	None	None
12. No source given	7	0.64	No response	None
TOTALS	386	100.00		

The second stage codes yielded the results shown in Table 5.48, where the sources used were viewed in terms of the kind of information they were providing for the learners. When teaching evolution, the content required is that which will convince someone of the validity of the theory, and oftentimes what convinces people most is the evidence of evolution. Therefore, the sources were referred to as providing primary evidence or secondary evidence. Primary evidence provides direct access to the evidence that can be seen and interacted with as for the artefacts, sites and the fossils. On the other hand, secondary evidence provides information about evolution in a secondary form, where learners are either told, or read for themselves, or watch and listen to videos and other sources that can provide such

information. Such sources were therefore given the code '*secondary evidence*' while the former were coded '*primary evidence*'. The results of the stage 1 codes are shown in Table 5.48, while those of the stage 2 codes are shown in Table 5.49.

Table 5.48: Types of sources learners use to enrich understanding of evolution

Types of sources learners use	Responses (n = 788)		Percentage of learners (%)
	N	Percentage (%)	
Print media	341	43.26	97.99
Digital media	251	31.85	72.13
Humans	171	21.70	49.14
Artefacts	14	1.78	4.02
None	4	0.51	1.15
No response	7	0.89	2.01
TOTALS	788	99.99	226.44

Table 5.48 shows the types of sources that learners use to enrich their understanding of evolution. These have been categorized in terms of the source type as well as how that source communicates the information to the learner.

Table 5.49 presents the type of evidence provided by the sources used by learners to enrich understanding of evolution by the type of evidence those sources would provide. The majority of the responses show that learners required secondary sources.

Table 5.49: Type of evidence provided by sources used by learners

Type of evidence	Responses (n = 788)		Percentage of learners (%)
	N	Percentage (%)	
Secondary evidence	763	96.83	219.25
Primary evidence	14	1.78	4.02
None	11	1.40	3.16
TOTALS	788	100.01	226.43

The results from this question indicate that learners have mostly been using books and other print materials to access information about evolution. Other sources used include the internet and television and other digital media, followed by human beings. The human beings include teachers and other scientists as the main source among the 'humans', even though family members and peers have been consulted as well. As stated above, humans, books, and other media provide secondary evidence as opposed to actual artefacts, like fossils or sites where fossils have been identified and excavated. This therefore shows that learners have mainly

used the sources which provide secondary evidence instead of having hands-on experiences with concrete evidence. This raises the question of access to concrete evidence by learners, and the impact of having little or no access to concrete evidence, particularly for a topic where beliefs are important for meaningful learning. The secondary sources could deny access to reality, and continually raise questions of validity for the learners, and thus affect their acceptance of evolution negatively.

(h) Learners' feelings about the way their Life Sciences teacher is teaching evolution

The purpose of this instruction, "*Describe how you feel about the way your Life Sciences teacher is teaching evolution*", was to find out the opinions of learners about the way they were taught evolution. The expectation was that the responses would provide an insight not only into the kind of teaching they were receiving but also into what they found working or not working for them in the classroom. The question was concerned more with the teaching of evolution and not necessarily with the teachers' overall teaching repertoire.

As with the earlier analyses, the responses were categorized first by considering those that communicated similar messages. For instance "my beliefs were undermined" and "my beliefs were insulted" were categorized together with feeling "sad" to indicate being emotionally unhappy. Then the 12 categories that emerged from this question were assigned codes in two stages. The first stage ('Codes (1)') looked at whether the feelings were negative or positive, to which 'very' was added where the feeling was inferred to be strong.

These feelings were then examined closely to find out what they could have been based on. Going back to the responses themselves, those factors were picked up, generating second stage codes. The second stage coding ('Codes (2)') determined if learners' responses reflected an emotion they felt, in which case the code assigned was '*affective*'. Examples of these affective codes were feeling "sad" or feeling "happy". In cases where the responses related to learning such as understanding, the code assigned was '*cognitive*'.

Furthermore, the responses were also examined relating to what was said about the teacher, and this generated the third stage of codes ('Codes (3)'). The question that was asked was whether a response indicated the teacher's content knowledge or pedagogical knowledge, or both – that is pedagogical content knowledge (PCK) – or whether there were other factors contributing to the learners' feelings, such as learners' beliefs. Taking category 8 as an example, where learners were "happy" the teacher "has a lot of knowledge; is able to explain;

gives examples and is able to vary strategies to make us understand; corrected mistakes; have learned a lot", the code assigned was '*affective*' in stage 2 and '*PCK*' in stage 3. Category 7, with "happy; teacher open, encourages expression of views, group discussions and debates, encourages us to work independently" was assigned the code '*affective*' in stage 1 coding and '*pedagogical*' in stage 3. Category 2, with "bad; bored; not interested in what the teacher is doing; against my beliefs" embodied an emotional side as well as the beliefs. I could not assign the PCK of the teacher to this one, because not liking what the teacher was doing could have been influenced by learners' emotions more than by the teacher's knowledge. Therefore the code was '*Affective'* in stage 2 and '*Religious*' in stage 3.

Three categories, 10, 11 and 12, were found to be unclassifiable in the second stage analysis, and this was because the learners' emotions were not stated in the responses. The results presented in Table 5.50 show the categories, n-values for the categories and the codes at stages 1 and 2 for this question.

Table 5.50: Learners' feelings about the way their Life Sciences teacher teaches evolution

Categories elicited from learners' responses	n	%	Feelings	Learning domains	Factors
1. Sad; my beliefs undermined; insulted	8	1.52	Very negative	Affective	Religious
2. Bad; bored; not interested in what the teacher is doing; against my beliefs	18	3.42	Negative	Affective	Religious
3. Confused; do not understand what the teacher is doing; lacks enough information; lacks passion	16	3.04	Negative	Cognitive	Pedagogical
4. Satisfied/Good; teaches it as science; to separate our personal views from evolution; relates to us	38	7.21	Positive	Affective	PCK
5. Happy; comfortable; teacher respects our views and; allows questions; does not force us to believe evolution	36	6.83	Positive	Affective	Pedagogical and Religious
6. Happy; teacher is fair; does not take sides; we sometimes disagree but end up agreeing; warm	23	4.36	Positive	Affective	PCK
7. Happy; teacher is open; encourages expression of views, group discussions and debates; encourages us to work independently	43	8.16	Positive	Affective	Pedagogical
8. Happy; has a lot of knowledge; able to explain; gives examples and able to vary strategies to make us understand; corrected mistakes; have learned a lot	199	37.76	Positive	Affective and Cognitive	PCK
9. Very happy; covered all evolution; passionate; motivated to learn more; can make one believe it; makes learning enjoyable; best teacher of evolution	138	26.18	Very positive	Affective	PCK
10. Allowed us to use home language	2	0.38	Positive	Affective	Pedagogical
11. Referred us to relevant sources	1	0.19	Positive	Cognitive	PCK
12: Good; teaches what is in the book	5	0.95	Positive	Cognitive	PCK
TOTALS	527	100.00			

Table 5.51 has condensed the information from Table 5.50 and presents occurrences of the negative and positive feelings of respondents.

Table 5.51: Feelings of learners about the way in which their teacher teaches them about evolution classified into positive and negative feelings

Learners' feelings	Responses (n = 527)		Percentage of learners (%)
	N	Percentage (%)	
Positive	485	92.03	139.36
Negative	42	7.97	12.09
TOTALS	527	100.00	151.45

Table 5.51 shows the positive and negative feelings of learners about the way in which their Life Sciences teacher taught them about evolution. The results show that the majority of the learners felt positive about the way in which their teacher taught them, as shown by the proportion (92.03%) of positive occurrences in their responses.

Figure 5.9 presents the results after closer examination of the negative or positive responses given by the learners, looking more closely at the teacher factors or other more personal factors of the learners themselves. The information is represented in the column labelled 'Codes (3)' in Table 5.50. Table 5.52 gives the views of learners about the way in which their teacher teaches evolution in relation to the learning domains.

Table 5.52: Learners' feelings about their teacher related to learning domains

Domain / Feelings	Affective	Affective and Cognitive	Cognitive	Totals	%
Positive	280	199	6	485	92.03
Negative	26		16	42	7.97
TOTALS	306	199	22	527	
Percentage (%)	58.06	37.76	4.18		100.00

The information in Table 5.52 is presented in Figure 5.9, showing that the responses are mostly in the affective domain (58.06%), followed by affective domain combined with the cognitive domain (37.76%). In Figure 5.9, the x-axis represents the domains of learning objectives, affective and cognitive, while the y-axis represents the number of positive or negative responses for each domain. The frequencies for positive responses are longer in the affective domain and also when both cognitive and affective domains are combined, indicating that learners were happy with the way their teacher taught them. For the cognitive domain, the frequency of positive comments is slightly lower than the negative one, and this is because learners' responses in this category indicated that learners could not understand their teacher's explanation.

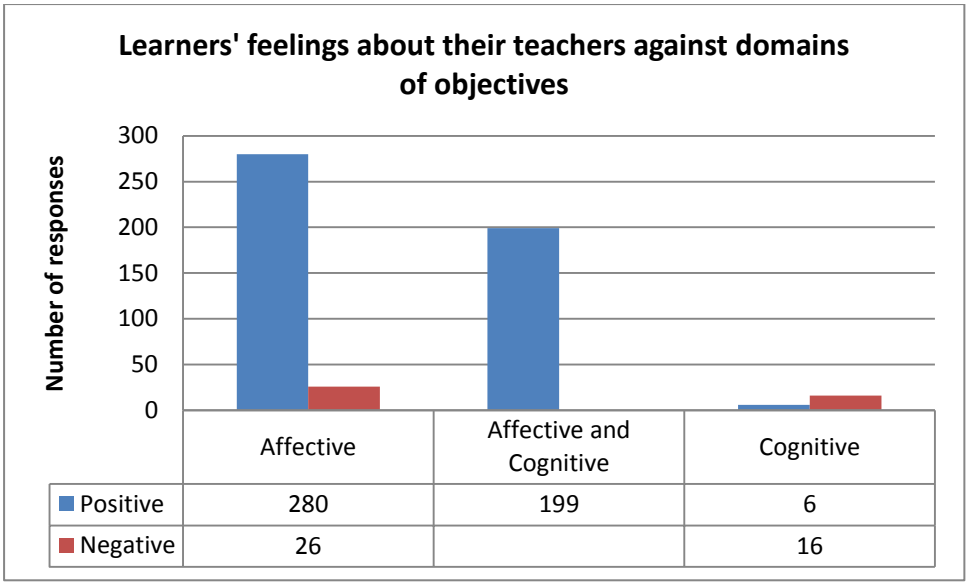

Figure 5.9: The feelings of learners about how their teachers teach them evolution in relation to the domains of learning objectives

Table 5.53 shows the views of learners, comparing how they felt about the way their teacher teaches evolution in relation to the teachers' pedagogical and content knowledge as well as to learners' religious views.

Table 5.53: Learners' views about the way their teacher teaches evolution against factors contributing to those views

Teachers' PCK and learners' beliefs / Learners' views	Teachers' PCK	Teacher's PCK and learners beliefs	Teachers' Pedagogical knowledge	Learners' religious beliefs	Totals	(%)
Positive	266	174	45		485	92.03
Negative			16	26	42	7.97
TOTALS	266	174	61	26	527	
Percentage (%)	50.47	33.02	11.58	4.93		100.00

As reflected in Table 5.53, the majority of the learners (92.03%) were positive about the way their teacher taught them evolution. The responses in categories coded as negative were due to learners' religious reasons (4.93%) and because they could not understand the teacher or perceived the teacher not to have enough content (3.04%). A proportion (33.02%) of learners gave responses which had a religious aspect to them as well as including the PCK element, and this indicates that learners' religious beliefs did not influence their perceptions of the teacher negatively. Figure 5.10 presents the views of learners in terms of being negative or positive, as shown in Table 5.53, related to possible factors resulting in such views. The x-

axis represents the factors contributing to the negative or positive views of learners and the y-axis represents the frequency of responses for each factor.

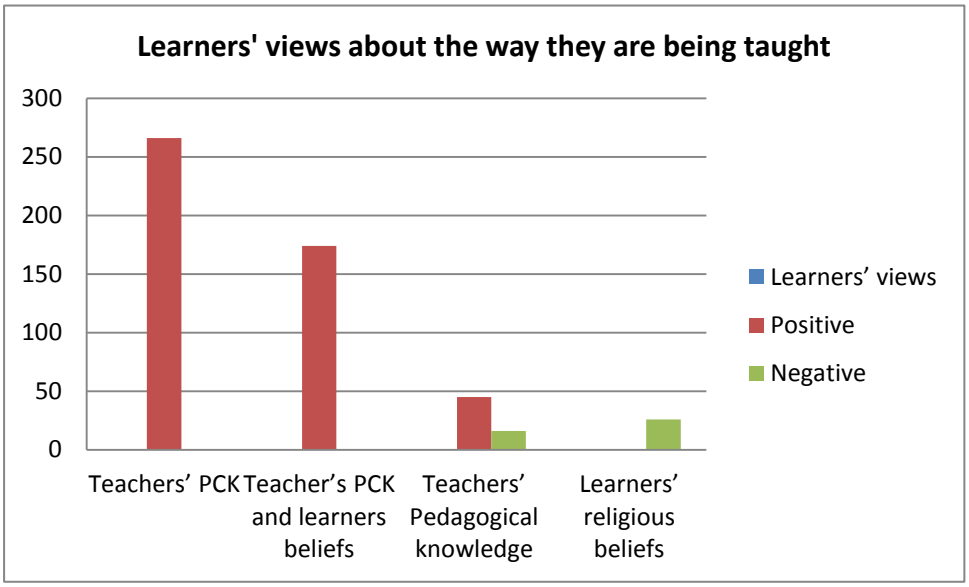

Figure 5.10: Learners' views about the way their teacher teaches them evolution in relation to factors contributing to such views

It is not a surprise that the affective domain has the higher number of occurrences than the cognitive domain, since this question asked about the learners' feelings. Learners were therefore likely to reveal the emotions they went through during the teaching about evolution, rather than how the teacher taught them. The responses which related to the affective domain alone (58.06%) were more than those related to the affective domain combined with cognitive domain (37.76%) and the cognitive domain alone at (4.18%). Furthermore, learners were affected both negatively and positively, though less negatively (7.97%) than positively (92.03%), as shown in Table 5.49. When teacher characteristics were examined from the learners' responses, the pedagogical content knowledge of the teachers was judged positively by most (50.47%) learners, so that even when it is mentioned together with the religious beliefs, PCK still scores more positively (33.02%). The instances where religious views are presented without mentioning the teacher's characteristics (4.93%), show negative feelings. This may suggest that learners gave such responses because they were simply concentrating on their emotions at the time of responding to the question, and not so much on what the teacher was doing nor his or her role in arousing those emotions. Even though the proportion of responses that reflected this was small, yet this highlights that sometimes learners will be affected by their beliefs so much that no matter what the teacher does, they will still not be able to learn meaningfully. It could suggest a strong influence of the beliefs of the learners

who gave those responses. Maybe this is also where border crossings will be impossible for such learners when learning about evolution – because of their beliefs.

(i) Learners' suggestions regarding the teaching of evolution in schools

The purpose of this instruction, "*Provide suggestions you wish to make regarding the teaching of evolution in schools*" was to find out how learners felt about the way in which evolution was taught. By providing suggestions about the teaching of evolution, this could give an insight into learners' areas of dissatisfaction and how they felt improvements could be made. As with the preceding questions, the responses were categorized and the developed categories were coded twice.

As shown in Table 5.54, responses ranged from those suggesting removal of evolution from the curriculum (14.79%) to those saying evolution should remain because it was important (14.04%). The first coding ('Codes (1)') was done by using phrases to summarize the categories of responses. In the second coding ('Codes (2)'), codes were formed by checking if the responses indicated a curricular, content or classroom issue, or a combination of these issues.

The responses which related to the curriculum were given the code '*curricular*'. There were also responses which related to classroom teaching and learning, such as "teachers should respect learners' beliefs and not try to change them … or impose their own beliefs", and those that suggested specific teaching and learning strategies like research, projects, debates, group discussions. These were given the code '*pedagogical*'. Responses such as "include creation and other views", "base evolution on the Bible" and "leave out the theories which have not been accepted" related more to the content of evolution to be taught and were therefore given the code "*content*". Some responses were found to relate to both the content and the pedagogy. Examples were "invite experts", "provide resources in schools" such as labs, internet, books, videos, models and more time for teaching evolution and "provide evidence", "visit educational sites", "visit museums". The understanding was that, by inviting an expert, one would be looking for someone who has richer content knowledge, while at the same time this would enhance the teaching repertoire. Similarly, providing the resources or taking learners to sites where they would see and interact with evidence of evolution would also enhance their content knowledge as well as the teaching practice. These responses which combined both the content and the pedagogy were given the code '*content and pedagogy'*. The results for this question are presented in Table 5.54.

Table 5.54: Learners' suggestions regarding the teaching of evolution

Categories elicited from learners' responses	n	%	Suggestions	Reasons
1. Remove from the curriculum; of no use to us	59	14.08	Remove from curriculum	Curricular
2. Teachers to respect learners' beliefs not try to change them or impose their own; be warm	34	8.11	Respect learner beliefs	Pedagogical
3. Teaching/learning strategies: learner investigations – research, projects; debates, group discussions, presentations	70	16.71	Learner centred strategies	Pedagogical
4. Provide resources in schools: laboratories; internet; books; DVDs, Videos, Models, Posters; more time	63	15.04	Provide resources	Content and Pedagogical
5. Provide evidence; visit educational sites such as at Cradle of Human kind, museums	67	15.99	Provide evidence	Content and Pedagogical
6. Invite experts	9	2.15	Invite experts	Content and pedagogical
7. Empower teachers: training in content and methodology; teach more	8	1.91	Teacher training	Content and Pedagogical
8. Make it optional	14	3.34	Optional subject or topic	Curricular
9. Include evolution in lower grades	8	1.91	Expand to lower grades	Curricular
10. Keep in the curriculum; important	56	13.37	Keep in curriculum	Curricular
11. Use home language	1	0.24	Teach in home language	Pedagogical
12. Include creation other views, compare evolution and creation; base on Bible;	10	2.39	Include creation	Content
13. No suggestion given	16	3.82	No suggestion	
14. Teacher to tell learners of his/her beliefs	1	0.24	Teachers be open about beliefs	Pedagogical
15. Give notes	2	0.48	Give notes	Pedagogical
16. Leave out theories not accepted	1	0.24	Exclude some content	Content
TOTALS	386	100.00		

The information from Table 5.54 is also presented in Table 5.55 to reveal the relationships between learners' suggestions and issues about evolution in the classroom.

Table 5.55: Learners' suggestions regarding the teaching of evolution in relation to other issues

Issue / Suggestion	Content	Content and Pedagogical	Curricular	Pedagogical	No suggestion	Totals	%
Remove from curriculum			59			59	14.08
Respect learner beliefs				34		34	8.11
Learner centred strategies				70		70	16.71
Provide resources		63				63	15.04
Provide evidence		67				67	15.99
Invite experts		9				9	2.15
Teacher training		8				8	1.91
Optional topic or subject			14			14	3.34
Expand to lower grades			8			8	1.91
Keep in curriculum			56			56	13.37
Teach in home language				1		1	0.24
Include creation	10					10	2.39
Suggestion not given					16	16	3.82
Teachers to be open about their beliefs				1		1	0.24
Gives notes				2		2	0.48
Leave out some content	1					1	0.24
TOTALS	11	147	137	108	16	419	100.02
Percentage	2.63	35.08	32.70	25.78	3.82	100.01	

Table 5.56 gives the information in a condensed form to show the total responses for each of the codes from the second stage. The curriculum area incorporates contrasting views such as to remove from the curriculum (14.08%) and keep in the curriculum (13.37%) which have figures close enough to each other that one may not know what decision to take on the matter. It is interesting, though, that learners do consider the place of evolution in the curriculum, and that But in the content and pedagogical areas, suggestions related more to enhancing those areas by adding to what was already in place. There was also the idea of including creationist ideas and the Biblical teachings in evolution, which may be an issue of debate. Some respondents suggested that teaching about the origin of species and diversity of organisms

should include divine creation as the explanation of those phenomena. Considering that the curriculum indicates discussion of other views, that part may well have been taken care of.

Table 5.56: Issues relating to learners' suggestions about the teaching of evolution

Issues related to learners' suggestions	Responses (n = 419)		Percentage of learners (%)
	N	Percentage (%)	
Content/Pedagogical	147	35.08	42.24
Curricular	137	32.70	39.37
Pedagogical	108	25.78	31.03
Content	11	2.63	3.16
No suggestion	16	3.82	4.60
TOTALS	419	100.01	120.40

The results from this question indicate that learners would like improvements in the content and pedagogical areas as well as in the curriculum. The aspects related to curricula are beyond the teachers' responsibilities since the teachers receive the curriculum from the government, but they are required by the curriculum to design classroom activities based on the local context, although they may not modify the core elements of a curriculum subject like Life Sciences. Within the core knowledge area 'Diversity, Change and Continuity', evolution is the main topic in Grade 12, and it has been examined every year since 2008 when it became part of the curriculum (DoE, 2003a). This means that teachers have to teach it, whatever their own views on the subject.

Although very few respondents (1.91%) suggested the teaching of evolution in lower grades, this might help by exposing learners to the concept early in their school life and averting future problems over the acceptance of evolution. However, this may give rise to issues of teacher training that focus on increasing knowledge and understanding of evolution at those levels. It has been found that teachers of lower (elementary) grades are more uncomfortable with evolution than those of higher grades (see Fowler & Meisels, 2010), underscoring the need for professional development for teachers at that level.

With regard to pedagogy, issues raised and which rated highly were 'provide resources' (15.04%) and 'provide evidence' (15.99%). The two are closely linked, in the sense that resources are likely to provide the evidence required to understand evolution. The evidence required could be obtained by visiting places where learners may view evidence such as fossils. On the other hand, resources could include DVDs and more books. In their individual

capacity, teachers may not be able to provide such resources as it would require the involvement of school management to procure the necessary items.

Providing evidence which supports evolution is important not only to convince the learners that evolution is actually taking place, but also to enhance learners' understanding of the nature of science. As learners interact practically with the evidence, they are able to engage in the investigatory processes followed by scientists. As suggested by Clores and Limjap (2006, p. 79), conducting research about evolution allows learners to draw conclusions, fostering their understanding of the nature of science, and a better understanding and acceptance of evolution. It is therefore imperative that teachers afford learners opportunities to engage with and explore the abundant evidence available about evolution, the processes involved in the investigation as well as how the theories are arrived at and validated.

5.2.1.4 Relationships among the open-ended questions

The responses to some of the open-ended questions were inter-correlated (see Table 5.57). The purpose was to investigate if the responses to the questions were related in such a way that a certain response in one question would mean a particular response in another question. Data for the open-ended questions made a provision for multiple responses which meant that more than one answer could be supplied per question. For each of these questions, therefore, there was a pool of quotes with the same 'pool value'. For instance, there was 'pool value 01' in all the questions. It was, however, noted that the pool values given to the codes for the responses in the questions were not necessarily related in such a way that 'pool value 01' in one question meant the same in different questions. As was done with earlier analyses on these data, we shifted from the number of questionnaires, or respondents, to numbers of responses. We then used the percentages which were calculated from the total number of responses and then worked backward in order to reduce everything to 348 respondents. This would enable us to approach the open-ended questions with their multiple responses and compare them. The multiple responses of the respondents were weighted and transformed back to supply the Chi-square tables where the grand total was equal to the number of questionnaires processed in the study. This gave a crude estimation of associations, crude because no statistical corrections were applied. Table 5.57 presents selected data from the statistics outputs when the open-ended questions were compared.

Table 5.57: Statistical output from investigations of associations of learners' characteristic variables in relation to learning about evolution

Questions	Df	χ^2	p	Conclusion
Q13 vs Q14	8	83.37	<.0001	The learners' beliefs about evolution are associated with what they believe regarding the origin of species. What the learners believe regarding the origin of species depends on what they believe about evolution.
Q13 vs Q15	8	61.15	<.0001	The beliefs of learners about evolution are associated with how they learn evolution.
Q14 vs Q15	8	134.06	<.0001	Learners' beliefs about the origin of species on earth are associated with how they learn evolution.
Q16 vs Q15	8	53.71	<.0001	The influence of beliefs on learning evolution has an association with the attitude towards learning evolution at school.
Q15 vs Q19	8	78.87	<.0001	The way learners feel about how their Life Sciences teacher teaches evolution has an association with how their beliefs influence their learning of evolution.
Q15 vs Q20	8	103.21	<.0001	The suggestions learners make about the teaching of evolution in schools are related to how the learners' learning is influenced by their beliefs.
Q16 vs Q17	9	97.16	<.0001	The experiences that learners go through when learning evolution have an association with their attitudes towards evolution.
Q16 vs Q19	8	110.89	<.0001	The way the learners feel about how their Life Sciences teacher teaches evolution has an association with their attitudes towards evolution.
Q17 vs Q15	9	88.71	<.0001	The experiences learners go through when learning evolution are associated with how their beliefs influence their learning of evolution.
Q18 vs Q20	11	89.73	<.0001	The sources learners used to enrich their knowledge about evolution are related to the suggestions they make about teaching evolution. The sources might have been sufficient or not sufficient, whereupon suggestions would also depend on what was available or not available for them.
Q19 vs Q20	11	166.28	<.0001	The way the learners felt during the learning of evolution has association with the suggestions they make about improved teaching of evolution. They will suggest what worked for them or what they lacked but which they thought would have enhanced their learning.

As noted in Table 5.57, in all the comparisons the probability is far less than 0.05, which means that the probability that the association between the questions is one of chance is very low, and hence the association is significant. We can therefore accept that the responses to the questions compared are not independent of one another and whatever is given as a response in one question is likely to relate to the response in the related question. However, the tests do not tell the type of association existing between these variables and acceptance of evolution.

5.2.1.5 Summary of results from learners' questionnaires

The purpose of administering the questionnaire to the learners was to gather information from a large number of learners in the five schools. As already indicated, 348 learners responded to the questionnaire, although not completely in the case of some. Three types of information were gathered by means of the questionnaire: (a) the learners' biographical data, (b) a measure of learners' acceptance of the theory of evolution, and (c) learners' beliefs about evolution, including their experiences and feelings about learning about evolution.

Results from the MATE revealed low acceptance when first analysed using the sums of scores, but when means were used, results suggested moderate acceptance. Investigation of the characteristic variables concerning acceptance of evolution revealed that some learner characteristics had a significant effect while others did not. To obtain more reliable results, the four-point data were converted into two-point data. The variables which had no effect on the acceptance of evolution were gender and frequency of attendance at religious services. However, age, religion, the person from whom a learner first heard about evolution, and the length of time since the learner first heard of evolution all gave significant Chi-square results with a p-value of less than 0.05 for some of the items, indicating that the effect on acceptance was not merely due to chance.

The findings from the open-ended items in the learners' questionnaires generated more in-depth data which revealed some insights not found in the closed-ended questions. For instance, the moderate acceptance of evolution is better understood from the open-ended questions of which there were nine in the questionnaire. In answering some of these questions, learners revealed their beliefs about evolution and also stated their views regarding the validity of evolution as a scientific theory, such as in questions 11 and 13. Responses to these two questions indicated that learners mostly regarded evolution as a valid scientific

theory. To understand those responses better, inferences were made as to the perspectives from which the learners could have given those responses. The inferences concerned the worldviews which learners could have been using when they were answering the questions. Because evolution is a scientific concept apparently accepted in the modern scientific world, one of the perspectives from which learners could assess its validity was that of science. Furthermore, learners spoke about their religious beliefs when supporting their responses. Therefore the other perspective inferred from the learners' responses was that of religion. There were, however, some responses which did not reveal a scientific or religious disposition, and such responses were classified as personal. Thus the interpretation of the responses involved construing whether they were given from a scientific worldview, a religious worldview, or simply involved a personal view. A personal view here includes any non-religious and non-scientific worldview. Since modern science is currently known as an objective form of knowledge, personal views can therefore be taken as subjective. Likewise, cultural beliefs and Indigenous Knowledge Systems are included with the personal viewpoint.

The learners' comments about evolution revealed that 46.91% found evolution to be a valid concept while 40.12% found it not to be valid and, regarding their beliefs about evolution, 47.09% of the respondents indicated acceptance and 27.93% did not accept evolution. In this question and others in this section, reasons for lack of acceptance included lack of validity, while reasons for acceptance included a belief in the validity or truth of the concept of evolution. The responses reflecting validity of evolution were supported by scientifically-inclined statements, while those not finding it valid were supported by religious or personal statements. This was also observed in a question about respondents' beliefs, where 54.73% said species were created and the reason was religious, while the 32.99% who said species underwent evolution gave a scientific reason for their answers. Another interesting finding was the effect of beliefs on learning, where 42.80% of the respondents were positively influenced and wanted to learn more, implying a smooth border crossing, and only 28.22% were negatively influenced, while 39.16% experienced a hazardous border crossing. It was further found that 33.96% of respondents showed a negative attitude towards learning about evolution, as some gave an impression of a conflict between religion and their religious beliefs (23.42%) or their personal beliefs (10.54%) which were not necessarily based on religion. The majority of the respondents, 61.12%, showed a positive attitude toward learning about evolution and 56.21% a complementary relationship between their beliefs and religion. The learners' attitudes also indicated their level of motivation to learn about evolution, where

61.12% showed motivation in general, or for examinations (10.54%), and 23.42% lacked motivation to learn about evolution because of their religious beliefs.

Learners went through diverse experiences, which ranged from being very frustrated during lessons to enjoying learning about evolution, and generally learning occurred – as reflected in 75.13% of the responses, while 83.68% reported scientific reasons for learning new things.

The sources used by learners to enrich their understanding of evolution were mostly books and other print media (43.26%) and others such as television, CDs and internet (31.85%), humans (21.70%) in the form of teachers, relatives, friends and peers, otherwise artefacts (1.78%). The books included a prescribed text for schools to which learners had access. Responding to how they felt about the way their teacher taught them, 92.03% were positive and only 7.07% were negative. While reasons for being negative were mainly religious, e.g. "because the teacher was teaching something against my beliefs", reasons for positive perceptions were various. These included enjoying what the teacher was doing, or learning new things. The suggestions regarding the teaching of evolution covered areas of the content (2.63%), pedagogy (25.78%), content and pedagogy together (35.08%) and the curriculum (32.70%). Not all the suggestions were in favour of evolution teaching. For instance, some curricular suggestions wanted evolution to be removed from the curriculum, and, for the content, some wanted creation to be included, and the removal of some areas like 'human evolution'. However some respondents were in favour of improving or expanding the presence of evolution in schools, such as by teaching evolution in lower grades, training teachers or inviting experts.

Responses to questions 11, 13, 14, 16 and 17 (see the questions in Appendix 1) had a strong worldview aspect and were analysed accordingly. In all the questions except one, Question 14, learners' responses indicated a stronger scientific worldview than a religious or personal viewpoint. In Question 14 learners were asked to give their beliefs about the origin of species, and their responses there reflected a stronger religious worldview than a scientific one. Of the total responses to Question 14, 54.73% were religious, while 32.99% were scientific in their reasoning. Perhaps this is a question where learners tapped more into their religious worldview than into their scientific one because the issue of origins is often treated from a philosophical perspective, especially by people who have religious beliefs.

Responses to question 16 revealed that the majority of the learners (61.12%) have a positive attitude towards learning about evolution, and that the same proportion of learners is motivated to learn, and many of those (56.21%) gave responses implying a scientific worldview. Generally, as reflected from the responses to question 17, this group of learners seemed enthusiastic about learning about evolution since 83.68% of the respondents indicated that learning had occurred and 8.55% indicated that they enjoyed learning about evolution.

When investigating the inter-correlations among the open-ended questions, the results gave p-values of less than 0.0001 ($p<0.0001$) for all the correlations tested, indicating that the associations were significant (see Table 5.57). For example, in relating question 13 with question 14, the significant result indicates that learners' beliefs about evolution are associated with what they believe regarding the origin of species. What the learners believe regarding the origin of species thus depends on what they believe about evolution. Similarly, relating question 13 to questions 15 and 16 revealed that learners' beliefs about evolution and about the origin of species influence how they learn evolution. Also, the correlation between questions 16 and 17 shows that, when learning evolution, learners' experiences relate to their attitude towards evolution.

5.3 FINDINGS FROM TEACHERS

It was expected at the time of the research that teachers would have had sufficient classroom experience with evolution to reflect upon and provide valuable insights for the study. Apart from discussing their beliefs, exploring their teaching strategies would add to this understanding and identify any gaps that might exist in teaching about evolution. The teachers' questionnaire looked for biographical information and had open-ended questions that teachers could answer in the spaces provided. This section presents the biographical information. This is followed by findings from the open-ended part of Section A. The last part presents results from the verbal interview sections of both interviews. For the open-ended questions and the interview questions, the pattern used to present the results is similar to that used for the learners' interviews, described above. The question is given followed by its purpose; this is followed by a presentation of the responses and discussions concerning them. The findings from the open-ended questions and interviews are also supported by quotes. For each question, a short summary of what has emerged from the responses is given at the end. The presentation concludes with a summary of all the findings from the teachers' interviews.

5.3.1 Teachers' biographical information

As already indicated, five teachers took part in the study; four of them were male. At the time of the study the ages of the teachers ranged from 26 to 53, with two being below 30 and one above 50 years of age. Four of them belonged to the Venda cultural group, while the fifth, Tapfu, was not South African but was a Zimbabwean national. All the five of teachers professed to be Christian, with two being Protestants and three belonging to the Pentecostal denomination. The two teachers who had a Bachelor's degree and an Honours degree had learned about evolution at university. The Zimbabwean teacher was educated outside South Africa had first learned of it in secondary school and later at university. Two teachers had never learned about evolution in a formal educational setting; one heard about evolution for the first time from his parents, while the other heard of it when she went for a job interview.

It is interesting to note that the variation in characteristics within this sample of teachers is not very wide. For instance, they belonged to only two main Christian denominations. For the teachers with university degrees, the number of years of teaching Life Sciences at Grade 12 was equal to the total number of years that they had been teaching Life Sciences. The others taught Life Sciences in the lower grades before taking it up to Grade 12. Furthermore, the years of teaching evolution was equivalent to the number of years that evolution has been in the Grade 12 curriculum.

The biographical information showing the variable characteristics of the teachers is presented in Table 5.58. The names used in the reporting and discussions are not the teachers' real names; some were suggested by me and others by the teachers themselves.

Table 5.58: Biographical information about the sample of teachers (from the teachers' responses)

Teacher (pseudonyms)	School	Gender	Age	Highest academic qualification	Religion	Years teaching	Years teaching Life Sciences	Years teaching Grade 12 Life Sciences	Years teaching evolution	Location of school	From whom or where 1st heard of evolution	Level at which studied evolution	Years since first heard of evolution
David	A	M	53	Post school Diploma	Protestant	27	25	7	5	Rural	Parents	Never studied	40
James	B	M	49	Honours degree	Pentecostal	22	22	22	5	Rural	Religious leader	University	25
Tapfu	C	M	27	Bachelor's degree	Pentecostal	6	6	5	5	Urban	School teacher	High school; University	15
Mashudu	D	F	39	Post school Diploma	Pentecostal	5	5	2	2	Urban	Work interview	Never studied	15
Thabo	E	M	26	Bachelor's degree	Protestant	2	2	2	2	Urban	School teacher	University	5

Section A of the interview schedule included three open-ended questions which the participants answered by writing on their own copy of the interview schedule. These questions and the responses to them are discussed in Chapter 6.

5.4 FINDINGS FROM SCHOOL VISITS

As part of the aim of the study there was a need to understand the reality of the classroom with regard to teaching and learning about evolution. Classroom observations were therefore a necessary method of data collection to assist in describing the instructional practices employed by teachers in teaching about evolution. It was during the visits to the schools that the behaviour of both teachers and learners was observed at first hand, to the extent of noting some of the comments they made in class. The types of questions that were asked, and how they were asked and answered, illuminated some of the intricacies involved in teaching and learning about biological evolution. An observation schedule (see Appendix 5) was used to record the teaching and learning strategies used. During the visits to schools, notes were written about the observations made, especially concerning those matters which were not covered by the observation schedule. The notes included discussions that took place outside of the classrooms as well as my own reflections on what I had observed. This section therefore reports on the findings from the classroom observations and the school visits in general.

5.4.1 Findings from classroom observations

A total of twelve lessons were observed in the five schools from 12 February to 12 March 2012. This did not cover all the lessons given about evolution; instead, the number ranged from 2 to 3 per school.

5.4.1.1 Topics observed in lessons

As has been discussed in earlier sections, evolution is sometimes not accepted, usually on account of religious beliefs (see Clores & Limjap, 2006), especially for scriptural literalists. The conflict usually arises over the origin and evolution of humans, as shown in research (Clores & Limjap, 2006). For this reason, the lessons observed were selected to cover specific topics, including ‘Introduction to evolution’, ‘Charles Darwin’s theory’, and ‘Human evolution’. The main aim was to observe how the teachers presented evolution and how the learners received it in their turn. Furthermore, the assumption was that the religious beliefs of both teachers and learners would have an influence on what was taught and how it was taught

and learned. The observation schedule (see Appendix 5) was designed to explore teaching and learning strategies and activities employed during the lessons. Table 5.59 shows the topics that were taught in the lessons observed in each of the schools.

Table 5.59: Number of lessons observed and topics taught during school visits

School	Number of observations	Topics covered		
		Topic 1	Topic 2	Topic 3
A	3	Lamarckian theory	Erasmus Darwin; Charles Darwin	Speciation and natural selection
B	2	Introduction to evolution	Human Evolution	
C	2	Review: Lamarck and Charles Darwin	Evolution versus religion: Alternative explanations	
D	2	Introduction to evolution; Lamarck; Charles Darwin;	Human evolution; Alternative explanations	
E	3	Lamarck and Charles Darwin	Human Evolution	Alternative explanations

The results presented in Table 5.60 are derived from the observation schedule (see Appendix 5) used during classroom observations, and 'n' represents the total number of times an activity or action was performed. Only one tick was awarded for a particular action in each lesson, so that the score corresponds to the number of lessons where the action was observed. It follows that a highest score of 12 and a minimum of 0 are possible, the latter for actions not observed. The left-hand half of the Table 5.60 presents findings from teachers while the right-hand side is for the learners.

(a) Teachers' activities

Although the results in Table 5.60 show that five out of the twelve lessons were taught from the front; in the other seven teachers were moving around the classroom in between the rows of learners' seats. In three of the lessons learners were sitting in groups as they engaged in discussions and presentations.

Table 5.60: Teaching and learning activities observed during school visits

Teacher's activities	n	%	Learners' activities	n	%	Comments
Classroom organization						
Teacher teaches from the front of class	5	41.67	Learners in groups	3	25.00	They moved around
Lesson introduction: Teacher			**Learners**			
Reviews previous work	12	100.00	Participate in discussion	12	100.00	Learners free and open.
Gives overview of lesson content	12	100.00	Listen quietly	12	100.00	
Teaching methods: Teacher			**Learners**			
Reviews learners' everyday knowledge related to evolution	7	58.33				
Provides well-designed materials (hand-outs, pictures, models)	1	8.33				
Employs learner-centred approaches (small group discussion)	7	58.33	Participate in discussions	8	66.67	Mainly group-work
Invites class discussion	11	91.67	Initiate discussions	9	75.00	Learners asked questions
Uses teaching media (e.g. technology, computer, video)	2	16.67				
Asks questions	12	100.00	Respond to questions	12	100.00	
Invites questions	12	100.00	Ask questions	12	100.00	
Answers questions	12	100.00				
Teacher-Learner interaction: Teacher			**Learners**			
Solicits learner input	11	91.67	Are involved	12	100.00	Warm and free relations
Involves a variety of students	12	100.00	Actively involved	12	100.00	
Varies strategies to suit different learner needs	10	83.33				Variation limited: 3 strategies
Content: Teacher			**Learners**			
Appears knowledgeable	12	100.00				
Content is well organized	12	100.00				
Explains evolution and related concepts clearly	12	100.00				
Relates concepts to learners' experience	12	100.00	Bring a variety of experiences	9	75.00	
Uses learning experiences appropriate to level of learning	12	100.00	Relate to evolutionary concepts	12	100.00	
Includes concepts on creation	12	100.00				
Other points (post observation)						
English language used in discussions	12	100.00				Code switching in 10 lessons
Relevant content in evolution covered	12	100.00				
Meets the curriculum expectations.	12	100.00				

All the teachers started a lesson by reviewing previous work with the learners. The review of everyday knowledge was carried on as the lessons progressed in seven of the lessons. In all the lessons teachers asked questions, invited some from learners, and answered learners' questions. However, in only two lessons were some learning and teaching support materials used – being posters and use of equipment to demonstrate some phenomena.

All the teachers in all the lessons observed demonstrated sufficient knowledge about the aspects they taught. This was judged from their ability to respond to learners' questions sufficiently and provide appropriate explanations. Furthermore, teachers were able to cover the content for each lesson adequately. Although results show 100% use of English language as a medium of instruction in all the lessons, code-switching by both learners and teachers was, however, observed in ten of the lessons.

(b) Learners' activities

The activities of the learners were mainly directed by what the teacher did or expected them to do. Generally, learners were involved in classroom discussions and asked questions. They were free to express their views, and some of those with strongly-held religious beliefs voiced their rejection of evolution. In all the lessons, the learners seemed to relate to evolution, even though the relationship was mostly discordant. In general, learners were given opportunities to contribute in group discussions and to argue, or invited to ask questions or to respond to teachers' questions. Teachers tried to teach evolution as a science concept, avoiding mixing it with religious knowledge, and telling learners to do the same. But issues of religion would crop up from time to time, as learners questioned the validity of evolution in relation to their beliefs.

Table 5.60 gives, in quantitative terms, a picture of what was observed in the lessons. The part reported in this section does not give details of what went on during the lessons. The qualitative aspects of the school visits and classroom observations are reported in Chapter 6, giving details of what actually happened.

5.5 CONCLUSION

Chapter 5 has presented results for analyses of quantitative data gathered from learners and teachers using different methods. The presentations are mostly in the form of tables and figures which have reduced the data chunks into codes and numbers. Discussion on these findings is presented in Chapter 7.

CHAPTER 6
FINDINGS FROM THE QUALITATIVE APPLICATION OF THE STUDY

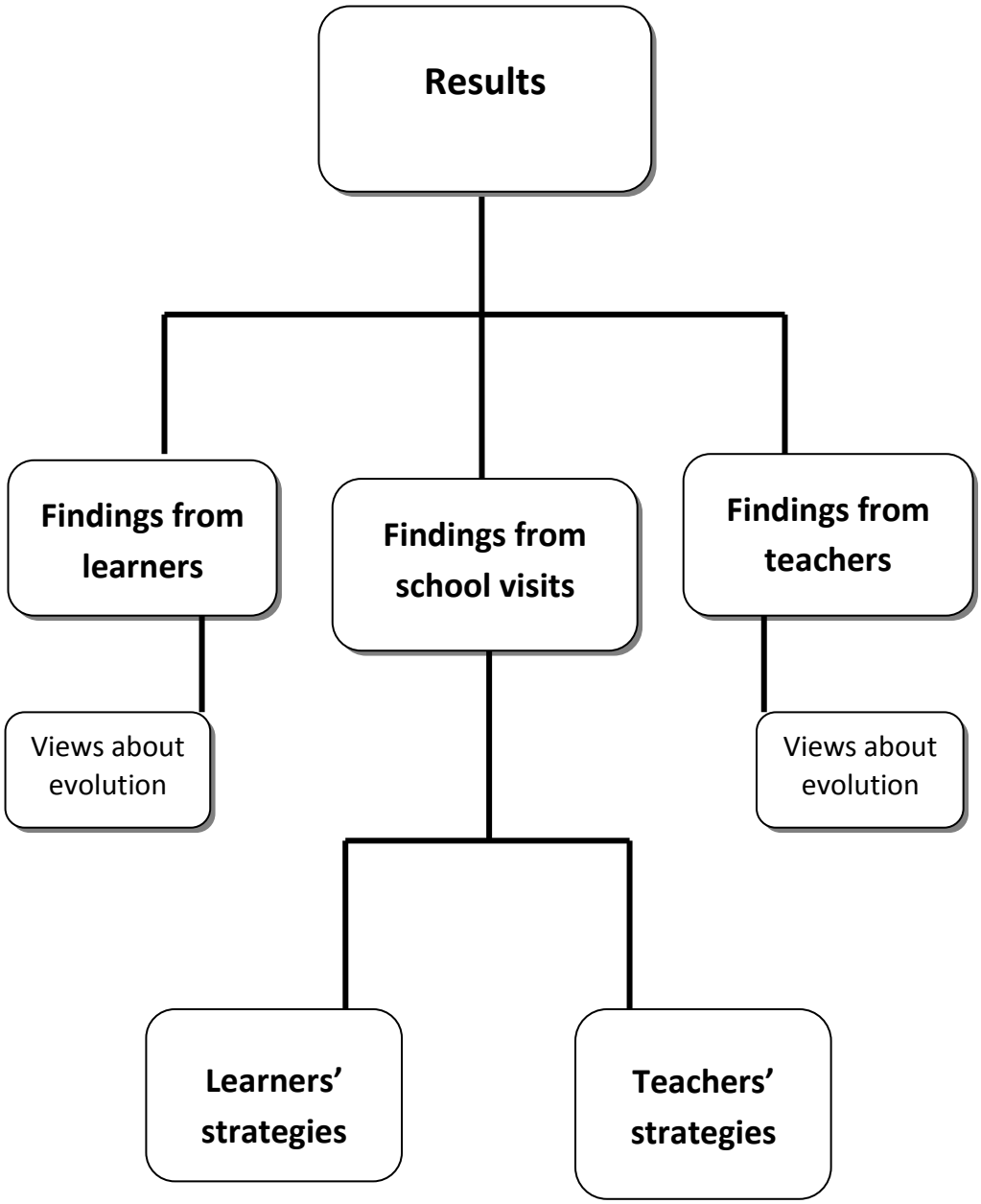

Figure 6.1: Overview of Chapter 6

"… when I'm teaching evolution I've got mixed feelings. First and foremost I would be teaching something that is against my religion, right, like I'm Christian, I believe I was created by God and Biblically I have my strength in that. But I am also a scientist because I teach science … So, at one point you are coming in as a Christian and you are also coming in as a scientist. So it's mixed feelings" (Tapfu, 2012. 03.14).

6.1 CHAPTER OVERVIEW

Chapter 6 discusses the findings from the qualitative data obtained in the research. There are five main sections: the first presents findings from the learners' interviews; the second addresses findings from Sections B and C of the teachers' interviews; the third section presents findings from the school visits, which include mainly field notes made during the visits; fourth discusses relationships among the findings from the different sources and consolidates them into the four research questions; and, lastly, the chapter ends with a conclusion about the findings.

At the beginning of discussion for each data source, the purpose of the method of collection and any issues pertaining to data collection and analysis is brought forth.

6.2 FINDINGS FROM INTERVIEWS WITH LEARNERS

There were eight questions asked of the learners during their interviews (see Appendix 1), which were meant to provide an insight into the learners' worldviews. For this reason, the aim was not so much to ask learners to define evolution, even though they would bring in their understanding of evolution in answering some of the questions. The purpose of each question is included in the presentation of findings for that question, but the questions were:

1. Before learning about evolution at school, what were your views about the origin of species on earth?
2. How did these views affect your learning of evolution?
3. What are your views now?
4. Please describe how you felt during the learning of evolution.
5. Please describe your opinion regarding the inclusion of evolution in public schools' curriculum in South Africa.
6. Are you for or against the teaching of evolution?
7. How do you think you will perform in a question on evolution in the examinations?
8. What are your future career plans?

A total of thirty-three learners from the five schools that participated in the research took part in the interviews. These learners had volunteered to be interviewed when earlier responding

to the questionnaire. All the learners who were interviewed had thus also responded to the questionnaire and had also been present during classroom observations. In some cases, therefore, my discussion with them included the observations made from lessons or what they had written in the questionnaire.

In presenting the findings of the interviews, each question is dealt with separately and is given as it appeared in the interview schedule. This is followed by a brief discussion of the question's purpose. In the discussion that follows, the issues that emerged from the interviews are presented. These findings and discussions are supported by extracts from the conversations or quotes from the interviews. At the end of a quote the speaker is identified by the alphabetic code for his or her school and a number distinguishing this learner from the others at the same school. For example, learner number 1 from school A is given the name 'SCH.A.L1', learner number 2 also from school A is designated 'SCH.A.L2', and learner number 2 from school B is named 'SCH.B.L2'. The numbers assigned to the learners follow the order in which they participated in the interviews in the respective schools. A short summary of what emerged from the responses concludes the discussion on each question. After all the questions are discussed, a summary is given highlighting what has in general been learned from the learners' interviews.

6.2.1 Pre-learning views about origin of species on earth

Although the purpose of asking this question was to find out what prior concepts were held by learners about the origin or species, the question did not ask directly about concepts of biological evolution. It was expected that the learners' responses would give an insight into their perceptions of causality, and hence their worldviews prior to learning about evolution.

Learners gave their views and supported their answers justifying why they held the concepts they did. The findings revealed that 32 (96.97%) of the 33 learners interviewed had heard something related to the origin of species or of humans at some stage before receiving instruction about evolution at school. Most of the learners' prior conceptions were that species on earth were created by God in their present form. This was not a surprise, considering that the majority (94.83%) of the 348 learners who responded to the questionnaire in this study were religious as shown in the biographical data, mostly (93.68%) being Christian [see Section 5.2.1.1 (b)]. Of the 33 learners interviewed, only one mentioned having had no views about the origin of species before receiving instruction about evolution,

even though he was a Christian. The categories which emerged from these responses were 'creationist – Christian', 'creationist – IKS', and 'scientific'.

6.2.1.1 Creationist views based on Christianity

Generally, responses in this category stated that species were created by God in their present forms. Of the thirty learners (90.91%) believed that animals or all things were created by God, twenty-eight (85%) believed in creation as Christians. Six learners had heard of evolution before; one from a father, another from brothers and sisters, two from a grandmother and two from primary school. Even for these learners, species had been created by God. One of those who had previously received some version from a grandmother had been told that 'humans originated from baboons'. He stated that when he later learned about creation from the Bible, he decided to believe the Bible's story and not the story provided by his grandmother.

One of the interesting observations from these responses was that thirteen of the learners (39.39%) referred to the creation of humans and did not make any reference to other species; only when a follow-up question was asked about other species did learners address that. For example, comments like: "*I believe in what the Bible says, that people were created in the Bible*" (SCH.A.L1), and "*My view relied on Christianity that every human being was created by God,…*" (SCH.A.L4) were original responses. Such responses were given despite the question asked being specifically about the origin of species, as it is shown in the vignette below.

> Interviewer*: Before you learned about evolution, what were your views about the origin of species on earth?*
>
> SCH.A.L4*: Ok. Before I learned about evolution what I know is that* ***all humankind came … they were created by God****. That was my only belief that I knew before … before I started knowing about evolution.*

This kind of response could imply that these learners think of themselves first, that is, as humans, when they have to address evolution. It is therefore on the basis of what they believe about their personal origins as humans that they evaluate the validity or truth of evolution. As one of the learners stated,

> *I believe that life begin with God and everything was created as Genesis, 1st Genesis declared it* (SCH.D.L1).

The learner who had heard about evolution from a father had this to say:

> *I believe in what the Bible says; that people were created in the Bible….. Everything that is based on the religion about creation that is what I believe in. But then, one day my dad told me about evolution….that people evolved and so forth. I started to think of evolution* (SCH.A.L1).

Another learner from the same school as this one stated that her creationist views stemmed from her Christianity. Because of those religious views she had found it hard to accept evolution although she later changed as she began to understand it better.

> SCH.A.L7*: At first when I heard about evolution, actually I didn't accept it well from the start but as the teacher introduced the topic I actually started to understand it.*
>
> Interviewer*: So you didn't accept it at first.*
>
> SCH.A.L7*: Yah, at first because of my belief, I am a Christian so, yah, we only have this view that everything God made. So, when the teacher was starting this chapter, actually I didn't accept it very well* (SCH.A.L7).

Two learners, SCH.B.L2 and SCH.A.L5, gave the impression that they had scientific views but, as the interviews progressed, it emerged that they had actually held creationist views earlier. Their first responses to the question reflected what they knew at the time of the interview, which was based on evolutionary understanding. For instance SCH.B.L2 stated believing that "*people came from chimpanzee*" before learning about evolution. But when further probed from, this learner said he had read from the Bible, "*The Bible say the people come from the God, a God where people coming from*", and that is what he believed, before hearing about evolution.

6.2.1.2 Creationist views based on Indigenous Knowledge Systems (IKS)

Two of the learners interviewed who had creationist ideas had heard about creation from their grandmothers. One of these learners, who reported having heard from his grandmother about another god besides the god of the Christians, said this:

> *…my grandmother told me that there is a god called* ***Ngwale*** *that they were raising him before Jesus Christ, and the environment of that particular time was now changed and changed, neh, until the hearing about God, and God around the world (Western-based religion). But … she told me that there is a god who created everything, and the god that they give them power, not god of those who came from heaven (Western-based religion). Yah, they have their own god that they believe to him* (SCH.B.L4).

Although this learner now believes in Christianity, from his grandmother he had also heard about creation as based on indigenous beliefs. The grandmother had emphasized that this was a god who was there even before Christianity, which came to South Africa from the West. He

chose to believe in Christianity. It should be remembered that results from the questionnaire showed only one learner belonged to an African religion. It is possible this current learner declared himself as a Christian, since he emphasized in the interview that this is what he is now. So, only the other one declared belonging to ATR in the questionnaire.

6.2.1.3 Scientific view of origin of species

Two respondents had views which were inclined to a scientific or naturalist perspective. One of these respondents, SCH.D.L4, had views that "*species were just natural things*", and this response was categorised as 'scientific' to indicate the naturalist or scientific way of understanding. It is possible that this learner does not understand much about the natureof science, but the reference to nature implies some scientific inclination. This, however, does not mean that the learner did not have religious beliefs, but just that the response he gave did not make any reference to religion, and was rather more inclined to scientific explanation, implying a perception of scientific causality.

Another learner from a different school had heard that "*we come from animals*" (SCH.B.L3). He said this of his grandmother: "*She said we are just developing. There are things which animals doesn't have but we have*" (*ibid*.). The grandmother of this learner had not been to school; therefore what she told the grandson was most likely based on cultural knowledge or IKS.

Responses from these two learners could have been classified differently, the first one as 'unsure' and the second one as 'cultural or IKS', especially because their responses do not give clear scientific explanations.

6.2.1.4 Unsure of beliefs about origin of species

Only one was not sure of his beliefs before learning about evolution (SCH.C.L3). This is what the learner said to show the uncertainty, "*Sometimes I did ask myself once but I didn't like, have fully understanding and information*". As the learner says, there was lacking of understanding and maybe general confusion.

In summary, what emerges from the learners' responses to this question is that these learners came to school with creationist beliefs which were predominantly based on Christianity. Secondly, the creationist beliefs of these learners were not based only on religions such as Christianity, but also on IKS, as we saw with the learner who had heard about another god

from grandparents. The ancestors of these learners, like those of other African people, had their own beliefs and understandings about the world, its origin and the origin of all species, including humans. They believed that everything was created by some supreme power, which some referred to as *Ngwale*, or the god of the Vha-Venda. What is similar about the responses of all the learners with Christian views as well as IK-based creationist beliefs, is that they indicate a perception of religious causality. We should remember that only one learner claimed to follow African Traditional Religions (ATR) in the questionnaire. That we now have two learners with indigenous creationist views indicates that one of these learners still held his IKS ideas despite declaring in the questionnaire that he was a Christian.

6.2.2 Effect of learners' prior ideas on learning evolution

Following on what the learners said they believed about the origin of species before receiving instruction about evolution, this question was meant to find out how those pre-learning views had affected their learning. It did not matter what type of views they had, whether creationist, scientific or otherwise. And since this was soon after learning about evolution, it was hoped that the experience of learning evolution would still be fresh in their minds so as to enable them easily to recall what they had learned.

Finding out whether the learners' prior conceptions influenced or did not influence their learning about evolution, including whether they believed in it or accepted it, was the main thrust of this research. Learners expressed feelings ranging from being bored and irritated to having fun and enjoying learning about evolution. Some found it interesting and providing them with knowledge about where they came from; some felt they had to compare it with biblical versions of creation in order to decide which one to accept; others did not even want to be in class and, if they had a choice, they would not study evolution. There were, therefore, negative influences, positive influences and some learners who claimed not to be influenced in any way because they found evolution 'normal like other subjects'. Three categories which therefore emerged from these responses were identified as 'negative influence', 'positive influence' and 'no influence'. In the next sections, we look at these three categories in turn.

6.2.2.1 Negative influence on learning about evolution

Some of the learners claiming negative influence spoke of evolution affecting their religious beliefs, which meant that they were afraid that learning about evolution and accepting it as true would affect their beliefs. Some of the learners found it difficult to learn because they

felt uncomfortable with the content or felt distracted from learning. Others stated that, despite not willing to study, they had to force themselves to do so in order not to affect their performance negatively. So the driving force was to pass the subject in the examinations. The two ways in which learners experienced negative influence are discussed next.

(a) Evolution difficult to learn

Three learners experienced difficulty with learning about evolution. One of these learners attributed the distraction he experienced to his spirituality, as he said the following:

> *Actually it had distracted me a lot as the more I grow up the more I become spiritually matured in other words, I become to believe more and more about spiritual things like Christianity itself, how God created heaven and earth and all the stuff, how I became a human, you get my point. So it's hard for me to adapt to the new learning, to the new information that I'm getting right now that is contradicting … contradicting with what I usually believe* (SCH.D.L7).

This same learner described how his religious beliefs were the reason it was hard for him to accept evolution:

> *Actually, I was passive, I was passive because we, at church, you are told to practice, actually I'm Christian, that's why I'm basing all the things or the fact that I'm saying on church things, because as a church goer, you are told to practice what you have been taught, and you are to stick to what you believe, you get my point. So I believed in creation and I believed God created everything that's why I'm here , that's why I'm able to pray and everything is done according to what I have prayed for. So it was hard for me to adapt to this evolution* (SCH.D.L7).

One other learner from the same school, who experienced difficulty because of his religious beliefs, said the following:

> *eih, some things, eih, I, there are some few, few things that I don't believe and sometimes is, …. hard to accept to them when our teacher is, um, busy teaching, we, I get to as many thoughts and many disagreements, and it is very hard to take things that you don't believe sometimes, you, you, you, you, it's just difficult to say, to … when … let's take for example when you are writing and you know that what you are writing as the answer you don't believe it. It's very difficult sometimes, but as we are learning we get to understand that it's (evolution is) all about changing* (SCH.D.L5).

What was interesting about some of these learners was that they stated that their learning improved as the teaching went on; one even mentioned enjoying learning about evolution. This implies that their prior conceptions regarding evolution may have caused the unpleasantness felt in learning about evolution but when they started to understand, such learners were able to overcome their earlier distractions and discomforts, an indication of coping with the conflict as mentioned by Barbour (2000). It could also be that they held

misconceptions about evolution, which they probably became aware of during learning more, and hence the tension they might have experienced prior to learning was now reduced.

Other reasons given by the learners who felt uncomfortable included the feeling that evolution was disrespecting one's religion, and that evolution was a lie. The following two quotations are examples of comments from some of these learners; the first one from a learner who felt that her Christianity was being questioned.

> *Personally I would not want to learn it, because it's… it comes back to religion. I grew up as a Christian so I feel like it's disrespecting God's will. And it says in the Bible we are not supposed to question God, right. That's what the Bible says, we are not supposed to question God and the things He does, 'cause that's just what He wants, right, He is supreme. So personally I wouldn't want to learn it because it's fidgeting with my beliefs and as … the more I learn it the more I am more curious, and the more I am more curious, is the more I want to find out, and the more I find out is the more I move away from …God* (SCH.C.L1).

> *Sometimes I just … or I would just say; Eish, evolution is just criticizing or just … sometimes when you are teaching about evolution, and we are being taught in class, sometimes I would just feel like …eish … what can I say, they are not respecting my God* (SCH.C.L2).

The quotation below is from a learner who was not willing to learn about evolution because she felt evolution was not true.

> *I was not willing to learn it but I had to. But I was not really willing 'cause, even, even from the beginning I believed that God created everything the way they are so, when I had to learn about evolution, it was difficult at first. I was not willing to learn evolution. Sometimes I used to say that I'm even lazy to study about evolution, 'cause it's all about lies* (SCH.E.L1).

For all these learners who said they experienced difficulty with learning about evolution, a conflict between the religious beliefs and evolution was experienced. They were therefore not willing to learn about evolution, or they were distracted by their beliefs and found it hard to accept evolution.

(b) Felt forced to study evolution

Seven of the learners were affected to a point where they felt they had 'to force' themselves to study evolution. The following two quotes, followed by a short conversation are from some of these learners.

> *When I was learning about natural selection it was fine but, ah, other things, ya, it was not good at all. I was not really willing to work, to, to learn but I forced myself to* (SCH.E.L1).

> *I have seen that, no, I can't, I can't go on because if I, I hated the, the evolution therefore it will affect my studies but therefore because, um, I'm just learning and, um, I need to be educated in. Yah, I just appreciate, er, that evolution, but I, I know it's not really who I am, it's not my real belief to evolution but, I, I'm just doing it because of I, it's a learning area, and I'm doing life science, and yah…* (SCH.E.L2).

The vignette below reflects part of the conversation with another learner:

> SCH.D.L8: *So I have to learn it yah, of course I have to learn it…*
>
> Interviewer: *But what do you think about that?*
>
> SCH.D.L8: *I think on my curriculum, it making me not to feel comfortable learning about evolution eh during this chapter of life sciences, of evolution, it, brings something that I don't understand most and when I think of it I just feel irritated … yah, yah.*

It should be noted that distinguishing between the different ways in which learners experienced negative influences was not easy, and overlaps are acknowledged. For instance, learners who found it difficult to learn were also uncomfortable and had to force themselves to learn. The distinctions made in the presentation stem from the learners' comments themselves and were meant to differentiate the level of difficulty or discomfort that the learners experienced. The learners who experienced difficulty were taken to have been the hardest hit, followed by those who were uncomfortable. Those who forced themselves to learn, while there is no intention to belittle their discomfort, were taken as better off than the others, since they were able to continue learning even if they had to force themselves, meaning that they were not completely dissuaded from learning.

6.2.2.2 Positive influence on learning about evolution

As already discussed, most of the learners experienced some form of discomfort in studying evolution, especially those who had creationist beliefs prior to learning. However, it is interesting to note that, despite the initial reaction of disbelief for some of them, some learners became interested in learning more about evolution. This was considered as an example of a positive influence, since learners were motivated to learn more. Examples of the comments from learners who were positively influenced could be the following:

> *I was interested in knowing more about evolution…. I was just interested in knowing, knowing and knowing* (SCH.A.L1).

The quotation shows two statements stating the learner's interest. She actually mentioned three times in different parts of the interview that she was interested in studying evolution so

that she could know more about it, perhaps showing the motivation of the learner. Other learners raised the following views:

> *My views didn't really affect my learning. They only made it even more interesting, because I wanted to expand on what other people believe and it's a learning experience. It doesn't really change what I believe in, but it makes space for me to explore what other people in the world believe* (SCH.A.L3).
>
> *Honestly, I felt interested in learning. I wanted to learn more, to know where actually we came from ... to compare what I am learning and what I thought before about evolution* (SCH.A.L6).
>
> *They did not affect me anyhow. I, I, I was actually interested in knowing, eh, about evolution and being able to compare it, to understand it more thoroughly so that i may able to, to compare it, to actually try to make sense out of what evolution is so that I may be able to know where I, where I belong* (SCH.D.L2).
>
> *As time went on I just started being used to learning about evolution and I wanted to find out more, on the topic* (SCH.C.L1).
>
> *I feel comfortable because I am interested knowing what ... how scientists explain things, because I am also doing science* (SCH.B.L5).

As can be seen from these quotations, these learners were interested in studying evolution for different reasons. For some, like SCH.A.L1 and SCH.C.L1, the reason was 'to know more'. For SCH.A.L3, the reason was 'to explore what other people believe', in other words, to be aware of other people's worldviews, and another reason was to know 'how scientists explain things' (SCH.B.L5). For SCH.A.L6 a motivation was to compare what he knew before with the new knowledge about evolution and to know where he came from. This was the same for SCH.D.L2, who added that, by knowing more, he would also know where he belonged.

Some learners did experience difficulty when evolution was first introduced, but were able to enjoy classes because of the way it was taught and the way in which they participated in the learning process.

> *At first like I said it was difficult, but as we go on we started to enjoy the learning because we could debate, I love to debate, so learners would make groups and we could debate, and, yah, you learn other things from other learners. Yah, it was fun. The experience at class was fun* (SCH.A.L7).

Some of the learners who were in the end influenced positively by learning about evolution had to go through some adjustment from being uncomfortable to finding it enjoyable to learn. For those who were interested, the motivation came from wanting to know more about it or to learn more and know other views besides their religious views about where they came from.

6.2.2.3 No influence on learning about evolution

Some of the learners indicated that their beliefs had no influence, because they put them aside when it was time to learn about evolution. As one said, "*I just keep my mind on the evolution part and forget about the Christianity, whereas I still believe in it so that it cannot disturb me, not at all*" (SCH.A.L4). This learner was sure that there was no influence at all on her learning. She reported separating her Christian beliefs from evolution by resolving that evolution was scientific, and her beliefs were different. She put it this way:

> *I did accept that Christianity is all about God and when it comes to evolution it's all about scientific things. So I have taken my mind off Christianity and let the science deal with evolution so that I can learn more …* (SCH.A.L4).

There were also learners who, although they separated their Christian beliefs from evolution because they wanted to focus on learning, still left room for the possibility of change in their views as they went on with studying evolution.

> *…when it comes to learning, learning comes first. Even if I believe something out there, when I come to school, that has to go away. … That's what I believe out there (creation), but when I come to school I have to go by the books. I have to look at the books and try to learn more. Maybe then my view out there will change because out there I am not going to learn anything, but when I am here, even if I believe in something else, as I am learning, there is a possibility that, that can change. So, the fact that I believe that we were created in God's image does not mean that I must not learn about evolution. It doesn't mean that I must say no to evolution. I must be open and allow new things"* (SCH.A.L2).

Apart from enabling them to learn better, for some learners putting their beliefs aside was for yet another reason. Their responses conveyed that they were afraid that learning about evolution would affect their religious beliefs, while their Christian beliefs could also disturb their learning about evolution. As one of them said,

> *So I have taken my mind off Christianity and let the science deal with evolution so that I can learn more, so that it (evolution) cannot affect me as I am a Christian"* (SCH.A.L4).

The statements from the learners indicate that their learning of evolution was not influenced by their beliefs because they separated their Christian beliefs from what they were learning. This indicates a way of coping for these learners and reflects Barbour's (2000) independence coping strategy.

6.2.3 Views of learners since learning about evolution

This question was meant to find out, as it says, the views of learners after learning about evolution. In the two previous questions they had stated their views prior to learning and how they felt those views might have affected their learning. Having learned about evolution, they were now expected to indicate if the views they had prior to instruction about evolution remained the same or if they had changed.

The responses given by the learners pointed to change in views as well as to no change in views, and this applied to those who had prior creationist beliefs or other types of belief. As shown in the responses to Question 1, many of the learners had creationist views before learning about evolution. For some of the learners interviewed, their views had changed and they accepted evolution, while for others their views did not change. There were also those learners who found themselves 'in the middle' and not sure what to believe, saying that they held both evolutionist and creationist beliefs. Some learners indicated being confused and not knowing what to believe any longer. The presentation below categorizes respondents according to the types of beliefs they had after learning about evolution, whether changed or not changed. Five categories which emerged were: 'religious views remain', 'religious and scientific views are mixed', 'religious views changed to scientific views', 'scientific views remain', and 'confusion'.

6.2.3.1 Unchanged religious views

There were learners who stated that after intruction in evolution, they still believed in the biblical version of creation. But these learners were in different states of creationist belief. Nine of them reported their beliefs not changing at all – in other words, they maintained creationist views undisturbed. This group was coded as 'still creationist'. There was, however, another group of learners who, although keeping their creationist beliefs, also believed evolution was happening and was true. This group was thus referred to as having 'mixed beliefs', indicating learners with both creationist and evolutionist views. Some of these 'mixed beliefs' learners indicated categorically that they were in the middle, while some said they still believed in biblical creation but also accepted evolution, without putting themselves in the middle position.

One of those learners whose creationist views remained did not agree with evolution because even after he had studied it, he felt there was not enough evidence to convince him that evolution does occur. This is what he had to say:

> *…even now (after studying evolution). I thought maybe it's something that people want to express science how it is and, and they want to know more about science. And it's according to how you understand science. But it remains, I strongly disagree with evolution, because I think there is no, there is lack…, there is no more evidence about evolution for myself and for my sake. And I will never believe evolution* (SCH.D.L8).

This learner 'strongly disagreed' with evolution, and the basis for that was his creationist beliefs based on Christian faith. He was so strongly against evolution and he even described how he "*sometimes I fe(lt) bored, and irritated because it's (evolution is) something that I'm learning but not agreeing on it and I'm not accepting that this, this thing happen*" (SCH.D.L8). He did acknowledge later in the interview that he did not understand it, and the reason for that was that he was '*not even interested in it'*. This is a display of a very negative attitude towards evolution. Again by his own admission, if he could be interested he would 'understand' and 'master' evolution, which means he was aware that his negative attitude was hindering his learning. Another way to look at this would be to say that if he could understand, then he would be interested. But by his own admission, the interest was lacking and perhaps impeding understanding. Another interesting observation is that he started with confusion, and as he went on learning about evolution, the more he found it incredible, to the point that he 'strongly disagree(d)' with it. He stated having problems with scientific theories, even though he planned to follow a career in a scientific field, which he said he felt passionate about. That he found evolutionary theory not valid is shown in the following dialogue:

> SCH.D.L8*: It's not valid,*
>
> Interviewer*: It's not valid, why or why not?*
>
> SCH.D.L8*: This thing of, of evolution, you know scientific things and these theories, they are not real for my sake but we have to learn it in order to meet our passion. Mining is my passion and I know that I love mining engineering so I will come across with these theories in science, in doing science, but to meet my passion I have to go through these theories and what will happen next I don't know.*

Later in the interview he said that he would learn new scientific theories that he would come across in the future, and maybe the passion he had for his planned career in engineering would improve his attitude towards learning about those theories.

One of these learners whose creationist beliefs remained as they were prior to learning, seemed to be more open than the one described above. Although she felt that knowing about evolution had no effect on her belief system, it made her open to knowledge other than what she already possessed.

> *It doesn't really change what I believe in, but it makes space for me to explore what other people in the world believe* (SCH.A.L3).

Like the one above, this learner still did not find evolution valid, as she said that it was 'not a fact'. The conversation around this issue went as follows:

> Interviewer: *But here you say that "evolution is not a fact. It is an opinion based on evidence" (referring to a response in her questionnaire). So how do you differentiate a fact and an opinion?*
>
> SCH.A.L3: *A fact is something which is said to be scientifically proven.*
>
> Interviewer*: And you don't think evolution is scientifically proven!*
>
> SCH.A.L3*: No. I think it's something which is real, like, in real essence, like real, which is fool-proof we can just see that, but I think it's somebody's opinion from back then, which when combined with all that evidence which were said to be found, they believe that it has occurred. But regarding areas like religion I think, I think it's all about your own personal beliefs other than facts.*

In her argument that evolution is not a fact, the learner says it is somebody's opinion, which could mean that it is not based on observation but on inferences by somebody. This could be a sign of lack of understanding and misconceptions regarding evolution. It could also indicate that her personal beliefs are affecting her decision. If she views evolution from the perspective of her religious faith, she might not accept the evidence about evolution, find it not to be a fact, and this would imply that she does not find it valid or true.

These two learners, and the other seven who still held strongly to their creationist beliefs after learning about evolution, had certain things in common. First, they had Christian beliefs, and probably used their religious perspectives to evaluate the validity of evolution. They declared not finding the evidence of evolution convincing, one even saying he did not think visiting the fossil sites would change his mind. Interestingly though, some aspired to follow science-based careers in future, such as engineering and medicine, which could indicate that the negative attitude applied to evolutionary theory more than to other concepts in science.

6.2.3.2 Mixed religious and scientific views

The other group of learners whose creationist beliefs did not change differed from the previous group in that these learners accepted evolution either in part or in its whole. For this reason they cannot be described as 'just creationist'. Although assigned the code 'mixed beliefs', among this group there was some mixing, from those who still held strongly to their creationist beliefs but were beginning to accept some parts or all of evolutionary theory, through those who were in the 'middle ground', and finally to those who were beginning to doubt their creationist beliefs in favour of scientific understanding and an acceptance of evolution.

The vignette below is from an interview with one of the learners who still held strongly to religious views though beginning to accept evolution:

> SCH.C.L4: *Mmm, at this time I cannot really tell because I still got… let me say, I still believe in both, at the same time.*
>
> Interviewer: *You believe in creation and …?*
>
> SCH.C.L4: *…. and evolution, and the main reason why I am saying this is because evolution is based on evidence, and the evidence I have been trying to look at it, it's convincing, and with …religiouswise, it's just belief, so that's what make me say that I believe in both now.*

This learner also said he became interested in learning about evolution, as he had already heard about it informally. Now he was happy that he was going to learn about it and had an open, favourable attitude towards it. During a class discussion, he had even opted to speak in favour of evolution and, although some learners were offended, to him it was 'just a subject' to learn. He was interested in knowing more about evolution.

Next, we have a learner who claimed to be in the middle:

> *They are not really changed. But then I am in the mid-point, let me put it this way, I am in the mid-point. I believe most of the things about evolution, but the only part I find hard to believe is the part that we (humans) evolved. Rather, we may share the same common ancestor, yes I believe, but not that we evolved from them* (SCH.A.L1).

Another one of those whose creationist views did not change after instruction had initially heard from his grandmother that humans came from animals. Even after hearing this, the learner still believed in the biblical version of creation. However, after learning about evolution at school he became confused as to which explanation to accept, and ended up being "*of two minds*". He said later in the interview, "*I said I have got, I have got two … I*

…ummm… in evolution I also accept it, and then in people's beliefs I accept it" (SCH.B.L3). The learner demonstrates an ambivalent attitude, as he stresses being of two minds. While this could be an indication of uncertainty on the part of the learner, it could also be an indication of strong convictions about both creationism and natural processes of evolution. The learners in this category reflect the theistic evolutionists as shown in Scott's (2000) continuum. This group shows people who believe that evolution exists, but that it is managed by a divine being or God.

6.2.3.3 Change of religious views to scientific views

Responses from seven learners indicated a change from prior creationist views to an acceptance of biological evolution. One of these learners stated that, before he learned about evolution, he believed things were created in their present forms as he had learned that from church. That was because young people "*were told about creation because when you grow up you are forced to go to church as a young person, so they do tell you are about originity of people. In other words you are told that you are here because of creation*" (SCH.D.L7). All that changed with learning about evolution, as he learned to understand what was going on with the environment and how organisms adapt to changes in the environment. This is how he stated his position:

> *All of it has changed because as we, we take a good look at, at the way things are right now. Our, what do they call it … everything is changing according to the way the environment is changing. We are, everyday are adapting to the new environment as we can take a good look in global warming, the temperatures which we are experiencing right now long before they were not here, right, but the more we live and the more as years pass by we are able to adapt to each and everything. So with evolution that's the only fact which I can agree with that indeed characteristics which we have or the features or our body itself it is able to adapt to the environment into which I am living in … I am living in, in that particular time* (SCH.D.L7).

As the interview continued, the learner admitted to not believing in some parts of evolutionary theory. However, later in the interview he also strongly supported the inclusion of evolutionary theory in the curriculum, although he felt that it brought conflict to the classroom.

Some of the learners who accepted only creation but did not accept evolution before learning about evolution stated that they were beginning to doubt their religious beliefs regarding the origin of species. While they accepted only creation at the beginning, they were now beginning to accept evolution as well, and to question some of their creationist beliefs. This

could mean that these learners were initially biblical literalists, but as they begin to understand more about evolution, they change to theistic evolutionists (see Scott, 2000), accepting evolution but still believing in God's involvement.

The learner who expressed a great change in his views said the following:

> *...ah, they have changed definitely because ah what I, what I used to believe is that God created everything. He created trees and animals first, and then human beings later atere, but what I used to, what I did not realize or what I didn't, or what I didn't brainstorm deeply is that ... the body plans. I did know where ... I did not hear about the body plans. But now that I know about the body plans ... the adaptation ... that's where I started to believe in evolution* (SCH.D.L6).

This learner said that she accepted evolution a lot, giving it a figure of 95% acceptance. She said the remaining 5% catered to the creationist views she still held regarding the origin of species.

One of the learners who had said that, prior to learning about evolution, she had believed all people, all animals and all species were created by God, indicated that she had accepted evolution since learning about it, using these words:

> *I now believe in evolution, I believe that ... we arose from common ancestors with apes, and then, we are what we are today because of, of changes that existed around the world. Yes, and if I go and live somewhere and someone stays there, then we cannot be the same, because we are trying to adapt in the environment that we are living in?* (SCH.E.L7).

Although this description is closer to what evolution is about, it has some contradictions. The same learner later showed lack of understanding when she said she believed that every species came from the dinosaur. She then declared her doubt regarding creation:

> *I doubt people were created by God. How did God put these people on earth? And then they... God created two people, Adam and Eve, then they gave birth to two children, and that was Cain and Abel, then Cain killed Abel, then there was Cain alone here. Where did other people come from?* (SCH.E.L7).

From this it can be said that this learner was confused about, and has questions regarding the literal the story of creation in the Bible. It seems that she is having difficulty in trying to understand the factual account of the Bible. Her questions regarding creation are shown in the comments she made:

> *It (Bible) says there were other people and where were they, the other people when God created the earth? Because we only know about Adam and Eve, and those other people, they just come, we don't know where they're coming from* (SCH.E.L7).

Later in the interview, she pointed out that there is a conflict between what the Bible says regarding the origin of species and what evolution says:

> *They have conflict, evolution is talking about people are risen from apes, and the Bible talks about people being created by God the way they are* (SCH.E.L7).

Her statement though, reveals some misunderstanding of the evolutionary theory as well, as she said evolution talked of people rising from apes. This is a common perception regarding the theory of evolution, which could cause people to reject the notion of evolution. For this learner who had been having trouble understanding or accepting some parts of the Bible, the confusion was obviously coming from both sides, creation as well as evolution. But according to this learner, the conflict for her arises from the literal interpretation of the Bible which is not agreeing with what evolution says. This gives an insight into the source of conflict for biblical literalists.

> *It affect the way I was learning evolution, in such a way that, er, I believe that everything is created by God, and evolution says, evolution says people … I believe that people were created by God and we come from Adam and Eve, and then evolution says people come from apes, others from common ancestors who is the monkeys and the baboons* (SCH.E.L7).

Although she had accepted the biblical story of creation, she had already been asking questions about the mechanism involved in creation, as shown in the quote below.

> *I believe that the Bible says that people were created by God, and then ya, people were created by God. And how did God create those people? Because Adam and Eve just come on earth, we don't know where they are coming from, why can't people nowadays be created like Adam and Eve? So that's why I believe that evolution take place* (SCH.E.L7).

Because of the questions she perceived regarding creation, evolution probably answered those questions, providing her with more acceptable answers to her long-standing questions about where she came from. She indicated loving to read about evolution and to learn more about it, which showed she was comfortable with it and did not experience any conflict.

6.2.3.4 Unchanged scientific views

There was one learner who had 'scientific' views before learning about evolution, and his views remained unchanged after learning about it. This is what he had to say: "*My view is that eh, humankind, let's say people and those species those who used to live long, long ago, they have a common ancestors*" (SCH.D.L4). That his views did not change was to be

expected, since the model of evolution accommodates a scientific explanation for the origin and diversity of species, and would evoke no change in such views, but rather enhance understanding.

6.2.3.5 Responses showing confusion

Two types of confusion were identified regarding the question of views after learning about evolution. Six learners were confused because they did not know what to believe now that they knew about evolution, which made sense to them, while at the same time they still believed in the biblical account of creation. The other type of confusion was observed among those learners who seemed not to have a clear conceptual understanding of evolutionary theory. Given first below are responses from four learners who seemed to be experiencing the first type of confusion, of not knowing what to believe between evolution and creation.

> *Well, it (evolution) actually got me confused. I don't know what to believe. Either we were created or we just evolved from those apes. I don't get it* (SCH.B.L6).

> *Right now I can say I am neutral because I don't know where to stand anymore. As I said there are unanswered questions about creation, right. Like you come from a Supreme Being who is God, but then there are a lot of people who like asking questions like 'where does God come from?', 'who created God, because he can't have just be there by Himself'. And then there are such questions don't know where to stand anymore because creation says we all come from God and stuff and stuff. And then in evolution like biologically, says the earth was once a big ball of fire and then it started like, in evolution, there are some questions that also don't tell you, right* (SCH.C.L1).

> *Because now I follow the word of God, I do believe, but I still have a doubt, or I don't know where to stand now* (SCH.B.L4).

> *And then I don't want to believe in evolution and all the things. I want to believe in Christianity and know that we were created, not made or just evolved from somewhere … some things* (SCH.C.L2).

The next response below shows the second type of confusion embodied in not knowing what to believe. The reasons given indicate a lack of understanding of evolutionary theory:

> *…we came from God. Let me say we were created by God with an ape, with common parts but different in behaviours. And we have the same brains, the difference is the face. Ours is gentle but an ape is stick* (SCH.A.L5).

What is interesting about this learner's response is the inclusion of the ape in the answer, and the emphasis that there were similarities (common parts) and differences (in behaviours). This could be a way of stating his belief that organisms were all created as they are at the same time, and that even the variations were there as they were created. This learner acknowledges the similarities and differences betweem humans and apes, which is an

acknowledgement of the diversity of species as well as some relationship between them, but does not accept the role of evolution. Later in the interview, he said that he gained experience from learning about evolution and that he believes 'a little' about evolution. When asked why he 'believed little', he said what is quoted in the following extract, which showed that he was confused. He seems to accept that humans came from apes, which is erroneous and a misconception, when he says:

> *Because I don't understand how … I don't understand where an ape came from. I just know a person came from ape but I don't understand where an ape came from* (SCH.A.L5).

While asking where apes came from could be a valid question, according to this learner it would seem as if the process of evolution started with the ape, hence begging the question about where apes came from. In summary, studying evolution had given learners a scientific explanation for the origin and existence of species on earth. Some of the learners who had come with prior explanations based on religion changed those views to a more scientifically-inclined understanding, while others retained their original views. As would be expected, the one learner who had scientific ideas before did not change those even after learning about evolution.

6.2.4 Learners' feelings during the learning of evolution

Learners expressed feelings which varied from feeling good, feeling comfortable and feeling uncomfortable when learning about evolution and their responses were categorised as such. Some of those who felt good and enjoyed lessons on evolution received motivation and encouragement from their teachers. They were motivated because they wanted to know more about evolution, wanted to pass their examinations, and they could understand their teachers' explanations.

6.2.4.1 Learners who felt good, comfortable and enjoyed learning evolution

There were seven (21% of those interviewed) learners who stated that they felt good, had fun and enjoyed learning about evolution.

(a) Feeling good about learning about evolution

Some of the learners who felt good gave the following responses:

> *I feel good just because for a long period of time I just want to know more about evolution and the teacher will help me a lot just because I ask a lot of questions that I*

> *know and the way they give me explanation, they give it the way I understand* (SCH.B.L4).
>
> *Yah, and I enjoyed it* (SCH.B.L6).
>
> *I actually felt great* (SCH.C.L5).
>
> *I feel so happy, I really enjoyed the lessons* (SCH.E.L7).
>
> *It's been…uuu…it's been fun. But some of the things, some of the ideas were rather very, seemed very impossible, but you know we make even more space to accommodate all those beliefs and try to understand why other people think that evolution was based on other things. And it's been … we interact a lot, and try to brainstorm and …. Yah* (SCH.A.L3).

That learners felt good and comfortable about learning about evolution is an indication of the *smooth border crossing* as described earlier, even though SCH.A.L3 found some things impossible. However, even though these learners had fun and enjoyed studying evolution, that was not always because they accepted evolution. For instance, learner SCH.A.L3 quoted above had written in her questionnaire that "*evolution is not a fact. It is an opinion based on evidence*". When asked about that during the interview she replied in the following manner.

> Interviewer: *But here you say that "evolution is not a fact. It is an opinion based on evidence". So how do you differentiate a fact and an opinion?*
>
> SCH.A.L3: *A fact is something which is said to be scientifically proven.*
>
> Interviewer: *And you don't think evolution is scientifically proven?*
>
> SCH.A.L3: *No. I think it's something which is real, like, in real essence, like real, which is fool-proof we can just see that. But I think it's somebody's opinion from back then, which when combined with all that evidence which were said to be found, they believe that it has occurred. But regarding areas like religion I think, I think it's all about your own personal beliefs other than facts.*

It is quite interesting that someone would agree that an 'opinion', as SCH.A.L3 refers to evolution, would have supporting evidence and still not be regarded as a fact. But this learner has shown how deeply entrenched beliefs can interfere with acceptance of something when it is perceived to be contradicting ones beliefs. This observation also shows that knowing about and perhaps understanding a concept is not necessarily an indication of acceptance of that concept. It is also interesting that the learner is still prepared to learn about evolution, though it might be based not on evidence but on some people's inferences.

(b) Wanting to know more about evolution

Some of those learners who felt comfortable also showed that it was because of the interest they had in learning about evolution, as shown in the quote below.

> *I feel comfortable because I am interested in knowing what … how scientists explain things, because I am also doing science* (SCH.B.L5).

SCH.B.L5 is an example of what can be described as the 'I want to know more kids' who aspire to learn more about evolution. There were eight learners altogether who stated wanting to know more, and two others who cited benefits of knowing more about evolution. Reasons for wanting to know more included: knowing where one came from (SCH.B.L5; SCH.A.L6; SCH.D.L7); understanding more so as to explain to others (SCH.C.L2); being able to evaluate evolution, " *Eee, since I said I am so interested in knowing more about it, I think I will do very well because I, like, uuuu, I try to evaluate the information on evolution and get to know more about it*" (SCH.C.L4); appreciating what evolution teaches (SCH.D.L5); and realizing that knowing more enables one to believe more:

> *I think it is good because learners are learning something that they wouldn't be knowing … I think because evolution has been introduced now people are becoming familiar, are now knowing about evolution and many of them are believing in it* (SCH.D.L6).

All the same, some of these learners want to learn more despite experiencing some cultural incompatibility between what is being learned and their personal beliefs; as SCH.C.L2 stated, she is still against evolution even though she wanted to know more about it. Her reason for wanting to know more was to enhance her understanding and be able to explain her views to others who do not know about evolution.

6.2.4.2 Feeling uncomfortable

The learners who felt uncomfortable did so for different reasons. One of them felt that her faith and God were being disrespected by evolution. She put her sentiments in this way:

> *At first it was very uncomfortable to be learning about evolution, coz then I felt they were questioning what I believe in, coz I am a Christian, I was a born a Christian, grew up as a Christian and I am still a Christian. So I felt like they were questioning what I grew … I was being judged in my believing in God. 'Cause some people in class don't believe that God exists and stuff, so I felt like … it's like discrimination and disrespect for … to what I believed in* (SCH.C.L1).

Some felt as if they were being forced to believe in evolution against their own religious beliefs. One such learner felt that the teacher was trying to make them 'believe in' evolution, as he said the following:

> *It felt awkward, umm, when the teacher, is as if the teacher eh, is trying to, to allow the whole of the class to believe in evolution. So it felt uncomfortable when they, when the teacher does not allow us to have our views. It's like the teacher… when teaching, eh, they try to, eh, make us to take evolution as it is, in their views thinking it is the way, is the only way that we can able to comprehend and understand what evolution is all about* (SCH.D.L2).

Interestingly, he was also one of the learners who had indicated that their creationist beliefs made them want to know more about evolution in order to compare it with his beliefs. After instruction about evolution his creationist beliefs remained unchanged and he experienced during learning the feeling of awkwardness captured in the quote above, and this made him quiet in class and not willing to participate. He felt that his views would not affect his performance or his understanding: "*I understand evolution separate from religious views, I take it as it is … I'm not influenced by my religion on how I look at evolution. Yah, so it doesn't affect me, I take it as it is, but I know what I believe in*" (SCH.D.L2).

6.2.4.3 Being confused

There remained learners who were confused and not sure whether to accept evolution as true or not. The vignette below gives a response from a learner who was confused.

> Interviewer: *Ok. So as you were learning about evolution … you were telling … you are saying that your views … your Christian beliefs are very strong, and you even told yourself that you were not going to accept anything. But then during the lessons, how did you feel?*
>
> SCH.C.L2: *Most of the time I used to ask myself sometimes, but what if evolution is true, because most of the things on evolution are physical things that we see every day, are things that are happening every day …*

6.2.4.6 Feeling forced to study evolution

One of the learners was affected to a point where he had 'to force' himself to study evolution, while four others felt they had to learn it in order to pass. The following four quotes are from learners who felt that way, with the first being from the learner who forced himself to learn.

> *When I was learning about natural selection it was fine but, ah, other things, ya, it was not good at all. I was not really willing to work, to, to learn but I forced myself to* (SCH.E.L1).

> *I have seen that, no, I can't, I can't go on because if I, I hated the, the evolution therefore it will affect my studies but therefore because, um, I'm just learning and, um, I need to be educated in, ya, I just appreciate, er, that evolution, but I, I know it's not really who I am, it's not my real belief to evolution but, I, I'm just doing it because of I, it's a learning area, and I'm doing life science, and ya … I would do it and pass it, not because of I believe in it …* (SCH.E.L2).

> *I feel, ah it's just a lesson and I have to learn about, yah, evolution and everything because it's part of my studies so I have to do it, as for my studies* (SCH.E.L6).

It should be noted that differentiating between these different ways in which learners experienced negative influence was not easy, and overlaps are acknowledged. For instance, learners who found it difficult to learn were also uncomfortable and had to force themselves to learn. The distinctions made in the presentation stem from the learners' own comments and were meant to distinguish the levels of difficulty or discomfort the learners experienced. The learners who experienced difficulty were taken to have been the hardest hit, followed by those who were uncomfortable. Those who forced themselves to learn, without denying their discomfort, were taken as better off than the others since they were able to continue learning, even if they had to force themselves, meaning that they were not completely dissuaded from learning.

6.2.5 Learners' opinions regarding the inclusion of evolution in the school curriculum

More than revealing learners' opinions about the inclusion of biological evolution in the curriculum, the responses to this question were expected to provide an insight into learners' general feelings about their own experiences with learning about evolution. To answer this question, they would have to draw on their own experiences with learning the theory, and use those to say whether on not evolution should be taught in schools. There were two kinds of responses: those which supported the inclusion and those which did not; therefore the categories assigned were 'support inclusion' and 'no support for inclusion'.

6.2.5.1 Support for the inclusion of evolution in the curriculum

The inclusion of evolution in the curriculum was supported by 22 of the 33 (66.67%) interviewed learners. There were various points raised to justify that support, such as evolution teaching people about where they come from; teaching about other perspectives and views including scientific views; and enableing people to think and choose for themselves what to believe. One of the responses in support of evolution in the curriculum was that it was good for people who believed in it as noted in the following quote:

> *Actually, as learners, let me just put it this way, sometimes we just learn to pass, but with this topic, it is a very sensitive topic, and I think the community of education or the department of education to include this topic in our curriculum or in our syllabus, I think it's a new thing, it is a new thing in which we ought to know, so that we can be able to know because, when you talk about evolution, we are talking about the present thing, things that are happening now and things that have happened, it's like knowing about where you come from or how the world began and all that stuff. So I think it's a good topic though, for people … most especially who believe … in it* (SCH.D.L7).

Another quote that more or less covered all the points in support of evolution in the curriculum is the following:

> *It's a good thing because a lot of us are curious; everyone wants to know where we come from. And though the Bible says this, but everyone would want to know because a lot of people believe in different things. So I may believe in creation, and someone may believe in something. So together, like, as a class, we all have different views. So evolution may be that one thing that may put us to believe … one thing that may put us to say; this might be the place that you all have evolved from, so it might also change our beliefs and what we believe. So it's a good thing because it may answer some of the questions that we have. It brings curiosity. It gives you the reasons why you should want to know. It makes you to think. People like, yes, should know how this came about, unlike just being told that this is what happened. But then if you are told that this is what happened, and then someone comes with facts, you are bound to believe that this might have been the real truth other than what you have been told, because you can see that this is it and there is nothing to deny … it's the truth, so this might be it regardless of what you believe in* (SCH.A.L1).

These responses arose in conversations with two learners who had creationist views prior to receiving instruction about evolution and who were affected by these views when they learned about evolution. Both learners had found evolution to be opposition to their religious beliefs but were able to understand it. The first learner still did not accept evolution after instruction, while the second learner accepted some parts of it. However, both learners felt it was 'good' to have evolution in the curriculum. Therefore, supporting the inclusion of evolution in the curriculum does not necessarily reflect acceptance of evolution; rather it has to do with a perception that evolutionary theory provides a view about the origin of species from perspectives not religious or cultural.

6.2.5.2 Do not support the inclusion of evolution in the curriculum

There were 11 learners (33.33% of those interviewed) who did not support the inclusion of evolution in the curriculum. Reasons given for this were that evolution: (1) has not been proven and it is not accepted by all people, (2) clashes with people's religious beliefs, and (3) makes people feel uncomfortable and unable to achieve understanding.

(a) Evolution has not been proven and has not been accepted by most people

Four of these eleven learners (12.12% of those interviewed) felt strongly that evolution was not proven and as such should not be in the curriculum. This is a clear misconception concerning evolution. To even give the reason that it is not accepted by most people because it is not proven also shows a misconception being used to as justification for the concept to be excluded from the curriculum. It could also be that the learners thought that, since evolution had not been accepted by everybody, it should then not be taught in schools where learners of Life Sciences had to learn about it. One such learner who questioned the acceptance of evolution and its inclusion in the curriculum had this to say:

> *I don't have a definite view I, think eh, eh, bringing about evolution … and there are many people who think it is not right, others think it is okay, and still bring it anyway. I, I don't actually support that. I, I think if there is something which is proven and is accepted by most of the people and convincing should be the one which South Africa should include in the curriculum…*(SCH.D.L2).

This quote could be interpreted as saying that this learner supports the teaching of evolution, but that would be the case if it was proven. But this quote does not mention evolution specifically. When questioned further during the interview, this learner shows that it was not evolution she was canvassing for, but topics such as 'agriculture' which according to her, are proven. The quote below shows another statement against evolution by this learner.

> *Yah, I don't believe that it's a valid scientific theory because it has many gaps within it …, it has many gaps to convince the person who is studying that actually evolution is taking place* (SCH.D.L2).

The second quote given for SCH.D.L2 highlights the misconception that evolution has many gaps, which she attributes to doubts that people have about evolution. It is mainly lack of understanding that makes people to have doubts.

Two learners did not support the inclusion in the content of evolution of Lamarck's theory (hypothesis) and others that were rejected.

> *Ok. Totally I disagree with that evolution of Lamarck but with that one of Charles Darwin, yah, it seems it is the true. But we want to see those skeletons that were… I mean those bones and skeletons with our own eyes, not being written on the books or drawings or at least they must provide a tour for us so that we can see* (SCH.D.L1).

> *I think the rejected theory … it has to be cut out…yes … it's very confusing when you get to learn something that is rejected* (SCH.D.L5).

Larmarck's theory is included in the curriculum to show the process of carrying out investigations in science, and how some theories are rejected while others are accepted, so that they understand why Charles Darwin's theory was accepted. This shows lack of understanding of the nature of science.

(b) Evolution is difficult and makes learners uncomfortable

One of the learners felt he just did not understand evolution and became bored and irritated when learning about it.

> *I think on my curriculum, it making me not to feel comfortable learning about evolution, eh, during this chapter of Life Sciences, of evolution, it, brings something that I don't understand most and when I think of it I just feel irritated … yah, yah. I just wish if I could…yah, I could skip this chapter* (SCH.D.L8).

The next response is from a learner who was not talking about herself but others, yet presupposes difficulty with learning evolution.

> *For others it (evolution) may pose problems, because they find it difficult to draw the line and understand it clearly that this thing is not something to be mixed with religion* (SCH.C.L3).

However, there is a perception from this learner that the difficulty of evolution rests with the fact that it clashes with religion. This is also implied in the responses to the next category.

(c) Evolution contradicts Christianity; yet evolution is in and Bible studies out

The other reason given by learner SCH.D.L8 was that evolution clashes with the religious beliefs of some of the learners, bringing to them confusion about what to believe.

> *It's not good, yah is not good because, this thing some, there are people here around here, who have beliefs and religions. There are different religions, and as a Christian I have to hold on what I believe on. And when the government put this thing of evolution some of, some of the people some of learners, they are, they have confusion, they are confused now that oh, what I'm doing is bad or is good. They don't know what to do or what to, what to believe on* (SCH.D.L8).

> *I think they shouldn't have included it….Ya 'cause it's against Christianity, it's against other religions* (SCH.E.L1).

Two learners felt that evolution was in conflict with their religion, and so should not be taught in schools. They expressed concern that 'Bible Study' (Bible Studies) was not in the curriculum and, instead, they had to study evolution which they felt was of no use or value in their lives. For instance, one of these learners expressed his problem in this manner:

> *I have a problem in that I don't have authority, but I have a problem ....I have a problem, why there is no longer a Bible study at schools but, er, the issue of evolutions, and we don't think, that issue of evolutions does not; it doesn't really applies in our lives for now* (SCH.E.L2).

The respondent said this with exasperation, showing that, if he had authority, he would not have allowed evolution to be taught in schools. According to him, scientists do not believe in spiritual things and, since they have not managed to prove that evolution was valid, they 'assumed that people come from another animal' – so evolution is 'just an assumption' by scientists. This learner shows two misconceptions: the first one is that not all scientists do not believe in spiritual things since theistic evolutionists believe in creation and accept evolution as well; the second misconception is that scientists have not managed to prove evolution, erroneous because scientists have observed and provided evidence for evolution. Evolution is therefore not 'an assumption' as this learner claims, and this is another sign of misconception from not being aware of evolution evidence.

This learner stated not wanting to learn evolution because it contradicted his religion, and his reason is based on erroneous ideas. He stated that he forced himself to learn about evolution in order to pass. If he had a choice, he stated, he would not study it. Despite the conflict he was experiencing, he was happy with their teacher for not forcing them to believe in evolution, and he wanted to study medicine or dentistry after secondary school. Nevertheless, he feels strongly that studying evolution should be optional.

The argument raised by these learners that evolution clashes with Christianity is a misconception. People classified as theistic evolutionists and Old Earth creationists (Scott, 1997, 2000) do not see a clash between evolution and their religion.

On the issue of schools not offering Bible Studies, another learner from the same school said the following:

> *Since it's in the curriculum, they cancelled Biblical studies, but then they put evolution. So I think that if only they put both of them, cause evolution is in our curriculum studies, we should study that, put our Christianity aside and whatsoever. So the fact that they cancelled Biblical studies and during L.O. (Life Orientation) period we used to do Biblical studies but then evolution conflicted with it. I think that's the main reason they cancelled it* (SCH.E.L4).

What the learner has said implies a perception that evolution took the place of Bible Studies, or that Bible Studies was removed from the curriculum because there was a conflict between the Christian Bible and evolution. The suggestion that Life Orientation took the place of

Bible Studies shows that the perceived clash with the Bible was not the reason for removal of Bible Studies. This is again a misinformed perception and perhaps it should be made clear to the learners why certain curricular decisions are made. Also, it is important that the misconceptions they hold are dealt with so that they do not make decisions based on them.

As shown above, learner SCH.E.L4 felt that evolution should be taught side by side with religion at school. Perhaps this suggests making it optional, so that one may choose between the two. Suggestions from two other learners from the same school clearly indicated that evolution should be an optional subject or topic:

> *Ah, I think er, evolution should be, maybe optional so learners who, who want to study, maybe those who are not Christian, should study, choose to study, maybe, er, they are two topics you could, you can choose from* (SCH.E.L5).

> *Ya, I think if the, the curriculum can make that it is optional like when somebody is in science and maths, and science and accounting and separate them, therefore some, some other people will go ahead for bible study and some other people will go ahead for evolution* (SCH.E.L2).

(d) Evolution has no use in my life

As already stated, one of the learners against evolution felt that evolution had no use in his life. Similar sentiments were expressed by another learner in this manner:

> *Personally I don't think evolution should be in the high school syllabus, Grade 12. It should be maybe in university for people who would like to go further into studying about evolution. but then 'cause now ... I don't see any use for it ... For myself, I don't see why evolution in the Life Sciences curriculum* (SCH.C.L1).

The last point centres on the issue of relevance. These learners do not wish to study about evolution because they do not find it of any use in their lives.

6.2.6 Learners' positions regarding evolutionary theory

Learners were asked the question, 'Are you for or against evolution?'. The purpose of this question was to find out if learners accepted or did not accept the concept evolution after they had studied it. Although the two possible responses expected were 'for evolution' and 'against evolution', some learners indicated being neutral or being caught in the middle between accepting and rejecting it.

Thus four positions taken by learners with regard to evolution were identified in this study: 'for evolution', 'compromise', 'caught in the middle' and 'against evolution'. These positions

can be related to Dagher and BouJaoude's (1997) four positions: for *evolution*, *compromise*, *neutral* and *against evolution*. As noted, the difference is in one position on either this study or Dagher and BouJaoude's study, which is in 'caught in the middle' and 'neutral'.

Fourteen (42.42%) learners stated that they were for evolution, but three of them seemed to be uncertain when they answered the question for the first time. There were fourteen (42.42%) against evolution, while five (15.15%) found themselves caught in the middle.

6.2.6.1 For evolution

For the eleven learners who stated being for evolution right away when the question was asked, some were not really 100% for it. One of these learners gave evolution 95% and said the remaining 5% was for his religious beliefs.

> *Yah, based on my religious I still have like, some – nevertheless I think that, yah, 95% for evolution* (SCH.A.L7).

6.2.6.2 Compromise

The three learners in this category stated they were 'for evolution', but when probed did not actually give a straight answer when asked if they were 'for' or 'against' evolution. They gave a response such as 'I am not against it', and only when they were asked to be specific did they say they were for evolution. It seems that these learners were in a position which they could describe as being 'for evolution', yet they were held back and could not commit fully to the idea, which suggests that they were in a 'compromising' position.

6.2.6.3 Caught in the middle

Five learners reported being in the middle, implying that they accepted some parts of evolutionary theory but rejected others. The response here was from a learner who could really not place herself in either camp:

> *I believe that I came from the same ancestor. I believe that … aa … I can't really say that I am against it because … I can't really say I am against it, neither say I am for* (SCH.A.L1).

The quote below is from a learner who was experiencing conflict and felt she had to choose between evolution and biblical creation, but could not decide which one or where to go:

> *Not really because as I said, I am like neutral right now, I am stuck in between because it's like evolution is pulling me one side and creation is pulling me the other side* (SCH.C.L1).

She indicated that, after studying evolution, she did not know what to believe. For her, evolution had some unanswered questions. Also, with creation, she had questions that she could not answer. Therefore, both evolution and biblical creation were problematic for her, yet she was a religious person.

> *Right now I can say I am neutral because I don't know where to stand anymore. As I said there are unanswered questions about creation, right. Like you come from a Supreme Being who is God, but then there are a lot of people who like asking questions like 'where does God come from?', 'who created God, because he can't have just be there by Himself'. And then there are such questions don't know where to stand anymore because creation says we all come from God and stuff and stuff. And then in evolution like biologically says the earth was once a big ball of fire and then it started like, in evolution, there are some questions that also don't tell you, right. But personally right now I burning off and then the world was created and all of that, so...* (SCH.C.L1).

One of the learners stated which parts she agreed with and which ones she did not agree with:

> *I don't believe the one that says we came from a common ancestor with apes, I don't believe that, but I believe the one, the speciation part. That one it is, it is true, that one is true, I believe that* (SCH.E.L4).

Generally, learners seemed to have made up their minds about what they believed in. Even for the group that was 'caught in the middle', they were clear that they wanted to keep their religious beliefs, but at the same time they accepted evolution, or part of it, as valid. Learners were not asked to give reasons for their position. However, two of them gave reasons, one for and one against. The learner who was against evolution said he was totally against –

> *... because, sometimes there's a someone who said that, sometimes ma.., er, majority is better, er, majority sometimes it can, can mean that all people are fools, as a, ya, so if I know, because if according to my religion sometime, I believe in Christianity, and there many people who are Muslim there and sometime, so I can't say that, ok because many peoples in my class they are not Christian therefore I have to, I have to turn or to change my religion. Therefore I have to stick to my religion, ya* (SCH.E.L2).

What emerges from SCH.E.L2's response is perhaps the dilemma that this question subjected learners to, requiring them to make a choice 'for' or 'against' evolution. It would seem that learners, or some of them, felt that this choice was between evolution and religion, whereby choosing 'for' evolution meant abandoning their religions or religious beliefs. Therefore, to show that they still maintain their religious beliefs, they would choose 'against' evolution. One gets a similar impression from SCH.A.L7's response, cited above, that even though he opted 'for' evolution, he had to leave somethingfor his religion, i.e. 5% , and give evolution

95%. This question could also have given varying messages to the learners, and their answers could have been given from different viewpoints.

6.2.6.4 Against evolution

As stated above, fourteen learners stated that they were against evolution. All these learners had religious beliefs. As would be expected, some of these learners had difficulty learning about evolution, as they experienced confusion. However, what is interesting is that, contrary to expectation, some of these learners did enjoy studying evolution. Another interesting observation was from a learner who indicated that, given a choice to learn or not learn about evolution, he would choose it because he wanted to have more knowledge:

> *I'll be against, I am against evolution but I will still study to know more information* (SCH.C.L2).

6.2.7 Learners' thoughts about performance on evolution questions

In order to find out how confident learners felt about their understanding of evolution, they were asked the question, 'How do you think you will perform in a question on evolution in examinations?' If they said they would perform well, that would be taken as a high level of confidence; but if they said the opposite then it would mean they doubted their understanding of evolution. As it turned out, 29 of the learners (87.88%) felt that they would perform well in the topic, even those who did not accept evolution felt that they had studied it sufficiently to enable them to do well in it.

There was one learner who said that her performance was going to be 'about half-way', the reason being that she thought she was "*maybe ... halfway coz I don't strongly believe in evolution*" (SCH.C.L2). Despite having found evolution to have evidence supporting it, this learner felt that evolution was opposing her religion, Chrisitianity, and if she 'was not strong in faith', she was "*going to lose hope (faith) in God and believe in evolution*" (*ibid*.). This learner was so affected by evolution that she reported "*... and we are being taught in class, sometimes I would just feel like ...eish ... what can I say, they are not respecting my God. ... they are rude to my God*" (*ibid*.). However, later in the interview she indicated she would still learn evolution in future.

> *Because, most of the things we didn't know them, but as soon as we started to learn evolution, we started to learn more things, more information, and then in some other way it's just a test if, to test your faith that if you are strong, if you strongly believe in*

> *your God or you are just there just to … to increase the number of people going to church, or some things* (SCH.C.L2).

In other words, despite not 'believing in evolution', she would still learn about it in order to know more.

There was another learner who was not sure about how he would perform, and indicated lack of understanding as the reason for saying that. The lack of understanding was due to lack of interest in learn about evolution, as is indicated in this dialogue:

> SCH.D.L8*: I can't predict that but, I have to, I have to tell you, how will I perform but I think I will perform because this thing I do study about it but I don't understand. Ee I don't understand but … … because I don't, I'm not even interested in it…*
>
> Interviewer*: You are not even interested in it! … but if you were interested do you think, do you think you would understand it?*
>
> SCH.D.L8*: I would understand, I would master it.*

This shows that the learner's attitude arose from lack of interest on his part and, as he said himself that was affecting his learning. The same learner felt 'bored and irritated' when learning about evolution, was against evolution being in the curriculum - he had found himself having to learn evolution because it was in the curriculum whereas he would have skipped it if he had a choice, and his creationist beliefs about the origin of species had not changed even after studying evolution. What was interesting about this learner was that he was planning to study mining engineering, which is science-related, an indication that he was not against science *per se*. He was merely against evolution, as he categorically stated that evolution was not valid, and followed that up by saying the following:

> *This thing of, of evolution, you know scientific things and these theories, they are not real for my sake but we have to learn it in order to meet our passion. Mining is my passion and I know that I love mining engineering so I will come across with these theories in science, in doing science, but to meet my passion I have to go through these theories and what will happen next I don't know* (SCH.D.L8).

Although he was opposed to learning about evolution, he was still interested in learning other sciences, although he did not feel too comfortable with scientific theories.

6.2.8 Learners' future plans

The purpose of asking learners the question, 'What are your future plans?', was to find out if their future aspirations involved a science-related career or not. This would provide an insight into whether the learners regarded science to be of use to them. It was expected that learners

who did not experience any conflict when studying evolution would not have problems with choosing a science-related career. This does not imply, however, that learners who choose a non-science career are against evolution or against science. However, if learners chose a science-related field when they are not happy learning about evolution, then it could be said that whatever negative issues they had were not related to science as a discipline, but to evolutionary theory in particular. It cannot be concluded though, that learners who experienced difficulty in learning about evolution, and then choose a non-scientific career, do so because they are negative towards science or towards evolution. Besides science itself, there are other factors, some of them related to schools, socio-economic environment, or family background, which determine learner career choices.

Although some learners interviewed were still undecided about their career aspirations, twenty-two of those interviewed (66.67%) were planning a science-related career, or were going to study something related to science, including biology (Life Sciences) (2). Some of the scientific-related careers were genetics (2), microbiology (1), geology (2), biotechnology (2), medicine (5), and various engineering fields (5), veterinary science (1) and actuarial science (2). Other learners who responded to this question were either undecided (6) or wanted to study something that was not science-related. The five learners who were planning to enter a field not related to science gave the reason for that as not wanting to study science after secondary school. Only one of these learners was unsure of his performance in the examination on a question about evolution, while the others stated they were going to perform well. This indicates that the choice of a career may not necessarily be related to performance.

6.2.9 Summary of findings from learners' responses

The findings from the learner interviews generated more in-depth data which revealed some insights not found in the questions. For instance, to interpret some of the observations reflected in the quantitative data from the questionnaires, learners were interviewed to understand their pre-learning ideas about evolution and their perceptions about the effect of those pre-learning ideas during the learning of evolution.

More than ninety percent (93.68%) of the sampled learners declared being Christian in the biographical data, and 90.90% of those interviewed had pre-learning creationist views about

origin of species based on Christianity. In other words, these learners believed that species, including animals and humans, were created by God or a Supreme Being.

Responding to how their prior ideas affected their learning, learners gave a range of responses suggesting a negative influence, a positive influence or no influence. Furthermore, the negative influences could be sub-divided into two: 'evolution difficult to learn' and 'felt forced to learn'. With regard to the learners' views about evolution since learning it, five themes were identified from the responses, which related 'unchanged religious views', 'unchanged scientific views', 'mixed religious and scientific views', 'change from religious to scientific views' and 'confusion'.

As to learners' feelings during the learning of evolution, four themes emerged from the responses. These were 'good, comfortable, enjoyed learning', 'uncomfortable', 'confusion' and 'forced to study'. Learners' opinions about the inclusion of evolution in the curriculum were categorised into two main themes: 'support' (66.67%) and 'no support' (33.33%), depending whether the response supported the inclusion or it did not. Reasons for 'no support' included that the notion of evolution is 'not valid', it 'is difficult', 'contradicts Christianity' or it has 'no use in my life'. Reasons for support included acknowledging that teaching about evolution in schools is *good* 'for those who believe in it', because 'it teaches people about where they come from', and 'so that people can accept evolution'.

Learners were also asked to state their position regarding evolution by choosing if they were 'for' or 'against' evolution. Fourteen (42.42%) were against, another fourteen (42.42%) were for with eleven (33.33%) giving the answer right away, while three (10.00%) of them seemed to be in a compromise position, and five (15.15%) in the middle. Regarding how they thought they would perform, twenty-nine (87.88%) felt strongly that they were going to perform very well, one was not sure and one felt that the performance would be 'halfway'. The last interview question asked learners what their future plans were. Twenty-two (66.67%) had chosen science-related or science-based careers, while one was not sure and the rest identified a non-science related field.

Generally, the results and findings suggest that, although most of the learners claimed to be religious and believe that organisms were created by God, most of them were motivated to learn about evolution. This motivation stemmed from various reasons, such as wanting to know more about evolution, or learning it well so that they could pass examinations.

Whatever the cause of the motivation, it does not seem as if the learners' religious beliefs were impeding their learning about evolution. Instead, these beliefs were in some cases a source of motivation for learners, as they could compare what they already knew and believed in with the seemingly contradictory evolutionary theory. For those learners who felt conflicted, learning about evolution involved separating their beliefs from what they were learning, a strategy that enabled them to focus on the scientific aspects of the theory and even accept it as a valid scientific theory, while still not believing in it.

The findings from open-ended questions in the questionnaires and from the interviews show that learners had beliefs ranging from religious to naturalist. Similar findings were reported elsewhere in South Africa, for students at a university. For instance, a study by Lawrenz and Gray (1995, p. 566) found that students at the University of the Western Cape showed beliefs on a continuum between naturalism and religion. In a similar way, the learners in this study displayed a range of worldviews, although their responses showed more of the religious worldview than a naturalist one. In most cases learners referred to their Christian beliefs when responding to questions and when explaining their responses. This could be an indication that their Christian beliefs served as reference point for them to make claims about what they believed regarding evolution. Learners in this study still managed to learn about evolution despite most of them having creationist beliefs. This means that their learning about evolution was not negatively influenced by their religious disposition, which is what other studies elsewhere have found. Some of those learners who felt that there was a conflict between their beliefs and evolutionary theory stated that they separated their beliefs from the theory in order to be open to learning. These learners therefore apparently felt that their religious beliefs were not a hindrance to their learning of evolution.

6.3 FINDINGS FROM TEACHERS

The findings presented in this section were from the open-ended part of the questionnaire (Appendix 3) and from the teachers' interview schedule (see Appendix 4). In this presentation of the findings, the purpose of asking each question is first given, then the responses to the question are presented.

6.3.1 Open-ended questions from the questionnaire

Section A had three open-ended questions to which teachers responded in writing. The analysis of the data involved categorizing responses and identifying emerging themes from

these categorizations. Table 6.1 presents a summary of the analysis, including the identified themes. The three open-ended questions are discussed thereafter.

6.3.1.1 Reaction on hearing about evolution for the first time

Teachers were asked to describe their reaction when they first heard about evolution. This question was meant to find out the participants' main reaction when they first heard about evolution. The expectation was that the responses, in addition to giving the reaction, would also reveal the emotions that the teachers felt. Although it was expected that the content of the evolution message would be responsible for arousing the reaction, there are other factors that can give rise to similar emotions.

In their responses, teachers described different ways in which they reacted when they first heard about evolution. The themes that emerged from an analysis of these reactions were 'emotion' and 'difficulty'. Some of the responses indicated an emotion felt by the respondent. For instance, David expressed "*feeling sad and shocked*" and James was "*astonished to hear that we have evolved….*" While both responses show 'emotions', the first one indicates a reaction to perception of threat or attack, while the second is more one of surprise or bewilderment, which may or may not reflect an emotion as strong as that in the first case. Responses from two other teachers reflected some 'difficulty' with the theory. Tapfu found the theory of evolution "*difficult to understand*" and Thabo found it "*very challenging*", which could mean that the theory was so complex that they were not able to conceptualize the meaning of it. The fifth and last respondent, Mashudu, was "*confused and even denied the theory*". Confusion could signal an inability to understand and some bewilderment, possibly to the extent of panic, where the respondent even denied the theory, showing that she did not want to have anything to do with evolution. All the teachers were Christian at the time when they first heard about evolution, which implies they already had religious beliefs. From their religious perspective, all species have been created in their present form by God, and hearing about evolution was for them hearing about a theory which opposed their beliefs. As Tapfu specifically said, having a Christian background was what led to his difficulty in understanding about evolution.

In summary, the responses to this question reflected various emotions from the teachers, namely: sadness and shock by David, astonishment by James, surprise and confusion by Mashudu. There were also perceptions that evolution was going to be challenging by Thabo

and difficult to understand by Tapfu. It would thus seem that their reaction to evolution is affected by teachers' prior beliefs and knowledge.

While admitting that the teachers' religious disposition influenced their reactions when they heard about evolution, we cannot exclude the contribution of other factors toward such reactions. Such factors could include, for example, the person from whom they heard about evolution, the context within which they heard about it, how it was communicated, and the reasons behind their being told about it. For instance, two teachers, David and James, aged 53 and 49 respectively at the time of data collection, received their education up to secondary level during the apartheid era in South Africa. The two teachers said they received the message that black people evolved from baboons or apes at a time when black people were regarded as inferior to other races in South Africa. The idea that people evolved from apes or baboons is a misconception. These teachers, however, showed different reactions to that earlier explanation of human ancestry. For instance, David, who was 'saddened and shocked' when first hearing about evolution, was told that human beings evolved from baboons, and he could not imagine himself being likened to a baboon. At the time he thought this referred to him as a black person, because such were looked down upon in South Africa at that time. To him, accepting evolution would mean succumbing to subjugation and accepting the status of a baboon. He obviously did not understand the correct meaning of evolution, resulting from an erroneous message having been communicated to him. The context of this wrong message was South Africa's historical colonial domination. To David, who has embraced Christianity and believes in one supreme God who created everything and all the different people, there is a conflict between this version of creation and that represented by evolution.

On the other hand James, who is both a teacher and a pastor in a Christian church and sees no conflict between evolution and the biblical story of creation, asserts that the idea of divine creation did not come to the Venda people with Christianity. Rather, the Venda already had their own god – named *Ngwale* – who they regarded as being responsible for the creation of all species on earth. He further stated that, at the time when he learned about creation, there existed the belief that black people evolved from apes or that apes were part of the ancestry of the black people. He thought that these beliefs could have come with apartheid ideologies, in which black people were regarded as less than human and closer to apes, and that these beliefs could have been passed to the Blacks in such a way that they believed in them as well – or rather used those statements as a mockery of apartheid. James found evolution

interesting to teach especially because learners also found it exciting as they mingled their own cultural or religious beliefs with knowledge about evolution.

What emerges from this is that lack of understanding, and the socio-political situation of the time when these two teachers learned about creation and evolution, could have caused their first reaction. If evolution was well understood at the time, then it would have been realized that it is all species that evolve, not only humans, and not only a certain group of people. David's response therefore reflects a psychological perspective and not so much the mechanistic view of what evolution is, while James seems to have reconciled both the mechanistic and spiritual views and hence the harmonious view that he holds.

6.3.1.2 Main feeling when having to teach evolution

In this question teachers were asked to describe their feelings whenever they have to teach evolution. The expectation was that their answers would reveal not only how teachers felt about teaching evolution but also their attitudes toward it. Also, it would point to whether teachers regarded evolution as a controversial topic to teach and hence give an insight into the teaching strategies they would use to deal with the controversy. For instance, if a teacher experiences a conflict between his beliefs and evolution, he/she might not teach the same way as when experiencing no conflict, or teach in a different way to a teacher who does not experience any conflict. That is, if a teacher is 'conflicted' by evolution, he/she might teach differently from the one who is a 'scientist' (see Griffith & Brem, 2004), by either not allowing discussion of alternative views in the class or teaching only the scientific aspects. It is assumed that, at the point when teachers first heard about evolution, they were consciously aware of how they felt, as by then they would have developed self-consciousness (see Roth, 2007), enabling them to be aware of and know their emotions.

When responding to this question, David reported "*feeling relieved from fear*". This response could not be analysed in terms of what was being looked for. However, it could indicate that this respondent had fear when he was supposed to teach evolution, and had to find ways to relieve himself of that fear. In a response to this question, James is telling himself "*not to be stressed because of*" his beliefs, but rather to be "objective" and focus on facts. He further tells himself that he would "*allay the fears*" of learners who are religious, an indication that he could be anticipating that religious learners will have problems learning about evolution. A third teacher, Tapfu, expressed "*mixed feelings*" because "*evolution is interesting to teach*"

yet brings challenges to learners who have religious beliefs. For Mashudu, it was overwhelming and challenging because the learners "*bring such diverse views*". Thabo became "*curious*" as to how learners would take and "*react to the concept*" of evolution.

In short, teachers' feelings include relief from fear, some stress about what they are going to teach, mixed feelings, anticipation of challenges from learners who have religious beliefs, anticipation of conflict with teacher's own beliefs, and curiosity about the effect of evolution on learners.

What is common to these responses is what the teachers thought about the possible reaction from the learners when they heard about evolution, a reaction which would be related to their religious beliefs. Not much was said pertaining to a conceptual understanding of evolution, i.e. whether or not learners would meet any cognitive challenges when learning about evolution. Evolution is a scientific concept which is based on evidence from observation of phenomena. However, as these teachers demonstrated by their responses, other concepts arise when they are to teach evolution, concepts which are not based on a naturalistic way of looking at the topic but are based rather on other perspectives, such as religion. The responses do not necessarily give one an insight into the teachers' worldviews *per se*, but into some of the factors that built up to their styles of teaching.

6.3.1.3 Teachers' comments about evolution

The last question required teachers to give their single most important comment about 'the theory of evolution'. The purpose of this question was to find out the strongest feelings of the teachers at the time of the study, which took place a number of years after they had first heard about evolution. This was a very open question, and teachers could have responded from varying perspectives. However, the expectation was that the responses would give an insight into the teachers' worldviews. By commenting on evolution, the respondents would be communicating in a way how they view evolution, in other words, how they relate to the concept.

A response to this question given by David made no reference at all to evolution, stating simply that "*All organisms were created by God*". This could mean that this respondent is signalling that he does not accept evolution, and does not even want to acknowledge its existence. Responses from James and Tapfu indicated that evolution is "*challenging*", but different reasons were given for this. The reason for the 'challenging evolution' given by

James was that there are "*missing links between different species*", and the challenge is how one explains these missing links when explaining evolution. James also commented that "*evolution does not explain the origin of the gaseous spheres*". The second comment relating to the *'challenging evolution'* came from Tapfu, who found that most of the content or subject matter on evolution "*revolves around ancient aspects*" which he says most learners and people find hard to understand. Mashudu reported that "*'Trends of human evolution' is not easy to teach*". Thabo's comment also relates to human evolution, which he says is controversial even though the other parts of evolutionary theory make sense. The controversy relates to the fact "*that humans share a common ancestor with apes*" which he says "*does not make sense to many people*". Thabo, however, found that other things about evolution made sense and gave the examples of Natural Selection and Extinction, which he says do happen in nature.

In summary, the comments indicate that evolution poses challenges for the following perceived reasons: the theory has missing links, the content is ancient in the sense that it refers to events in the past, human evolution in particular is controversial and not easy to teach, and teachers do not know how to explain the issues raised. One of the teachers, David, spoke only of creation in his comment.

As emerged from their responses, four teachers found something about evolution that challenged them with respect to their teaching. In his response, David made no reference at all to evolution, and it can be assumed that this was a sign that he had some misgivings about evolution, even to the point of denying it. He and the other three teachers taught the topic despite their reservations about it, and this can be an indication of compliance to teach what is prescribed in curricula. Indeed one of the teachers, David, pointed out in a later interview that in class one is "*supposed to teach*", so this was probably how these teachers felt. James, on the other, did not experience any conflict between his beliefs and evolution. He was observed to use scriptural material to explain evolution or illustrate to the learners that the evolution supports God's creation. How they managed the situation in class was determined from classroom observations and interviews. Findings from the observations and interviews are presented in the following sections, and the responses to these three questions and the issues that emerged from those responses are presented in Table 6.1. The questions head the columns in the table while the teachers' pseudonyms are on the y-axis and lead the rows. The text inside the middle boxes represents the teachers' responses.

Added to the y-axis is 'emerging themes', which indicates the issues that have emerged from the responses to each question. The themes identified are acceptance, content, human evolution, controversy/conflict, epistemological beliefs, self-efficacy beliefs and personal beliefs.

(1) *Acceptance*, as the term suggests, denotes issues of accepting or denying evolution.

(2) *Content* relates, in this study, to the content of evolutionary theory that has to be taught and learned. Specifically, the teachers in the study mentioned the issues of 'time' and 'content deficiency'. Time can be tied to the historical aspect of evolution while 'content deficiency' relates particularly to availability of evolution evidence and gaps existing in the theory. Among the beliefs that teachers possess as professionals are content-specific beliefs which reflect a teacher's epistemological conception of the field to be taught (see Kagan, 1992).

(3) *Controversy or conflict* relates to the controversy around evolution which brings about the conflict or discord between evolution and other ways of knowing like religion. Thabo stated that the theory of evolution is controversial and not everyone accepts it; controversy is placed with 'conflict' since it is the controversy that brings about the conflict between the scientific knowledge of evolution and other ways of knowing. Scientific knowledge is objective and empirically based, whereas religious knowledge is subjective and based mainly on faith. The conflict or discord between science and religion arises when these two ways of knowing 'compete' in terms of which one provides 'true' knowledge.

(4) *Human evolution*, though part of the content, is standing alone as a theme in this case because it is usually the major source of conflict or controversy as some religious people deny that humans evolved but that they were created.

(5) *Epistemological beliefs* relate to beliefs about the nature of knowledge and learning. This nature of knowing is usually viewed from two perspectives: objectivism and subjectivism. Depending on a teacher's disposition, teaching may emphasise one form of knowledge and employ strategies that will promote it in the learning process.

(6) *Self-efficacy beliefs* relate to perception of teachers about their self-worth in relation to influencing learning and its outcomes (see Bandura, 2001; Kagan, 1992; Settlage *et al*., 2009).

(7) *Personal beliefs* include any predispositions or assumptions about knowledge and the nature of that knowledge. These personal beliefs may stem from one's religion, whereupon they become religious beliefs. Alternatively, personal beliefs may be informed by one's culture or any other values espoused by the holder.

Table 6.1: Summary of findings from three open-ended questions to teachers

Question / Teacher	Main reaction when first heard of evolution	Main feeling when you have to teach	Comment about evolution
David	I was feeling sad and **shocked** (***emotions - personal***)	I am **relieved from fear** (***personal***)	All living organisms are created by God. (***detached - conflict***) (***Acceptance***)
James	**Astonished** to hear that we have evolved from small micro-organisms and eventually evolution led to the formation of human beings (***personal beliefs***) (***acceptance***)	One should **not be stressed (because of) his belief**, but be **objective** to the facts and observations of other scientists. I **allay fears** of religious beliefs amongst the learners (***personal to learners***)	The challenges are the **missing link between different species** and how one explains them. Evolution does not explain the origin of origin of gaseous spheres (***content - deficiency***) (***epistemological beliefs***)
Tapfu	Having a Christian background, **it was difficult for me to understand it** and more of an unrealistic scientific idea. However, I finally grasped it, with a passage of time. In a nutshell, I was surprised. (***personal beliefs***)	The **feelings are mixed**. Evolution content is **interesting to teach** even though you face challenges from learners who may fail to grasp the content due to their **religious backgrounds**. (***personal to learners***) (***epistemological beliefs***)	Most of the content or subject matter on evolution revolves around **ancient** aspects which makes it a **challenge to most learners** and people at large to understand. (***content - time***) (***epistemological beliefs***)
Mashudu	It was very **challenging** at that time. I tried by all means to explain the way I would handle the topic, making learners understand what evolution is. (***epistemological beliefs***) ***(self-efficacy)***	It's overwhelming, hearing so many views that the learners can bring forth. And it is so very **challenging** because if you are not sensitive your views and your belief can interfere with your lesson activity (***self-efficacy***) (***personal to learners***)	Theory of evolution is so very **challenging** the trend of **human evolution** is **not easy to teach**. (***human evolution***) (***epistemological beliefs***)
Thabo	I was a bit confused and denied the theory even though I didn't deny it verbally. The reason being that we grew up knowing a different story with regard to the formation of the world and all those other things (***personal beliefs***) (***acceptance***)	I become very curious as to how learners will take evolution and even as to how they will react to the concept. (***personal to learners***) (***acceptance***) (***epistemological beliefs***)	There are other things which make sense about evolution .e.g. natural selection, extinctions, etc. which happen in nature. Some of it tends to be **controversial e.g. human evolution** (***human evolution***) (***controversy***) (***acceptance***)
Emerging themes	• ***Acceptance: teachers*** • ***Epistemological beliefs: teachers*** • ***Personal beliefs: teachers*** • ***Self-efficacy***	• ***Acceptance: learners*** • ***Epistemological beliefs: teachers and learners*** • ***Personal beliefs: learners*** • ***Self-efficacy***	• ***Acceptance: teachers*** • ***Content: time, deficiency*** • ***Controversy; conflict*** • ***Epistemological beliefs: teachers*** • ***Self-efficacy*** • ***Human evolution***

6.3.2 Teachers' oral interviews

There were seventeen questions in the first interview which were the same for all teachers. The second interview was used to clarify issues from the first interview and other data, and to add any extra information required to answer the research questions. Findings are presented and discussed in the next section. As with other sections, the purpose of each question is given prior to presenting the findings.

6.3.2.1 Teachers' understanding of evolution

The first interview question asked was: 'What do you understand about evolution?' The purpose was to find how much understanding of evolution teachers had at the time of the study. Although the responses varied from one respondent to another, there was generally a reference to evolution being (a study of) "*change of organisms*" over time due to environmental factors, and organisms adapting to environmental changes. One response said that evolution was a link between past and present, a definition close to the one given in the textbook prescribed for learners at his school:

> *I think – some of the things that we are having – eh – they are coming from the past, many things we are having nowadays, they are coming from the past – ah … or else one would rather say that there is a link between the past and the present* (David, 2012.02.16).

Other responses were:

> *I do understand … what I understand about evolution is that, … there is a process in which characteristics of living organisms are changing…really, there is change of characteristics of the living organisms* (Mashudu, 2012.04.12).

> *Evolution is the formation of life from its origin. And … it has started off from simpler substances such as a single cell which evolve by multiplying and becoming multicellular organism. Those organisms change over time due to the environmental factors which shape them. Those which cannot survive they died. And, until today, so that they can cope with the environment, they must be able to adapt well. So this process takes many millions of years, until we see the different species today* (James, 2012.03.19).

The points that emerged from these responses therefore, were that evolution involved "*the study of trends of main development*" (Tapfu, 2012, 03.14), changes in the characteristics of living organisms, "*a change with regard to the Earth itself and also the organisms which are found on Earth*" (Thabo, 2012.05.16), a link between the past and the present, development and change of organisms from simple to complex, and the ability to adapt to changing environmental conditions.

Some of the responses are indicative of misconceptions. For instance, responses that "organisms change" and "organisms change from simple to complex" imply that individual organisms

undergo changes and not so much the species. This could be an example where the process of evolution is viewed as deterministic where organisms aspire to change and adapt to changing environmental conditions. Similarly, stating that it is 'characteristics changing' shows that there is not enough understanding. The responses also indicate cause-and-effect,

6.3.2.2 Teachers' sources of evolution knowledge

The second interview request was: 'Please indicate the sources you use to enrich your knowledge about evolution'. The purpose was to find out what sources teachers preferred as well as to provide an insight into what was available to them. The teachers mentioned resources which included books, internet and television programmes and other digital material like videos and compact discs. The books included prescribed textbooks for learners, and in all five of the sampled schools two books stood out as the main preference. The reasons for the preference were the ease with which the book could be read, the clarity of the content and, most importantly for the teachers, the alignment to the final examinations of the book's content and its presentation.

6.3.2.3 Teachers' beliefs about the age of the earth.

The third request was: 'Please describe what you believe regarding the age of the earth'. The expectation was that the responses would indicate what the teachers knew about the age of the earth and also provide an insight into their worldviews – for instance, which worldview in Scott's (2000) typology. For all the teachers the age of the earth is 4.5 billion years old or even more. However, one of them had doubts and added that it could be 100,000 years instead. There was another response where the teacher indicated not believing in evolution, but saying so because that is what they are made to believe, that it is 4.5 billion years or even 50 billion years. Therefore, even though all the teachers had creationist beliefs, none of them could be described as Young-Earth Creationists or literalists since all of them believed the earth was far more than 10,000 years old, showing aspects of Old-Age Creationism.

6.3.2.4 Teachers' beliefs about the origin of species on the earth

The fourth request was: 'Please describe what you believe regarding the origin of species on the earth'. The purpose of this request was to find out if the teachers' views regarding the origin of species were creationist, evolutionist, or fell somewhere between the two extremes. This would give an insight into their worldviews.

In responding to the question, all five teachers stated that they believed that species were created by God. They said they had that belief because they were Christian. One of them, David, even

supported his answer by quoting from the Bible. He stated that God said "*let it be*" and animals were found in water and different places the way they were created. He added that God created a human being and then put the living spirit in him. Similarly, Thabo categorically stated that species originated in the Garden of Eden as is outlined in Book of Genesis:

> *You see as a Christian, as I said, I am a protestant. I believe that what do exist, when you talk about the biodiversity that are found on earth … that has been created by the Almighty. Ummm, it's either by the word as you heard it from the bible… when God said "let it be" either animals in the water, you find animals are there, or either through the way how God has created man* (David, 2012.02.16).

> *I believe that the species originated in the Garden of Eden. Or humans or all people were created by God* (Thabo, 2012.05.16).

Mashudu supports her creationist beliefs, stating that species were created as they are, "*so … if you can think about the belief if you are Christian or believe that God created everything not in … which means individually he created everything individually. If he created human being, he created a human being and he created an ape*" (Mashudu, 2012.14.12).

James believes that all species were created, but also goes further by bringing evolution into his response, comparing evolution to creation and showing that the two synchronize. His answer shows creationist as well as naturalist beliefs, and it does not seem as though he finds any conflict between the scientific theory of evolution and his religious beliefs. James would be classified as a theistic evolutionist using (Scott, 2000). Although he believes in creation, he also recognizes evolution.

> *My belief is that … eh … everything was created by God. That is my belief. And then according to the scriptures we read, it goes well with evolution when we compare the two, because it started with the earth itself, with no living thing in it, and then comes the day and night, all the firmament was created. And then comes living things which does not include human beings. Plants and animals were created, and then eventually, human beings, after everything was created, the human being was also created* (James, 2012.03.19).

However, Tapfu, who also mentions evolution in his response, states that evolution is not a match to creation.

> *Umm, with my background of religion – I strongly believe that the species were actually created by God. And the aspect of evolution even though it's there as a scientific theory – it cannot match that one of religion* (Tapfu, 2012.03.14).

The beliefs of the five teachers are thus creationist. Three of the teachers, Thabo, David and Mashudu, did not mention evolution in their responses, implying that, for them, the species were created and nothing else was involved in their origin. The other two teachers, James and Tapfu, mention both evolution and religion in their responses. Interestingly, those two responses give an

insight into the kind of relationship both teachers perceive between science (evolution) and religion. James recognizes that evolution also explains the origin of species, and mentions that it supports creation. But for Tapfu, evolution 'is no match for religion'. For James, evolution and creation support one another implying a complementary "cousinly" (Staver, 2010) relationship. This is indicative of Barbour's (2000) 'dialogue' relationship. On the other hand, Tapfu's statement that evolution is 'no match' for creation suggests that evolution, a scientific concept, is in 'competition' with religion in which, according to Tapfu, religion is the winner. This clearly demonstrates Barbour's (2000) 'conflict' relationship. That three of the teachers did not mention evolution or science in their responses implies a perception of discord between science and religion in terms of which one of the two gives a true or truer explanation of reality for the world. Using only one of the two explanations suggests that the one chosen gives the truer, if not the only true, explanation.

6.3.2.5 Teachers' perceptions about evolution as a scientific theory

The fifth question for the teachers was, 'What do you think of evolution as a scientific theory?' The expectation was that the responses would give an insight into the teachers' positions regarding the validity of the theory of evolution, and how reliable it is as a true explanation of the origin, existence and diversity of organisms on earth. The teachers' responses varied, in that some stated that evolution was valid, or not valid as evidence for it was insufficient.

(a) Evolution is not a valid scientific theory

The teacher who found evolution hard to accept as a valid scientific theory was David. His main reason was that there was not enough evidence to support evolution.

> *Um, it's hard to believe that, that it is a valid theory, because you see when you try to check some of evidence of evolution, there are lots of gaps in between. Even though some of the things one happen to believe, that you know, this is that way and that way, but realizing that there are a lot of gaps in between, you cannot link point one and point two exactly. And some of the things you know, they are not facts…. It's hard to believe that* (David, 2012.02.16).

(b) Mixed feelings about the validity of evolution

Two of the teachers would not come out clearly and support or refute the validity of evolution. For instance, Tapfu did not state whether or not he finds evolution valid, even though he admitted that what the theory of natural selection stipulates is "*practical even today*". He agreed that organisms are forever competing for resources where the stronger ones will succeed and even reproduce. According to him, "*Organisms that are stronger will survive and those that are weaker will not survive. And as he* [Darwin] *states it, that is true, and those who will be able to*

reproduce are those that are stronger. So that element of evolution is correct" (Tapfu, 2012.03.14). He then mentioned that there were other scientists who came up with other theories. He cited the Lamarckian theory as an indication of lack of validity for evolution because, as he says, Lamarck's "*contribution … is a theory - law of use and disuse, but when you try to put it in a practical sense, it defies logic*" (Tapfu, 2012.03.14).

Unlike Tapfu, Mashudu acknowledged that there is some evidence and this is what makes her reluctant to say evolution is not a valid scientific theory. Her main problem is that Darwin's theory does not stipulate the beginning of the first species (from which all others evolved) and this is where it lacks evidence. She stated her dilemma in this manner:

> *I am afraid to say it's [evolution is] not a scientific theory because by now … those scientists when they say it's a valid scientific theory, they have done some research. There are some experiments which have been conducted, and maybe that is why we think … most of us think evolution is very challenging because I can't say it's not a scientific theory because there are some evidence"* (Mashudu, 2012.04.19).

She goes on to state that "*scientists are interested on answering the question of … why there is a change of characteristics … but if we can think about creation, where things start to develop, those scientists never reveal that information*".

The concept of biological evolution is based on scientific theory. As such, it seeks truth through empirical means (Staver, 2010) and provides evidence to support the truth. Religion is similar to science in that it is also trying to provide truth about the world. However, religion seeks its truth from God (*ibid*.). The teachers' responses show that they are assessing the truth of evolution in terms of the evidence it provides – in other words, they are questioning the validity of the empirical processes employed in establishing the truth about evolution. Those who find that evidence lacking, like David, find it hard to accept evolution. Similarly, Tapfu uses Lamarckian theory as an indication of insufficient evidence for evolution, even though he accepts Darwin's model of natural selection as true.

(c) Evolution as a valid scientific theory

The remaining two teachers, Thabo and James, found evolution to be a valid scientific theory. James accepts evolution as valid since, according to him, "*even evolution is part of the system which God has done",* and *"…scientists are interpreting what God has already done*" (James, 2012.03.19). Thabo, on the other hand, thinks it's a valid scientific theory because of the evidence available. He supports this by showing that "*if you are talking about scientific things or theories they require that there must be evidence, so I think they* [scientists] *have enough evidence to prove that evolution can be a scientific theory*" (Thabo, 2012.05.16).

(d) Summary of responses from teachers about their perception of evolution

There are therefore mixed ideas about the validity of evolution, with some teachers finding the evidence to be lacking, while others find evidence to be sufficient. What is interesting is that all the teachers used evidence as an indication of evolution's validity. Of the teachers who find that evidence lacking, David does not accept evolution while Tapfu and Mashudu partially accept it as a valid scientific theory. Tapfu used Lamarck's theory to highlight the lack of evidence in support of evolution. Lamarck's theory is presented in the textbooks as an example of a theory that was not accepted by scientists, while Charles Darwin's was. This teacher is therefore supporting the assertions made by scientists regarding the two theories, although he did not say so himself. Mashudu acknowledged the empirical investigations in support of evolution and the fact that it is accepted by the scientific community as true, so she cannot say it is not valid. But equally she did not clearly say that it is valid, which implies that there is a conflict between her religious beliefs and scientific assertions.

The two teachers who acknowledged the validity of evolution, James and Thabo, emphasised the importance of scientific enterprise in carrying out investigations in order to come up with theories. What is interesting is these two teachers who support the validity of evolution maintain their creationist beliefs and one of them, James, even found evolution to be complementary to biblical accounts of creation. Also interesting is that, although some of them demand evidence for evolution, they do not ask for it to prove their religious or biblical beliefs.

6.3.2.6 Teachers' feelings when teaching evolution

In the sixth question, teachers were asked: 'How do you feel when you have to teach evolution?' The responses expected were descriptions of feelings that relate to emotions and perceptions with regard to teaching about evolution.

Despite their creationist beliefs, some teachers do not find teaching about evolution to be a problem. David, for instance, feels that he is performing his duty as a teacher, and that he is "*not forcing anybody to be part of that* [evolution]*, you see. It's a matter of knowing that this is what other people are talking about, from there … as an individual you have got a right to choose whatever you want to choose*" (David, 2012.02.16). David had stated that he did not see evolution as a valid concept. By not being valid, evolution cannot therefore be a true explanation of the origin, existence and diversity of organisms on earth. As a consequence, teaching for him is to expose learners to different ways of understanding. The learners, as he stated, will then make the choice themselves as to whether to accept evolution or not.

James finds evolution "*practical*", in that he can involve learners in evaluating the evidence. To him, "*even though evolution takes millions of years but we can also see something which is taking place recently, which we can try to make sure that learners could be able to realise that indeed if you can return to the period, evolution is taking place*" (James, 2012.03.19). However, he finds teaching evolution "*challenging because I don't have the practical side of it*". When asked to explain 'practical', he said: "*you fail to substantiate yourself because you have to explain it [*evolution*] in theoretical* [not practical] *terms*" (James, 2012.09.04).

Two of the teachers, Tapfu and Thabo, experience mixed feelings when they have to teach evolution. Tapfu attributes these to his creationist beliefs. He said the following:

> *Umm, when I'm teaching evolution I've got mixed feelings. First and foremost I would be teaching something that is against my religion. Right, like I'm Christian, I believe I was created by God and biblically I have my strength in that. But I am also a scientist because I teach science, where I also see light in this study. So, at one point you are coming in as a Christian and you are also coming in as a scientist. So it's mixed feelings"* (Tapfu, 2012.03.14).

For Thabo (2012.05.16), "*it becomes a mixed feeling wherein you have to move away from what you believe and focus on other things. And then besides that, you also have to face other people who you are not sure of what they believe in, and then which means it becomes very … its mixed feeling, in other words*".

For the fifth teacher, Mashudu, evolution becomes "*a very challenging topic*" when it comes to 'Human Evolution'. She stated the following:

> *…because if we can … when we think about the creation then … that is why I said I have got a problem with the trend of human evolution… if you cannot study it very well you get confused … So, as a Life Science teacher teaching this part now I also think about maybe what we have to learn now is … we are also interested about something that has already being created, we are not supposed to think about, at the beginning where do this thing come from scientifically. But in creation, if you believe there is God, the God is the one who created everything, then is where you can start from there but you think God created an ape-like, and you think this is the human being that we have now* (Mashudu, 2012.04.12).

This teacher finds it easier to accept the Genesis version of creation because it talks about how species, including humans, originated. She finds the evolution model lacking in this aspect, and this is what causes challenges for her.

For those who face challenges, the main issue was dealing with their own beliefs and having to teach something they do not believe in. However, in one case, teaching was about exposing learners to what other people say and not so much because he believed in what he was teaching.

6.3.2.7 Influence of teachers' beliefs on evolution teaching

In responding to the request, "*Please describe how your beliefs influence your teaching of evolution"*, teachers were expected to describe the way in which their beliefs affect their teaching of evolution. It was also expected that the responses would provide an insight into the kind of relationship they perceive to exist between the concept of evolution and their beliefs. Since all the teachers are religious, the relationship would presumably be that between their religion and evolution.

From the responses, three points emerged. Firstly, some teachers felt that there was no effect. Others had to be open to the learners about their beliefs, while some simply focused on what had to be taught. In the latter group, teachers separated their beliefs from what they taught and did not reveal those beliefs to the learners.

David finds that his beliefs have no effect on his teaching. As he had already reported when responding to the previous question, he teaches what he has to teach and learners can decide thereafter whether or not to believe it. What he says is in line with what Ertmer (2005) reports: that a learner may gain knowledge of a proposition but may still decide, thereafter, if it is true or false, a decision which can then lead to acceptance or rejection of the proposition. It is interesting that David says he has no problem teaching evolution and that his religious beliefs have no effect on his teaching of evolution, and yet he reported having been 'sad and shocked' when he first heard about evolution. He seems to be taking the Bible literally in some respects, as he said the following during his first interview, "*It's either by the word as you heard it from the bible… when God said "let it be" … either animals in the water, you find animals are there*" (David, 2012.02.16). When asked about the age of the Earth, he gave different answers but which were in the millions (100 million, 50 million), at which he said he was "*forced to accept what [*other*] people are saying*" (David, 2012.-2.16), implying that he might not believe it himself. But he cannot be classified as a YEC because the age he gives is not in the thousands. He adds that

> *There is no need that it should affect my teaching. You see teaching and religion - these are two different things. Because you know when you talk about or of a belief, … You need to hear the word and after hearing the word, then you are convinced by the Holy Spirit, …*(David, 2012.02.16).

James and Tapfu, on the other hand, acknowledge that learners might have different beliefs concerning the origin and diversity of species. James tries to be objective: "*I must be honest with them, because we have got different beliefs, so that they can try to compare the scientific findings and their beliefs and then we share the common knowledge*". Tapfu anticipates that some learners will be Christian or belong to other religions where they believe in creation. He has been

faced with questions where he had to reconcile his religious beliefs with science, and had problems responding to those questions. He stated:

> *Yah, in most of the cases you realize that - there are some questions that are asked - because evolution also describes the origin of man – which even if you are a teacher, you may fail to answer. Like someone asks you, you are a scientist. Do you believe man have got a spirit? You say 'yes'. Then they will say 'have you ever seen the human spirit? The answer is no. "And if man evolved, then why is it men do not know their spirit?" Is some of the things you cannot answer* (Tapfu, 2012.02.14).

Tapfu, therefore, emphasizes to the learners that they have to learn about evolution so that they can pass examinations. He does not try to change their beliefs, just as David does not. Mashudu also does not attempt to change the learners' beliefs. She has realized that learners already have ideas about evolution and have acquired religious beliefs before learning about evolution in this grade. So, before teaching, she checks on those beliefs and ideas. She does not believe in revealing to the learners her own beliefs or the questions that she has concerning what exactly happens in evolution, so as not to influence learning. She wants her learners to decide for themselves what they believe in without being influenced by her personal beliefs. As she revealed in her second interview, sometimes she feels as though she is being defensive about her own beliefs as she tries to explain about evolution to the learners. That learners come to school with ideas about evolution and also have religious beliefs makes it difficult for her when teaching. She explained her predicament further:

> *So it will also force you as a teacher maybe to be defensive because you are trying to make them understand what they are going to write about* [in examination]. *So it's not easy to … I find it difficult. Even if you are trying by all means not to show the religion you belong to, you may find yourself the way you explain it, you can force them to accept whatever you are trying to tell them* (Mashudu, 2012.04.09).

Perhaps what Mashudu is avoiding is what Tapfu encountered when learners confronted him about his beliefs. Mashudu is in a way separating her religious beliefs from her scientific knowledge when teaching. Even though she has some unanswered questions about evolution, she does not reveal these or any ideas she has for fear that they might influence learning, possibly in a negative way. Similarly, Thabo separates his religious beliefs from evolution when teaching. To him,

> *… it's a matter of putting what you believe in aside, and focus on what you are supposed to do, because, uu… in most if you focus on both things at the same time, you may end up not doing what you are supposed to do perfectly or appropriately* (Thabo, 2012.05.16).

All the teachers, while they have their own religious and creationist beliefs, teach learners what they are supposed to know about evolution, without bringing their own beliefs into the classroom. They do not aim at changing the learners' beliefs or making learners believe in

evolution. Rather, they encourage learners to study and understand about evolution. They allow discussions on various views in the classroom. That they don't aim at changing learners' beliefs is understandable, considering that they also do not accept evolution fully.

The fact that teachers anticipate certain reactions from learners, for which they will leave their own beliefs aside when teaching, or try to reassure learners that the teacher is not trying to change their beliefs, is an indication that teachers are aware of their own personal beliefs prior to and when teaching about evolution. Some of the teachers have their own tensions to deal with, but they try by all means to hide these from learners in class. The influence is therefore reflected in what teachers do and do not do to avoid conflicts in the classroom.

Teaching about evolution may evoke a certain level of self-consciousness about one's beliefs regarding evolution. Teachers such as Mashudu show affirmative neutrality (Hermann, 2008), since she does not want to state which vantage point she supports, although she allows learners to discuss evolution from different viewpoints.

6.3.2.8 Teachers' experiences regarding evolution teaching

In addition to the way teachers perceive the influence of their beliefs on their teaching about evolution, their actual experiences are important to understanding that influence. It is, thus, desirable that teachers should be able to describe their experiences, as this would give an insight into how they understood those experiences in relation to their own dispositions. The teachers' responses to the eighth request, 'Please describe your experiences with regards to teaching evolution', showed experiences ranging from those who experienced a negative reaction from learners, to those who learned something useful from the learners and the lessons.

David found it hard at first because the topic clashed with his personal beliefs, but he decided to focus on his "*duty*", and then the "*sadness*" and "*fear that would surround*" him when he dealt with evolution left. He experienced a negative reaction from learners who do not accept evolution but feel that they are being forced to believe in it.

James had not experienced problems, because his learners understood what he taught them, except "*… the only challenge is that you must give them something which can try to open their understanding*". Thus to illustrate evolution, he used the example of pathogens mutating rapidly and the need for patients to take medication as directed to avoid being re-infected by mutant strains. To him this mutation "*... it's a very recent example of...that evolution is taking place*" (James, 2012.03.19).

Tapfu received from his learners' questions he was not able to answer:

> *... in most of the cases you realize that there are some questions that are asked ... because evolution also describes the origin of man ...which even if you are a teacher, you may fail to answer. Like someone asks you, you are a scientist you believe man have got a spirit? You say 'yes'. Then they will say 'have you ever seen the human spirit?' the answer is no, 'and if man evolved, then why is it men do not know their spirit?' ... is some of the things you cannot answer"* (Tapfu, 2012.03.14).

Mashudu's experience was that some of the learners' "*beliefs contributed a lot in the lesson because some ... are Christian so they believe that God created everything the way it is*" (Mashudu, 2012.04.12). She has also noted that, as teaching progresses, learners start to understand why they are learning about evolution. "*We have to know ... when the environment changes ... how it influences the characteristics of the living organisms that are found in that particular environment... so now some they can show that they can differentiate their belief in Christian*" even though some experience conflict and still continue to ask questions about evolution. Thabo's experience has been the learning of a lot of new things from his learners. Usually learners who are against evolution "*come up with their own beliefs or other things that they know about the origin of species and the earth and all those things, and then you tend to learn other things you were not well aware of... or you get to know what those learners believe in and what they think about all those other things regarding the origin of the earth or origin of species*" (Thabo, 2012.05.16).

All the teachers interviewed realized that learners have different views about evolution. In some cases they will ask a lot of questions which are difficult for the teachers to answer, as in the case of Tapfu. For Mashudu and Thabo, the experience has been enriching in the sense that they have learned from the diverse views of learners, and these were even incorporated into class discussions. It was in this context that Mashudu stated that learners contributed to the lessons.

6.3.2.9 Teachers' strategies for dealing with learners' lack of acceptance of evolution

As a follow-up to question 8, this request, 'Please describe how you deal with learners who do not accept evolution as a valid explanation of the existence of organisms in the earth in their present form' was an attempt to find out how teachers reacted to learners' rejection of evolution, where it existed. Except for one teacher, James, all the others have had learners who were negative towards learning about evolution and did not want to accept it as a valid scientific concept. James has "*never had that... they didn't come forward to say we do disagree with you*" (James, 2012.03.19).

Those who had learners who did not accept evolution had to find a means of dealing with that situation in order for learning to progress. David states that the negative attitude arose when learners thought that the teacher wanted them to believe that they "*are coming from animals, because most of them you know, they are Christians"*. He has tried "*to convince them that, no, I am not teaching you about, you know, a certain religion, I am not a preacher here. So I just want to expose you to different types of things that you need to understand. It's up to you whether you believe it or not. You take whatever you want to take; you leave whatever you want to leave. You are free*" (David, 2012.02.16).

The other three teachers encouraged learners to study evolution by emphasizing the importance of learning about it so that they could pass examinations. For instance, Tapfu emphasized "*the fact that on the academic profile, evolution is essential. It's part and parcel of what they are supposed to know, which means rejecting evolution is rejecting passing. So I usually encourage them not to mix the two ... religion and evolution as a study*" (Tapfu, 2012.03.14). Mashudu, on the other hand, encouraged learners to study "*so that you may to go and do some research also so that you must come up with evidence and show that this is not what is really happening*" (Mashudu, 2012.04.12). Thabo, in addition to encouraging them, "*to move on without any disturbance", stated "I allow them to have their own point of view, to say or to argue against evolution, and then when they are done, it's then that I get a chance to move on with the topic*" (Thabo, 2012.05.16). Thabo stated that this helps, and that:

> *... because they* [learners] *tend to argue, they relieve themselves of the burden which they were having. Maybe if they were ... I mean, evolution is a controversial topic, and then as it is, which means if you give them a platform to express their views, and then it leads* [them] *to calm down, in such a way that you may be able to move on with the topic* (Thabo, 2012.05.16).

Except for the one teacher who has not encountered learners who say they reject evolution, the other four are conscious of the alternative views that learners have. When learners experience a conflict and do not accept evolution, these teachers find ways of encouraging them to learn. One of the ways is to show learners that they might fail examinations if they do not learn about evolution, and that they need to learn it to pass their Life Sciences subject. One of the teachers allowed learners to express their viewpoints and to argue, while another encouraged them to engage in scientific research so that they could argue against evolution from a scientific perspective. The strategies that the teachers adopted were aimed at motivating learners to learn.

6.3.2.10 Teachers' opinions regarding the teaching of evolution in South African schools

This request, 'Please describe your opinion regarding the inclusion of evolution in public schools in South Africa', takes the teachers out of the classroom and from their daily classroom routine.

Responses to this issue should give an insight into the teachers' attitude toward the inclusion of evolutionary theory as a school subject. Except for one teacher in the study, four did not learn about evolution at school, with two learning it at university and two having no formal education in it at all.

Although one of the teachers, James, was concerned that teachers who had not formally studied evolution may experience problems teaching it, like the other four teachers, he supported the inclusion of the theory in the curriculum. Mashudu was similarly concerned that teachers who lacked understanding might diverge from what was supposed to be taught. Varying reasons for supporting the inclusion in the curriculum of evolution were given. For instance, James states that evolution is "*part of what is going on our lives*" (James, 2012.03.19), while David feels that evolution tests the strength of people's religious beliefs. As he put it: "*whether you are a Christian or not, being exposed to something else is not a sin, but that* [exposure] *helps you to have got deep roots to what you believe in*" (David, 2012.05.16).

Tapfu also thought it very important for evolution to be in the curriculum, since "*not all the people are religious people. There are those who are not religious who may also need to know where they come from*". He went on further to state, in what could be the summary of the purpose of teaching about evolution in schools, that:

> *... also, in most cases people make mistakes where they think evolution states that men came from other things, where actually evolution the main point from my own understanding is that when you have a look at human beings and other organisms, they share a common ancestor, not that they come from that ancestor but they share a common ancestor. And you can also prove it. So it is very important, it enables us to know our stand in the, ... history of the earth, what makes us similar to other primates, what makes us different from other primates. And also, when you study evolution, especially when you have a look at natural selection, you understand other forms of bio-diversity in a better way* (Tapfu, 2012.03.14).

Some teachers added suggestions about improving the teaching about evolution. One suggestion was for the Department of Education to provide education for the teachers by conducting workshops. This is especially important for teachers who have not received any formal education about evolution at all. The second suggestion was that evolution should be included in lower grades because, by the time learners come to Grade 12, they already have other ingrained beliefs which might contradict the concept of evolution and cause them to perceive evolution as controversial, thus posing problems for learning about it. Thabo put it in this way:

> *The ... thing is that, they* [The Government] *have included it in Grade 12, which is the last grade of secondary level. I think ... wherein, you find that a learner has grown up or has been groomed believing in certain things and then at a later stage they introduce evolution, wherein you have to teach a learner, and that other learner has certain beliefs,*

> *which tend to make it to be more controversial. I think if it is also included in lower grades it can also help - that when a learner reaches grade 12, they also have knowledge of evolution, they have been told about evolution when they are still in lower grades, and then it may also decrease the controversial aspects or controversy when the learner is in Grade 12* (Thabo, 2012.05.16).

Although teachers have given different reasons for supporting the inclusion of evolution in the curriculum, the reasons they have given all add up to their support for its inclusion. By giving suggestions about improving the teaching of the concept, teachers show that they are not opposed to it and that they find it a valuable addition in the curriculum that would enhance the learners' repertoire of scientific knowledge.

6.3.2.11 Teachers' perceptions about learners' performance related to evolution

In response to this request, 'Please describe how you think your learners will perform in questions on evolution in the final examinations', teachers were expected to look back into their own teaching and the learning that could have resulted, and from that predict the performance of their learners. This would indicate their confidence level in the way they perform as teachers.

All the five of the interviewed teachers stated that their learners would perform well. One of the teachers, Thabo, supported this by saying that:

> *... because... I try by all means to make sure that whenever we move to another aspect all learners are well aware of the aspect that we talking about, or they have the knowledge of what we are talking about or teaching. And then what I like again about those learners, even though there are certain learners who don't believe in evolution, but when it comes to the questions, they tend to answer the questions in a way that they are required to answer* (Thabo, 2012.05.16).

It is interesting to note that despite some challenges faced by the teachers and learners when teaching and learning about evolution, teachers still feel confident that they do their job well and that the learners would perform well.

6.3.2.12 Schools communities' concerns regarding evolution teaching

The twelfth question asked was: 'What concerns are there regarding the teaching of evolution at your school?' was meant to find out if other people in the schools' communities had raised any concerns about the presence of evolution in the curriculum. This would give an insight into whether teachers were experiencing any pressure from other people not to teach evolution.

None of the teachers had heard of any concerns from the school or other members of the community, such as parents or religious leaders. One of the teachers even stated sharing knowledge about evolution with colleagues not involved in Life Sciences. Some of these colleagues were not aware of evolution, but enjoyed discussing it with the teacher:

> *… where I am now, aaaaa, there is no concern, except that, you know, I am very proud of teaching evolution. Even though some of my colleagues who are not part and parcel of Life Sciences, I used to share these things with them. Some of them they become aware, of certain things they were not in the know. Ummm, they are happy while discussing about all those things* (David, 2012.02.16).

That teachers did not hear of any concerns, and that one of them feels proud to teach evolution and even shares it with other colleagues, is a sign that evolution's place in the curriculum is not threatened. The lack of negative comments or concerns about evolution leaves teachers free to do their work without any outside pressure or influence.

6.3.2.13 Teachers' inner tensions between beliefs and teaching evolution

The thirteenth question, '"Do you experience inner tensions between your beliefs and having to teach evolution? Please explain', was meant to find out if teachers feel conflicted due to their personal beliefs when they teach evolution. Three teachers stated that they experienced tension, while two said they did not.

(a) No tension

The two teachers who said they did not experience any tension were David and James. David treats his beliefs and evolution as two different things, and states that by doing so, he does not experience any tensions

> *Aaah, not at all, not at all. You see, I know that these are two different things. Imparting what you are supposed to impart to somebody else, but not forcing him, it's a duty to do that. Believing on the other side, where I am not being forced by somebody to believe, that was my will, that's another part now. So I don't have any problem* (David, 2012.02.16).

This is an interesting response from David, considering that he has indicated that he does not regard evolution to be a valid scientific theory and has stated that his beliefs do not support evolution. It is an indication of a possible conflict similar to that described by Barbour (2000). Perhaps in this response, David is showing how he manages what could be a conflict for him, by separating evolution from his beliefs. In this sense David, as he states, experiences no tension, and this may be because he has managed to separate his beliefs from evolution, falling into the independence category of Barbour (2000). James on the other hand, understands evolution as dealing with change over a long period of time with humans being the last to evolve just as much as they were the last to be created. To him, creation and evolution do not clash; he believes in both. In this sense James can be in the dialogue category, as well as in the integration category.

(b) Experienced tension

The other three teachers stated experiencing some form of tension, especially Tapfu and Thabo over human evolution. Mashudu, like the other two teachers, believes that everything was created by God, so evolution is against what she believes in and she sometimes gets confused. Thabo described his tension in this way:

> *Yah, I do, especially when it comes to human evolution, wherein we are talking about the evolution of man and where man or human life started. You may find that it's totally … they have got totally different things from what I believe in, so there lies the tension between the human evolution and the formation of humans, with regard to what I believe in. … the thing is I am also a human being, so … a bit emotional …* (Thabo, 2012.05.16).

The tension that these teachers experience results from the clash between their creationist religious beliefs and evolution which is a scientific naturalistic theory. Tapfu summarised his opinion about evolution thus:

> *Personally … to me evolution is … it's not something that I believe in. It's something that I teach. Let me put it like that … I treat evolution like science … only* (Tapfu, 2012.03.14).

By expressing that he does not believe in evolution but treats it like science, Tapfu gives an indication that a scientific concept may not need to be believed in. In this manner, one may accept a concept without believing in it. The worst clash, it seems, was said to happen between religion and human evolution.

6.3.2.14 Teachers' perceptions about learners' inner tensions between their beliefs and learning about evolution

The question, 'Do your learners ever experience inner tensions between their beliefs and having to learn evolution? Please explain' was meant to find out if teachers were aware of any tension experienced by their learners. Responses would give an insight into the way in which teachers reacted to any tension.

Except with one teacher, learners experienced some tension with evolutionary theory. In one school, the teacher realized that the tension arose because learners had not been exposed to evolution earlier. He said this to show how he was able to deal with this problem:

> *You see when we are preparing all those learners in lower grades, because we are communicating with our friends, so as they would be teaching there, they are trying by all means to expose them, to try to let them know the difference between the two, so I don't have any problem (David, 2012.02.16).*

One other teacher does not think the learners have problems because

> *"they are performing very well* [in the topic], *which means there is no tension to that point wherein it can also hinder or affect their performance* (Thabo, 2012.05.16).

Two of the teachers mentioned that the tension existed with regards to human evolution. Mashudu noticed that her learners "*have this idea, I don't know where they get it from, that human being, ... they said human being come from apes. This is what they say. As they are Christians - some they said they are Christian, they don't agree with human comes from apes, whatever. So it was not easy to explain to them that evolution has to be the changing of characteristics*" (Mashudu, 2012.04.12). Tapfu felt that the tension arose because learners were Christian and believed in the biblical version of creation, so they felt as if they were being persuaded to believe in a scientific theory. He explained:

> *... most of the learners, you know, they are Christians. And in Christians there is the term creation. Right, so - and some of them, though they are young, but they have got strong faith, they are religious people. And when you tell them that in evolution the word creation does not exist, we use the word evolution, meaning we are saying men were not created by God. Actually when talk of evolution the word God does not exist. Then some of them will take it in a different way. They may even think that you are trying to move them away from their religion, they may even think that you are trying to persuade them to believe in science, some of them will even fail to understand the whole concept behind evolution* (Tapfu, 2012.03.14).

For Tapfu's learners, the tension came when he explained "*the origin of man*", which was where the biblical account of creation clashed with evolution.

Even for one of the teachers who stated that there was not so much tension now that the learners were being exposed earlier to evolutionary theory, what surfaced was that learners did at some point experience some tension. Teachers then had to find ways of assisting learners to deal with the tension, or even to try and avert it.

6.3.2.15 Teachers' planning for evolution teaching

Teachers were asked: 'Do you find that you plan differently for evolution than for other topics?' It was expected that responses to this question would provide an insight into whether evolution receives special treatment and what special strategies teachers put in place when teaching it.

Somehow teachers do plan differently, although the teaching strategies used may not be different to those used for other topics. David liked the "*approach wherein ... learners are more involved than the teacher, unless otherwise it's too hard for them!"* (David, 2012.02.16). James, on the other hand, felt that "*the planning will be the same, since for each and every chapter it would* [should] *be different*". In other words, every topic is treated according to its uniqueness. However, James acknowledged that evolution needed a lot of resources because learners did not have resources of their own. So he "*must consult different areas to get resources, so that they*

can learn then in the class [where] there is lots of … if you have posters, the whole class is covered by the posters of evolution" (James, 2012.03.19). For instance, he mentioned that the resources needed in his school included videos which learners could view to observe evidence of evolution.

One other reason for planning differently was because a teacher might not have proof to support what he or she taught, unlike other topics based on concepts that learners might experience easily from day to day. Thabo expressed it in this manner:

> *If you taking all other things, you may find that there are things that occur in nature. Learners experience those things each and every day, in such a way that you may not have a problem. But when you are teaching something totally different, which they have no proof of, or they have never seen proof of, it tends to be controversial, and then it also has something to do with the emotions of people in such a way that it may also cause tension… you have to prepare in a certain way, and then you might just also expect to come across anything … ee… how can I put it, you must expect to come across a new idea, which may come out of what you are teaching about evolution* (Thabo, 2012.05.16).

Another teacher considered the pre- knowledge that learners would need in order to facilitate their learning. For instance, as Mashudu states, if one starts by teaching "*nucleic acid then you go to evolution, it becomes very easy for them to understand*".

The planning involved in teaching about evolution, therefore, meant different things for different teachers. Some found that they had to engage learners in some activity which would enable better understanding when evolution was introduced to them. Two other things were deemed essential: ensuring that learners had relevant prerequisite knowledge, and finding special resources for the topic. There was also allusion to evolution not being part of everyday life, and a suggestion of a certain level of abstraction which some learners were not able to deal with.

6.3.2.16 Learners' ideas about evolution before teachers teach the topic

Teachers were asked: "Do you try and find what ideas learners have about evolution before you start teaching it? If so, how does that help? If not, why?' The purpose was to gain an insight into the teaching strategies that teachers use when dealing with evolution, and if those strategies recognized that learners come to evolution classes with views related to the existence and diversity of organisms on earth.

All the teachers interviewed made an effort to establish learners' prior ideas related to evolution before teaching it. They found this strategy helpful for different reasons. They learned about the alternative views that learners have and bring to the classroom, and knowing these helped teachers to approach teaching about evolution, by knowing where to start, and even the kind of pre-knowledge learners would require in order to understand evolution better.

James requested his learners to "*ask your parents about the origin of life"*. This enabled him to learn about any prior beliefs learners might have regarding the origin of life. The answers they came up with were then discussed. James also assessed the views of learners, and if those views were religious, he would introduce the topic accordingly. He says this is helpful for learners, "*Because they try to think where actually do we really come from. So when we come with the scientific approach, then they try to merge that we come from somewhere. But the other group they talk of God that they were created by God. These are most of them, but traditionally or according to their beliefs, except this one which is Christianity, they do not have more facts about it"* (James, 2012.03.19).

David also tried canvassing learners' ideas before teaching. Both teachers tapped their learners' religious beliefs, whether they concerned the VhaVenda notion of God or the Christian God. The Christian and indigenous beliefs endorsed creationism, in that they referred to the creation of living organisms. Tapfu used the same technique because he had earlier realized that if one doesn't know what learners think, it may be difficult for a teacher to introduce a new concept. For Tapfu,

> *Knowing how or what they think, especially where they think they came from, where other organisms came from, would also help you, you will also know how to handle them. Like if you realize that most of the learners are based in their … what … or are soaked in their religion, then you need to find an approach which will enable them to differentiate their religion and their studies. But if you realize that you are in a class, maybe where religion is not really an issue, then you will also be able to introduce your concept without wasting a lot of time* (Tapfu, 2012.03.14).

Some teachers use the strategy to identify any alternative preconceptions that learners may have in relation to evolution. Mashudu starts in this way in order to find out what learners think about evolution and creation, and how they relate them to religion. She has also noted that learners have the misconception that humans come from apes, so she is able to deal with such alternative conceptions.

As stated by Thabo:

> *…it is essential to try to find their views, because when you try to find their views, it also gives direction as to how to approach the topic, or which strategies you can use to teach the topic. Because if you just go there and start teaching without finding their views, you may find that the approach that you are using is also increasing the way in which they are not …they don't believe in evolution, and then when you teach without knowing what they believe in, it may also cause a … it may also make the learners not to listen or be rebellious in that way* (Thabo, 2012.04.09).

In general, finding out their learners' prior views helped these teachers to avert conflict by eliminating factors that might have caused that conflict and hindered learning. Instead, the

teachers were able to identify learners' alternative ideas. Knowledge of learners' preconceptions was used to modify teaching strategies so as to enhance learning.

6.3.2.17 Teachers' suggestions regarding the teaching of evolution in schools

At the end of the interview, teachers were asked: 'Please provide suggestions regarding the teaching of evolution in schools'. Responses were expected to provide an insight into what the teachers considered to be shortcomings in teaching and learning about evolution in schools. Suggestions would also be seen more or less as a call for help, where such was needed by the responding teachers.

As stated by the teachers, there is a need to provide more resources such as videos and pictures illustrating evolution. Learners and teachers should be given opportunities to visit places where the evidence of evolution is available, such as in the Cradle of Humankind in South Africa. David suggested that "*... the first thing is to take teachers* [to the Sterkfontein caves] *so that, you know, they see things that they are talking about, because it is the problem of talking about things you have never seen*" (David, 2012.02.16).

In addition to an earlier suggestion that the teaching evolution should start in lower grades, there was also a suggestion that a simple way of explaining evolution must be found so that learners can understand what is going on. In other words, ways of demystifying it should be found. "*It must be taught in such a manner that it's very clear and open to the learners, so that they could see that indeed things are changing*" (James, 2012.03.19). Modern ideas could be introduced with which learners could better relate. By modernising the content of evolution teaching, learners might understand the concept, including the underlying theories like natural selection more easily. Some suggested including current environmental issues such as global warming, volcanoes, asteroid impact, diseases and others in the teaching as a way to show the effect on species of environmental changes. For instance, as suggested by Tapfu (2012.03.14):

> *... what i think is, when it comes to the teaching of evolution, one of the major challenges that we face is; we speak of, eh, time frame that is, of what ...too long. Right. You talk about maybe fossils that were found many, many years ago and you are going to explain this in the present world. So I think in future, if evolution is really to be simpler to understand and easy to grasp, then we also supposed to take things that are more modern and also things that are more practical, right. If you put it in a modern way and things that are practical and things that we see every day, because we can still have those kinds of examples, it can be easy to understand evolution.*

Other suggestions related to strategies where learners could be allowed to express their views about evolution. To make it possible to provide simple explanations, teachers felt they needed to be trained so that they could be empowered with knowledge about evolution, including examples

to use when explaining the concept, and strategies they might use to enable learners to understand it better. Furthermore, such training could help teachers who have alternative views so that they could deal with those and any emotions they might experience during teaching. In this way, teachers would also be able to assist learners who struggle because of their religious or other personal beliefs.

6.3.3 Summary of findings from teachers' interviews

The interviews with the sample of teachers indicated that the teachers in this study had creationist views regarding the origin and diversity of species. All the teachers were Christian, and therefore held particular religious beliefs. Some of them felt conflicted because of their religious beliefs, while one teacher found evolution and the biblical version of creation complementary to each other.

Like the teachers when teaching, learners experienced tension when learning about evolution, due to their religious views. Because of these tensions, teachers had to devise strategies that would facilitate learning and understanding without forcing learners to change their beliefs. They even tried hard to avoid giving learners the impression that they were being coerced to accept evolution. Appropriate resources were lacking in the schools, and teachers felt that, with more resources, learners would appreciate the evidence of evolution better and their understanding would improve.

Generally, the influence of teachers' beliefs on teaching and learning about evolution was not negative. Instead, while very conscious of their own beliefs and struggles to accept evolution or reconcile it with their beliefs, these teachers were trying hard to find strategies that would maintain harmony in class and improve learning.

6.4 FINDINGS FROM THE SCHOOL VISITS

As part of the aim of this study, there was a need to understand the reality of the classroom with regard to teaching and learning about evolution. Classroom observations were therefore a necessary method of data collection to assist in describing the instructional practices employed by teachers when teaching about evolution. It was during the visits to the schools that the behaviour of both teachers and learners was observed at first hand, and it was even possible to note some of the comments they made in class. The types of questions that were asked, and how they were asked and answered, illuminated some of the intricacies of teaching and learning about biological evolution. The classroom observation schedule (see Appendix 5) had a checklist component which was used to record the teaching and learning strategies used. During these

visits to the schools, notes were also written about the observations made, especially covering those matters which were not catered for in the observation schedule. The notes included discussions that took place outside of classrooms, as well as my reflections on what I had observed. This section reports on the findings from the classroom observations and the school visits in general.

6.4.1 Classroom observations

Classroom observations in the five schools took place between February and March 2012. Altogether twelve lessons were observed: two in three schools, and three in the two other schools. The main aim was to observe the teaching and learning strategies used during instruction about evolutionary theory. The strategies observed would give an insight into the teachers' epistemological and self-efficacy beliefs. The observation schedule used in the observations covered classroom organization, the way the lesson was introduced, the teaching methods employed, teacher-learner interactions, and the content of evolution that was covered in the class. There was also room left for other observations or points that could emerge during the lesson, such as the language used.

6.4.1.1 Organization of classrooms

In all the lessons observed, teachers taught from the front of the room with some movement around the classroom and sometimes they sat at the back during learner presentations. In one school the classrooms were so packed that there was hardly any room for the teacher to move around. However, group-work was observed in three of the schools but not in all the lessons in those schools.

6.4.1.2 Introduction of lessons

Two points were looked for in the introduction of the lesson. The first was whether there was a review of past lessons and, if so, how this was done; and the second was whether an overview of the lesson was given. In all the lessons observed, there was a review of previous work done. Teachers did this either by giving a brief summary or by asking questions to check if the learners still recalled what had been done and covered. Also, lesson overviews were given in all the lessons.

6.4.1.3 Methods of instruction used

Some of the points observed during the lesson were: review of learners' everyday knowledge related to evolution; use of learning and teaching support materials such as posters, hand-outs,

media and technology; whether or not the teacher asks and/or invites questions and/or responds to learners' questions; and if the strategies used were learner-centred.

It was observed that teachers reviewed learners' everyday knowledge related to evolutionary theory. They invited class discussions, asked questions, invited learner questions and answered the questions that learners asked. In some cases this involved asking learners about their knowledge and beliefs about certain aspects of what they were going to learn, not necessarily reviewing previous classwork. For instance, in School B, when James taught the lesson introducing evolution, he first asked the learners to say what they knew or believed regarding the origin of organisms or of Earth. A few learners related their knowledge and experiences.

Group discussions were organized on some topics related to evolution. These discussions were then followed by a presentation to the rest of the class by one or two group members. Following the presentation, there would be questions and comments to the group so that all the group members would have an opportunity to answer questions and add comments where necessary. Sometimes the discussions would take the form of an argument, where the presenters had to defend their position. In one school no group work was observed in any of the lessons. Instead, the teacher would invite learners to think critically about what was being taught and then give their views. There was an open active discussion where everyone was free to participate. At some point the discussions would turn into a heated argument between two impromptu 'camps' arguing for and against evolution.

As lessons progressed, more discussions were observed. In some cases the teachers would engage learners by asking for their everyday knowledge before or when a concept was introduced. Classroom discussions dominated the strategies used in the classrooms. However, what was not much observed was the use of media or other teaching and learning support materials (LTSMs). With the exception of one school, where a teacher put photocopies up on the classroom walls and referred to them when teaching, learners used textbooks or study guides to refer to diagrams during lessons. In one lesson, the teacher drew a diagram depicting humans and apes evolving from a common ancestor. This was shown at the beginning of a lesson in which the teacher asked learners if they agreed with the diagram.

In all the schools, teachers asked a lot of questions. They also encouraged learners to ask questions and to engage in discussions on issues related to evolution. In one school, many learners asked a lot of questions and raised many issues about evolution that affected them or about other learners who did not want to learn about evolution. When learners asked questions, teachers would answer some of them the first time, while others would be referred to fellow

learners. Whether a correct answer was given or not, the teacher would then add to the answer or modify it to give a more correct and appropriate explanation. Sometimes learners were asked to read more about the issue or ask around among parents or other people so as to get information. There was one lesson in which the teacher threw the questions back to the class so that the learners could think about the issues and attempt their own responses. The teacher would then come in later and engage learners in a discussion and/or argument, so that together with learners they could reach a common understanding of the issue.

What was lacking in this area was any provision of well-designed material in terms of, for example, hand-outs, pictures, models, overheads or digital projectors, let alone more advanced technology such as computers. Chalk and board were the main materials used. In all the sampled schools, all learners had access to a textbook which they sometimes shared with their neighbours. The textbooks were available and consulted in all the lessons observed. Materials like hand-outs and, posters were not commonly used. Only one school made posters out of pictures in the text-books and put them up on the classroom walls. The teacher would point to these posters during classroom discussions. This ensured that the learners focussed on the same thing during the lesson, and the teacher could interact with a lot of learners at the same time. In one school, also, the teacher brought some sewing needles and thread to demonstrate grips of animals.

Generally, it can be said that the instruction was more teacher-centred than learner-centred. The activities and flow of the lessons, as well as their content, were all initiated by the teachers. It would seem that teachers were careful not to deviate from the content they were expected and had planned to teach, lest the main point was missed.

6.4.1.4 Teacher-learner interaction

Here observations were made on whether the teacher invited learner inputs in the class, how he or she involved learners, and if he or she varied the strategies to cater for different learner needs. Observation in all the sampled schools showed that teachers solicited learner input by inviting opinion on any issue discussed, or by asking learners to react to views and questions from other learners. Learners were invited to take part in group or class work. Although teachers would sometimes concentrate on learners who were active and raised their hands to speak, in other cases they would encourage the quiet and less active learners to participate by directly asking them questions or inviting inputs from them. Teachers also used different strategies to suit different learner needs. There were, however, only limited strategies used, such as group work, presentations and whole class discussion with question and answer sessions. In one school

learners were invited to discuss posters on the wall. In another instance, learners were asked to demonstrate some behaviour of animals, to draw a diagram on the board and discuss it.

Generally, it can be said that, in all the lessons observed, learners were actively involved. They asked a lot of questions and brought in their own ideas to what was being discussed. Mostly they brought their creationist ideas, whether from their religious or cultural perspectives. Some of the discussions were heated, as some learners did not want to accept evolution because of their religious beliefs, while other learners would be accepting of the concept and the teacher would try hard to convince learners that evolution was indeed a valid scientific concept. In some cases learners would be very emotional and express their dissatisfaction with the Department of Education for including such a topic in their curriculum; some even demonstrated anger by stating that they felt insulted, or that their religion or their god was insulted and that their religious beliefs were not being respected. The teachers were able to accommodate learners' views with patience and understanding, encouraging them all the time to learn. Some teachers did not reveal their religious beliefs in class and learners even thought they were forcing them to believe evolution. However, the teacher who was also a pastor spoke freely about his Christian beliefs. This teacher even told the learners that there was no clash between evolution and creation, and that science was actually interpreting what had already been created by God, so, according to him, science and religion explain the same things but differently.

6.4.1.5 Content of 'evolution'

This part looked at how the teacher organized the content of lessons about evolution, if the teacher knew the subject matter, was able to explain the concepts clearly, related the subject matter to learners' everyday experiences, used the concepts relevant to learners' level, and included concepts related to creation.

With regards to the content, all the teachers appeared knowledgeable in that they presented the concept well and were able to give examples from a variety of viewpoints, even using the Bible sometimes, everyday social issues or indigenous knowledge, also concepts from geography to explain environmental changes, or genetics and variation concepts to explain the diversity of organisms, or even referring to cultural beliefs and Biblical creation to show diversity of thought and belief systems. Teachers were also able to respond sufficiently to learners' questions. The content was well organized and led learners from what they knew to the new, unknown material. Teachers even related some of the content to learners' own experiences. Learners were thus allowed to share their experiences, knowledge and beliefs. For instance, the variation in families observed in offspring from same parents indicates that offspring resemble but also differ from

their parents and from other siblings. Learners were also asked to demonstrate some of the ideas from Lamarck's theory.

As already mentioned teachers varied their teaching and learning strategies and those strategies were appropriate for learners in this grade, since they seemed comfortable and expressed their opinions freely. The strategies included group work, whole class discussions, arguments and question-and–answer sessions. Some learners even professed that they enjoyed learning, implying that the strategies were fitting.

Teachers were able to explain evolution and the related concepts clearly, using information from the textbooks and also from their own background knowledge. Some teachers had more than one textbook to refer to. The learning experience was at an appropriate level for learners, since they were able to participate and engage themselves in the learning process. Learners introduced a lot of their own experience, and teachers were able to deal with that. It was also interesting to notice that all the teachers in all the lessons observed included aspects of religious notions of creation in their lessons. For instance, besides the religious beliefs of the Christian learners, who formed the majority of the learners, some learners had heard of other explanations for the origin and existence of species, particularly of humans, from their grandparents. These alternative explanations were not scientific and were based on oral traditions of the indigenous knowledge systems. Learners shared some of those versions with the rest of the class. Sometimes the creationist aspects would be introduced by the learners and the teacher would accommodate that in the class discussions, with Genesis 1 as the main Bible source. Then consideration could be given to the story that there was a VhaVenda god, *'Ngwale'*, who had created the VhaVenda people long ago, as passed along from generation to generation until some of the learners heard it from their grandparents. These learners were, nonetheless, Christians themselves. Teachers made reference to the Bible but did not teach about creation *per se*. Learners were able to relate to the concept of evolution, even though most of those who had creationist beliefs and were strongly religious were unhappy with the idea of human evolution and felt that there was no way they as humans could have evolved from an ancestor in common with the apes, or that they had evolved from the apes. There were only four learners in the whole sample who belonged to the non-Christian religions (African Traditional Religion, Jewish, Muslim, Rastafarian), while two had no religion. The arguments opposing evolution were mostly from Christian learners who referred to the Bible.

Generally the challenges seemed to be with understanding the idea of descent from an ancestor shared with primates like apes.

6.4.1.6 Other points considered in the lessons

In this part of the observation process, any point that was relevant to the lesson but not reflected in the observation schedule was noted. This included the language used in the lesson and the ways in which the teacher and learners conducted themselves during the lesson. English was the language used in all the lessons, but code-switching with the vernacular, mainly the TshiVenda language, was observed among both teachers and learners in all but one lesson. Teachers sometimes resorted to the vernacular to explain certain concepts the learners were having difficulty in understanding when explained in English, and learners did the same when they seemed to have difficulty expressing themselves in English.

Considering the requirements of the curriculum, it can be said that, in all the sampled schools, the curriculum expectations were met. Teachers were conscious of covering the relevant material required by the curriculum.

In general, the observation of the lessons showed that teachers were trying hard to meet the expectations of the curriculum. For instance, they involved all learners in the learning process and did not discriminate against learners on account of their beliefs, as a result of which learners felt free to express their views. Those who had beliefs and views contrary to what was being presented were given an opportunity to voice their concerns and fears about learning about evolution. Group discussions and arguments facilitated the exchange of opinions and the sharing of ideas.

Furthermore, teachers tried to present evolution as a science concept even though they lacked the resources to do so. Their teaching was limited mostly to explanations of what was presented in the textbooks. Although they consciously tried to avoid mixing evolution with Biblical knowledge, there were many instances in all the lessons when creationist ideas came up. The teachers accommodated those and allowed discussions but encouraged learners to concentrate on evolution as a scientific concept. They distinguished between evolution and creation by stating that evolution as a scientific theory relied on investigations and evidence for people to accept as valid, whereas divine creation as based on religion required faith to believe in it. The two therefore explained the same phenomena but from different viewpoints. One of the teachers tried to resolve the conflict in a lesson where evolution was being related to religion by telling the learners that "*in class you learn evolution and in church you believe in God*" (Tapfu, 2012.03.08). In general, learners were given an opportunity to contribute in group discussions. Teachers tried to teach evolution as a science concept but included Biblical knowledge to strengthen some explanations, although they were not teaching about creation. Teachers

encouraged learners to explore cultural beliefs related to the origin of species, particularly humans.

Some teachers acknowledged that there is conflict between religion and science, as observed with evolution, but that learners should focus on learning about evolution as a science concept. Teachers therefore encouraged learners to articulate their own views and discuss them with their peers. This inclusion of discussions about creation enabled teachers to encourage learners to be aware of different viewpoints – as is stipulated in Learning Outcome 3 in the Life Sciences Curriculum (DoE, 2003a), where the expectation of the curriculum is that learners should be exposed to other viewpoints. Instead, the teachers encouraged their learners to learn.

The teachers in this sample showed some confidence in the way they presented their lessons. They encouraged and motivated the learners to learn and understand about evolution, and they attended to learners' concerns and any issues of contention that were raised during lessons. They relied heavily on the textbooks, and sometimes more than one textbook was used. The reason given for this was that different textbooks emphasized different aspects of the subject and, if only one textbook was used, there would be insufficient content material. However, there was one textbook which was treated as the main tool in planning and teaching. What is interesting is that, despite several textbooks being recommended by the Department of Education, all the schools in the sample used the same book and even the extra books used as references were similar. The teaching schedule for this topic and the lessons followed the sequence laid out in this book, and the learners used the same book as their prescribed text. The teachers provided some copies of the second or even third textbook simply as reference.

The general pattern observed was that teachers tended to use the same strategies when teaching different Life Sciences streams in their school, suggesting some consistency in their choice of teaching strategies. There were also some strategies which were only observed in some of the schools.

Some teaching strategies, such as the 'whole class discussion' and the 'question and answer', were observed all the schools. The differences between the schools related to the manner in which teachers engaged the learners. For instance, the instructional strategy of 'group-work and presentations' was observed only in School A, and in School E the teacher invited learners to the front of the classroom for some demonstrations. Also, in order to manage the conflict that arose during lessons, all five teachers in the different schools encouraged the learners to separate their personal beliefs from learning about evolution.

6.4.2 Field notes

Field notes were taken during the visits to the sampled schools. They covered mainly what was observed in the classrooms and learned in discussions held with the teachers. After every lesson that I observed, I asked teachers how they felt the lesson had gone and if they were satisfied with what had happened during the lesson, or if they felt they could have presented it differently. I also asked them about the resources used by them and the learners, how those resources were used, and if they were accessible to the learners. The questions I asked depended on the observations I had made during the lessons. For instance, as I tried to understand more about what I had observed, sometimes I would ask about specific incidents in the classroom or specific learners who had raised interesting comments. In some cases teachers asked me questions about some content aspects related to evolution.

Below are excerpts taken from the notes made on the lessons observed in the schools. These notes include the discussions I had with the teachers after an observed lesson and my views or impressions about the lessons, as well as teachers' and learners' comments. The lessons are named in the order in which they are presented in this chapter, and do not necessarily reflect any other type of order.

6.4.2.1 Lesson A

This lesson took place on 29 February 2012 between 07h30 and 08h20, for a group of 60 learners at School D, taught by Mashudu. The purpose of the lesson was to introduce evolution to the learners. The classroom was packed, with desks arranged in pairs. Each learner sat at his or her own separate desk and all had access to a study guide, either individually or by sharing with an adjacent learner.

The teacher started by reviewing the work done in the previous lesson, which had been on 'change', by briefly discussing how the characteristics of organisms may change from generation to generation. She then introduced the concept of evolution. She had asked learners to prepare for learning about this topic, and so she asked them for a definition of 'evolution'. When the learners did not give one, she did so herself. She went on to say that evolution involved beliefs or that it involved religion, because it dealt with the origin and existence of organisms, to which one learner added "*the origin of Adam and Eve*". The teacher then stated, with emphasis, that evolution is a theory based on evidence gathered after observations and investigations were made regarding certain phenomena, and is regarded as proven as a result. She then reminded learners about the 'structure of a cell' and 'cell division', and asked them to describe how the characteristics of organisms may change.

As the discussion went on, learners were expressing doubts about the certainty of evolution and many would chant together that they did not agree with it. To this the teacher pointed out that if they did not agree with evolution, they were welcome to do their own investigations regarding the origin of species, and come up with their own theory that would give an explanation.

Part of the notes, including my impressions, are given in the excerpts below.

> **Discussion with the teacher**
>
> After the lesson, I had an opportunity to talk to the teacher. I asked her how she felt about the way the lesson had gone. She stated that she was happy that she had been able to present her content well. But she felt that she was not able to convince some of the learners and felt unhappy about that. She admitted that she was also a Christian, but that she tries to separate her Christian beliefs from what she teaches in class. She requested help from me on how to deal with a difficult (controversial) topic like evolution.
>
> **My views of the lesson**
>
> This was a very lively and interesting lesson. The teacher allowed learners to raise their views concerning evolution and they were free and discussed openly. There were learners who were explicitly in favour of evolution and those who were not in favour of it, and the latter were more vocal and argued more, referring to their knowledge of the Bible to make their arguments. During the heat of the discussion, some learners really looked emotional, such as the male learner who said he did not want to learn about evolution and did not want to come to class when evolution was taught. He actually said he felt very angry about learning about evolution, and did not understand why the government put such a topic in the curriculum. Then there was another who stated he could not understand why the others were making so much fuss, when evolution was a scientific topic; the lesson was for Life Sciences, not religion.
>
> The teacher knows the biological content related to evolution. The way she linked today's topic with content in genetics, change and variation, cell structure and cell division, geography, environmental studies, structural organization and population studies was interesting and presented biology as one coherent whole. She seemed comfortable with the biological content. However, the openness of the lesson and the freedom with which learners were raising their views reached a point where, because there was no consensus reached about evolution, and as the learners kept arguing, the teacher felt tired. My feeling was that she was defending the validity of evolution as a science topic, not sure whether she believes in it herself or if she is teaching because it is what she has to do. Whatever feelings she has, even after declaring that she is Christian, she tried to teach evolution as she was expected to and covered what was in the curriculum.
>
> Learners also asked for my opinion during the lesson. They wanted to know if I believed in evolution or not. I told them my opinion was not that important, but that they had to follow what their teacher taught them. My feeling was that my opinion might influence theirs, and because of that I was not going to give it. I was after all, a non-participant researcher.

One of the interesting observations I made in the course of this lesson was that learners asked for my opinion in class. This happened during one of the discussions where learners were expressing their disbelief of evolution. It would seem as if they were desperate for an answer to resolve their conflict, and because, according to them, the teacher was in favour of evolution, they turned towards me for an answer. After the lesson the teacher also asked for my help, stating that

sometimes she was not able to control learners' emotions even though she would want them to accept evolution. On the one hand she also believed in the biblical version of creation, but on the other hand she accepted evolution on account of available evidence. She stated that her intention was not to change the learners' beliefs, but simply to help them understand the concept of evolution.

6.4.2.2 Lesson B

This lesson was observed in School C for a group of 31 learners between 10h00 and 11h00 on 8 March 2012. The lesson involved discussing beliefs about evolution in relation to religion or beliefs about creation. The notes in the excerpt were made soon after the lesson was observed. This lesson looked specifically at the beliefs of people in relation to their views about evolution, the purpose being to compare evolution to religion and people's beliefs. The teacher, Tapfu, started the lesson by saying that Christians believe in Christianity, and that the Bible says humans are created by God. He stated the Biblical verse from Genesis Chapter 1:'In the beginning God created heaven and earth …', to support his statement. He then reminded learners about evolution and asked for their opinion of it. To this, one of the learners responded: "*I do not believe I come from some ancestor"*. Then the teacher informed the learners that arguments for evolution were based on evidence, whereas for creationists or religion, faith is what convinced people. Therefore, as he stated, evolution and biblical creation should not be compared, since evidence for evolution was based on physical attributes whereas faith in religion was 'based on the spiritual'. He then informed the learners that most scientists who accepted evolution also followed a religion, "*but that for you* [learners] *you learn evolution at school and in church you believe in God*".

Below is an excerpt from the notes I took after this lesson.

> **Discussion with the teacher**
>
> After the lesson I asked the teacher how he felt about the way the lesson had gone. He stated that he was happy with the way it had gone. I asked him about his own beliefs and he told me he was Christian (whereas I had thought he was an ATR member). He reiterated a point he had raised in class, that he had a problem with evolution as a Christian but more so because of the gaps, according to him, because the evidence given dates to such a long time back when none of the scientists were there, so how do they believe all that? He was, however, teaching evolution only because it was in the syllabus. He regarded it, though, as a good topic for learners to think about, so as to make up their minds about what to believe.
>
> An interesting comment that came from one of the learners and the teacher's response to the learner's comment were:
>
> Learner: *Evolution is like a puzzle with missing pieces and there is not enough evidence.*
>
> Teacher: *I can say the same about the Bible.*

Learners in the class: (chanting) *NO*.

The teacher did not make his beliefs known during the discussion, and a number of times he would refer to Christianity and to African Traditional Religions (ATR) in his arguments. At some point I thought he was a member of an ATR or that he did not belong to any religion because he would counter the points based on religion which the learners raised. However, he clarified his position in our discussion after the lesson and in the interviews. The excerpt below gives my impressions of the lesson.

My views of the lesson

This was a lively and interesting lesson. The teacher allowed learners to raise their views concerning evolution and religion and the learners were free and could express themselves in English. He knew his biological content as well as geography and, this lesson being what it was (rounding up the topic of evolution), he was able to blend all the concepts so well. He refers to the Bible and he could argue from that perspective or from the religious perspective, depending on what kind of argument he wanted to raise or he was responding to. There were learners who were explicitly in favour of evolution and those who did not accept it. Some of the Christian learners could even quote comfortably from the Bible to support their arguments. They stated clearly that they hated evolution, that it was anti-God, anti-religion and they did not want to learn about it, even though they were forced to because it was in the syllabus. There were heated discussions between those who believed in evolution and those who did not because of their religious beliefs. I must say I thought the teacher belonged to ATR because of the way he spoke in class. He kept saying "*we from ATR, us ATR…*".

The teacher knows the relevant biological content related to evolution. The way he linked today's topic with content in genetics, change and variation, cell structure and cell division, environmental studies, structural organization and geography, including the historical and cultural aspects, was a demonstration of his knowledge and understanding. Apart from making the lesson interesting and reflecting biology as one coherent whole, branching into other knowledge areas, he also made learners relate to the content and to stay interested during the lesson. Learners were attentive throughout the lesson, asked questions or raised arguments. The teacher also taught them from what they knew, establishing what they knew then relating that to what was being said at the time. The teacher was very comfortable with biological and other content. He was in control and managed to keep the lesson on track, despite letting learners talk and express their opinions and views.

6.4.2.3 Lesson C

This lesson was observed at School E on 24^{h} February 2012 between 11h10 and 12h00 for a group of 75 learners. The teacher was Thabo and the topic of the lesson was 'Human Evolution'. The teacher had a diagram on the board showing 'common ancestor' branching into 'humans' and 'apes' as shown in Figure 6.2. He started by asking the learners to study the diagram and state whether they agreed or disagreed with the diagram. There was a loud '*NO*' from the learners with some going further to say that they agreed only with the Bible (the creation story in Genesis). Then the teacher stated that learners were going to disagree with him a lot during this lesson. He then informed them that even though they disagreed with evolution, evolution says

that humans share a common ancestor with apes, but not that apes were humans' ancestors. Learners still chanted a loud '*Ayi*' meaning '*No*', they did not agree. From the way they chanted, it was not clear if they understood the diagram. The diagram shows that humans and apes both come from a common ancestor, and not that humans come from apes, which is a common misconception encountered during this research.

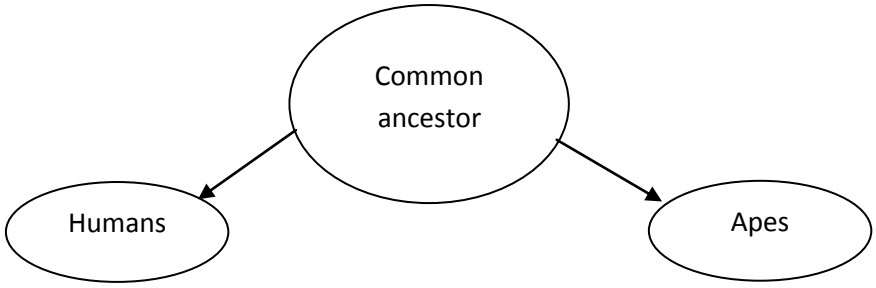

Figure 6.2: Evolution of humans and apes from a common ancestor (from the lesson observed in School E)

This was followed by a discourse on the characteristics similar in humans and apes. In the second part of the lesson, the teacher involved learners in demonstration of different hand grips, and the power and precision of the grip using needle and thread.

The excerpt below shows the notes I wrote after my discussion with the teacher immediately after the lesson.

> **Discussion with the teacher**
>
> I asked him how he felt about the way the lesson had gone. He was not surprised by the reaction of the learners toward human evolution (the diagram in Figure 6.2). He raised earlier sentiments of needing assistance to deal with evolution.

I also spoke to some learners afterwards to find out their feelings. They did not accept the notion of human evolution. They stated they were Christians and believed in the Bible which says that human beings were created as they are currently by God. This might be an indication of Young-Earth Creationism, where the creation story in the Bible is taken literally. However, the question is how much these learners understood about evolution. Perhaps their chants were caused, not so much by creationist beliefs but by misconceptions they held regarding ancestry and evolution.

In an earlier lesson, where this teacher was observed teaching about 'Theories in evolution' including Darwin's theory, he had expressed his own concerns regarding teaching evolution, as shown in the following excerpt from the notes I wrote on our post-lesson discussion:

> He said he was happy that he had been able to present the content well. But he felt that he was not able to convince some of the learners [about evolution] and felt unhappy about that. He expressed that he was a Christian, but he tried to separate his Christian beliefs

from what he teaches in class. He indicated that as teachers they need help (in-service) on how to deal with such controversial topics. His fear was that some of the learners' faith was being affected by learning evolution, and learning was impeded because they were strongly opposed to evolution because of their deeply entrenched Christian beliefs. He, as a Christian, felt bad about teaching learners evolution. But he wished they could separate their beliefs from evolution in class so that they could learn well.

6.4.3 Summary of findings from school visits

The findings from the school visits and the classroom observations indicated that teachers and learners had strong beliefs regarding the origin of species. Some of these beliefs were based on their religion or other knowledge that was not scientifically inclined, while others were based on the understanding of science.

For teachers and learners alike, some tension was experienced with regard to teaching and learning about evolution. Some teachers were, therefore, not very open about their own beliefs, mainly concentrating on the delivery of the relevant content concerning evolution. This was particularly true for Mashudu, who would even try to discourage learners from discussing the biblical version of creation. To avert potential conflict, teachers asked learners for their views regarding evolution. They encouraged learners to focus on learning about evolution as a scientific theory, and not to dwell on their religious beliefs. Teachers emphasized the nature of science to the learners, explaining how scientists come up with knowledge and trying thus to justify the validity of evolution to the learners. During lessons they stressed the notion that evolution is a scientific theory derived from observations and experimentation and therefore based on evidence, and they would use pictures in textbooks to present the evidence in, for instance, fossils. In some instances this did not help much, as learners indicated that they did not believe what they were shown, some even saying that scientists lie. One of the teachers, Tapfu, told learners they could not introduce their beliefs when learning about evolution. As he told them, science and evolution were accepted through evidence, while divine creation and religion were matters of faith. Another teacher, David would remind learners that they were in a science lesson, not church. Therefore, learners were discouraged from trying to understand evolution as based on their religious beliefs. Separating religion and science was thus a strategy used by four of the teachers. But the one teacher, who found divine creation and evolution complementary, treated the subject by showing this complementarity. The learners in this teacher's class did not seem to be experiencing tension. They did bring into the discussions their religious beliefs and the beliefs of their grandparents which were not based on Christianity but on African knowledge systems.

Perhaps learners also used the same strategy when they were studying on their own outside class, but during class they certainly brought their beliefs along. There were some learners who argued and quoted from scripture to support their arguments, especially the book of Genesis in the Bible, so as to show that they were using their religious knowledge and beliefs in judging the information they were being given about evolution. Even for learners in Thabo's class, who chanted 'No' on seeing the diagram showing 'common ancestor' branching to 'ape' and 'humans', the question is whether they understood the diagram for what the teacher wanted to show them or if they understood it differently. But for most of them, rather than dwelling on the conflict, the willingness to pass in the examinations became a motivator towards learning.

The strategies used in the classrooms could therefore have been affected by the beliefs that teachers and learners held about evolution, about how it should be taught and learned in order to maximize learning. We have seen that evolution has some connection with divine creation, in that they explain the same phenomena but from different viewpoints: one as an issue of faith, the other from a scientific perspective. The strategies used in classes were therefore indicative of the teachers' and learners' inclinations, either towards divine creation or towards evolution or towards something in the middle.

6.5 CONCLUSION

Findings from the qualitative data showed that teachers and learners in this study had beliefs that were informed by their religion and culture, although more of the sample presented religious beliefs. When it came to teaching and learning about evolution, these beliefs had a profound effect on teaching and learning strategies. On the one hand, teachers modified their strategies in order to accommodate learners' views and to try and avoid conflict. On the other hand, some learners were affected to the point of not wanting to learn about evolution, while others were even more motivated to learn about it. Both learners and teachers felt that there is not enough evidence to convince the learners of the authenticity of evolution. These teachers would want to have more resources so as to provide learners with that evidence. However, learning did not seem to be strongly impeded by the beliefs, especially since both learners and teachers felt that learners would perform well in a question about evolution, an indication of confidence in the way the topic was taught and learned.

CHAPTER 7

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 CHAPTER OVERVIEW

This chapter discusses the results and findings of the research, and provides conclusions and recommendations on the basis of the findings made. Following a presentation of the background, discussion covers the research findings related to learners' and teachers' beliefs about evolution and their influence on teaching and learning evolution. This also includes findings on the factors influencing the establishment of those beliefs, as well as how learners and teachers negotiate and cope with any conflicts when teaching and learning about evolution. Secondly, a discussion of the four research sub-questions is entered into. The points made consolidate the earlier discussions. The summary that follows is a response to the main research question. This summary gives the conclusions to be drawn from the research and highlights the possible implications of implementing evolution education in secondary schools in South Africa. The chapter ends with recommendations arising from the findings.

7.2 BACKGROUND

The aim of this study was to understand how the beliefs of teachers and learners about evolution influence education about evolution in South Africa, focusing on secondary schools around the Vhembe District of the Limpopo Province in South Africa. It was expected that, at the time of the research, teachers would have sufficient classroom experience with evolution to reflect upon and provide valuable insights for the study. Exploring the teaching strategies used would add to this understanding and identify any gaps that may exist in teaching about evolution. The study therefore aimed at understanding what was going on at classroom level regarding teaching and learning about evolution. Teachers' and learners' experiences were thus explored to determine the factors that influence the formation of their beliefs.

Methodological considerations for this study included the use of research methods which would elicit relevant information to answer the research questions of this study. Learners' biographical information and beliefs were surveyed by means of a questionnaire administered in a sample of learners from five secondary schools. In-depth information from the learners was obtained by individually interviewing a smaller sample of learners from each of the schools. One Life Sciences teacher from each school was individually interviewed at least twice in order to gather information about the teachers' beliefs regarding evolution and the strategies they use to teach the topic. In addition, lessons about evolution were observed in order to describe the strategies

used by both the teachers and learners to teach and learn evolution. The interviews with both learners and teachers were used to explore their experiences in order to determine the factors that could have influenced the formation of their beliefs. It was expected that the information obtained from these interviews would add to an understanding of the respondents' characteristics and how these relate to their beliefs concerning evolution and its role in education. In discussing the findings therefore, reference is made to the research method(s) that yielded them.

Evolution is a science topic which helps to present the world in scientific terms. However, it is a topic that often meets opposition, resulting in lack of acceptance not only by teachers and learners but sometimes by the general public, as has been observed in some parts of the world, particularly in the United States (Scott, 1997; 2000). The opposition to the idea of evolution often comes from religious fundamentalists or those religious believers who interpret in literal terms the scriptures in which only creation is mentioned, and not evolution (*ibid.*). Teachers' and learners' religious beliefs are therefore important when looking at a topic like evolution.

In order to understand how these beliefs influence teaching and learning about evolution, a main question and sub-questions were formulated for the study as presented in Chapter 1, and outlined again below. First, each of the four research sub-questions is discussed, followed by a summary of the discussion. The resulting conclusion presents the answer to the main research question.

Main question

How do the beliefs of teachers and learners influence evolution education in secondary schools in the Vhembe district, Limpopo Province, South Africa?

Sub-questions

1. What do teachers in Vhembe district believe about evolution and what influence do their beliefs have on their teaching of evolution?

2. What do their learners believe about evolution and how do their beliefs influence their learning of evolution?

3. What factors influence the establishment of the beliefs of these teachers and learners about evolution?

4. How do the teachers and learners negotiate potential tensions between their beliefs and the requirements of the curriculum when teaching and learning evolution in the Life Sciences classrooms?

7.3 DISCUSSION OF FINDINGS

This section discusses the results in four parts. First to be discussed are the beliefs of teachers, as well as the factors which might have led to the establishment of those beliefs, and their influence on teaching. Next to be discussed are the beliefs of learners about evolution and the factors which might have caused the establishment of those beliefs, leading to a consideration of the influence of those beliefs on learning about evolution. The third part discusses the factors that could have resulted in the formation of teachers' and learners' beliefs about evolution. Last to be discussed are the strategies which learners and teachers use to manage the tensions in classrooms during instruction about evolution.

7.3.1 Teachers' beliefs in relation to evolution and teaching about it

In Chapter 3, three types of beliefs common to teachers were discussed. These were the epistemological beliefs, self-efficacy beliefs and content-specific beliefs. As this study investigated a scientific topic, i.e. evolution, content-specific beliefs would seem to be the most relevant. However, since the study involved the teaching and learning of the topic, the other two types of beliefs were also relevant. For example, when a teacher says 'evolution is difficult to explain', all three belief types are reflected. The teacher's statement suggests that the content of evolution is giving problems, and this reflects content-specific beliefs. The statement also suggests something about the ability of the teacher to explain the concept, thus something about his/her confidence regarding teaching about evolution – namely self-efficacy beliefs. In addition, the statement can also reflect how the teacher came to learn and know about evolution, and this refers to epistemological beliefs about the teaching and learning of evolution that also might affect how a teacher teaches. This discussion therefore looks at teachers' beliefs in terms of all three: content-specific, self-efficacy and epistemological beliefs. In addition, the teachers' beliefs will be discussed in conjunction with their possible worldviews.

As stated in Chapter 5, all five of the teachers who participated in this study reported being Christian and believing that all organisms on earth were created by God, mostly in their present forms.

7.3.1.1 Teachers' worldviews

As already mentioned, all the five teachers thought of themselves as Christians who believed in the creation by God of all species in their present forms. Because they believe in the existence of God the creator, these teachers can be described as theists. They distinguish between evolution and creation, believing that 'creation' implies the divine creation of forms which do not change.

Evolution is a scientific theory, the knowledge of which is obtained rationally through investigation and experimentation. On the other hand, 'creation' is perceived through faith. Furthermore, with theism, God is known through revelation (Naugle, 2002), and this is what David expressed when he said:

> *You see as a Christian, as I said, I am a …I am a protestant. I believe that what do exist, when you talk about the biodiversity that are found on earth … that has been created by the Almighty. Ummm … It's either by the word as you heard it from the bible… when God said "let it be" … either animals in the water, you find animals are there, or either through the way how God has created man* (David, 2012.02.16).

Similarly, Tapfu said:

> *Christianity also states that men were created by God. So I'd rather take my religion than my study (knowledge of evolution)* (Tapfu, 2012.03.24).

However, unlike Tapfu who says he believes only in medicine (in the form of pills) and nothing else in science, not all of science is unbelievable to David. He accepts, for instance, that mitosis has been proved beyond doubt; therefore, he accepts that it happens just as described by scientists.

> *Um, it's hard to believe that, that it [*evolution*] is a valid theory, because you see when you try to check some of evidence of evolution, there are lots of gaps in between. Even though some of the things, one happen to believe, that you know, this is that way and that way, but realizing that there are a lot of gaps in between, you cannot link point one and point two exactly. And some of the things you know, they are not facts…. It's hard to believe that* (David, 2012.02.16).

The idea that there is not enough evidence supporting evolution is a misconception. Also to say that it is not valid because it has gaps shows lack of understanding of how science works.

James also obtains his knowledge from the Bible. He has rejected the idea that a conflict exists between evolution and creation. Instead, he found the theory of evolution to be complementary to creation, stating that, in explaining evolution, "*scientists were explaining what God has done*" – in other words, evolution follows on creation and does not refute it. This stance reflects 'theistic evolution', a notion declaring that religion is compatible with scientific explanation regarding evolution. However, the other four teachers felt there was contradiction and conflict between the theory of evolution and the notion of creation, especially as the Bible describes it. While James discussed issues of creation in evolution classes so that learners could appreciate the harmony between the two, the other four teachers decided to separate their religious beliefs about creation from the scientific view of it, and encouraged their learners to do the same.

Regarding the age of the earth, David found it hard to give it, except to repeat what he had been told, that it was 50 or more million years old. James believes it is more than 4.5 billion years old. Mashudu does not know the exact age but knows that it is in the billions, Tapfu and Thabo believe that the earth is around or more than 4.5 billion years old. Tapfu, though, says this is from what he has learned, which could mean that he has some doubts. However, this belief indicates that none of the teachers is a Young Earth Creationist (YEC) or a literalist in his or her beliefs. Even though David does show some tendencies towards literal interpretation of scripture, by giving the age of the Earth in the millions (50, 100 or 600 million), he does not belong to YEC. As James states, he supports his beliefs "*because one day according to* [his] *belief is equivalent to 1000 years*". Outlining his beliefs, James said the following:

> *My belief is that, eh, everything was created by God. That is my belief. And then according to the scriptures we read, it goes well with evolution when we compare the two, because it started with the earth itself, with no living thing in it, and then comes the day and night, all the firmament was created. And then comes living things which does not include human beings. Plants and animals were created, and then eventually, human beings, after everything was created, the human being was also created.*
>
> *… I see the link because it has started with something which, according to the fossil records, those species which were formed first, they are having the older fossils. Human beings are having the recent …* (James, 2012.03.19).

Because he believes in the sequential creation of plants and animals over long periods of years, James can be classified as 'Old-Age creationist', specifically Day-Age (Scott, 1997; 2000).

By declaring their religion, that is, their particular form of Christianity, these teachers identified themselves with a certain way of thinking about and understanding the world. David acknowledged the biodiversity on earth and attributed that to creation by God who, according to the Bible, said the word, and organisms came into being. This was his view of reality and truth as revealed to him in the Bible. As he said so himself, he read it in the Bible and he believed. The same view was shared by the other teachers. They had learned about and accepted creation as it was described in the Bible, a belief which was the foundation of their Christianity. Although religious and Christian in this way, these teachers had some ideas about evolution. They accepted some aspects of evolution but had problems mainly with human evolution, which they found difficult to accept. Two of these teachers seemed to be experiencing a strong conflict over the matter: one did not even acknowledge evolution when asked about the origin of species. James experienced no conflict at all, and so evolution complementary to creation.

7.3.1.2 Teachers' beliefs about evolution

As described in Chapter 3, teachers usually have a disposition towards a specific academic content, that is, they have content-specific beliefs (Kagan, 1992). The findings of this study have

shown that some teachers found evolution to be a valid concept while others, particularly David and Tapfu to some extent, did not. Apart from his deeply rooted religious beliefs, David finds the evidence supporting evolution inadequate, and he stated that this is what prevented him from accepting evolution as valid. Two teachers, Mashudu and Tapfu, had mixed feelings about the validity of evolution, while the remaining two, Thabo and James, found it valid even though Thabo did not accept human evolution because of his religious beliefs. Thabo, however found evolution to be a valid concept because he believed the evidence from fossil records, even accepting that the age of the earth was 4.5 billion years.

> *I believe that the earth is 4.5 billion years old, um…especially if you look at the fossil record; it indicates that they were created long ago. And then, once again, I don't think it is possible for those kind of fossils to be formed like that within, maybe, a short period of time. So it takes a lot of time in such a way that it also shows that the earth is very old* (Thabo, 2012.05.16).

The issue of evidence to support the claims made by science has seemed crucial for the acceptance of concepts like evolution. As stated by Sinatra *et al*. (2003), acceptance depends on the systematic evaluation of evidence. However, it seems from this research that for some people, beliefs have a strong influence on the acceptance of evolution. Beliefs have been understood to be subjective ways of knowing and, therefore, regarded as personal truths not based on systematic evaluation (Sinatra, *et al*., 2003). Thus, rejection or acceptance of evolution on account of beliefs means that rejection or acceptance is based on personal truths and not on systematic evaluation of evidence. It would, therefore, seem that evolutionary theory, unlike most topics in science, overlaps with other 'subjective' ways of knowing because the phenomena it explains have explanations also based on personal truths for some people. Personal truths can amount to speculation, hence form a subjective way to knowing. Issues of theory formation, arising from speculation, which could also be characterized as 'faith', allude to the seeming tentativeness of science. Depending therefore, on the worldview an individual has by which they understand and accept reality about the world, evolution could appear as true or untrue, depending on how its supporting theories and evidence were viewed.

Furthermore, when David found it difficult to believe that evolution was valid, because there was not enough evidence but "*lots of gaps"*, and because *"nobody has ever seen it* [evolution] *happening*", he was expressing a different way of thinking and formulating expectations, a different way of understanding knowledge as provided by science. He was demanding 'evidence' – of a nature different to that already employed in supporting the concept of evolution. This suggests that David treated his religion differently from science; he accepted faith in religion but demanded a specific and unspecified sort of 'evidence' in science. Something like this was also

professed by Tapfu (2012.03.14): "*Ah, no, I'm saying, I don't usually compare the two at the same time. I will treat them differently*", i.e. separately. "*I think ...people should also, ... when they are having a look at evolution, take it as a scientific idea, take it as a study, and don't mix the two. I mean evolution and religion*".

Therefore, 'creation' as described in the Bible is more believable to Tapfu than is evolution, or it is the only thing that he believes in. According to him, evolution lacks evidence because it happened so long ago that none of the scientists could have witnessed it. Because Tapfu and David emphasized the fact that religion was dependent on faith while evolution needed 'evidence', these teachers even told their learners to separate their beliefs from evolution when learning. Thabo and Mashudu also believed strongly in the biblical account of creation, yet they accepted some supporting arguments for evolution, like natural selection, and Thabo even accepted the evidence of fossils.

When these teachers doubt the validity of evolution on the grounds of lack of evidence (thereby rejecting the evidence accumulated over two centuries), this shows lack of understanding of evolution as a science concept, and of the nature of science. Their demand for evidence for evolution and not for religion suggests an understanding that science is based on observation, but their lack of awareness about abounding evolution evidence shows misconceptions about evolution. Could this mean that they use faith in assessing both evidence and religion, denying the one and accepting the other? A similar observation was made by Hokayem and BouJaoude (2008), when most of the students in their study appeared to have dismissed the theory of evolution on the grounds that much of the evidence used to support it was speculative. Given that some teachers allude to their religious beliefs when describing their scepticism about evolutionary evidence, the question becomes what Hokayem and BouJaoude (2008, p. 411) ask, "if the basis of science depends on 'faith' in the fundamentals, then how [could] 'faith' in other ideas … be dismissed from the classroom?"

Anderson (2007) has suggested four categories in which teachers may view the relationship between science and religion. These categories are 'conflict', 'independence', 'dialogue' and 'integration'. The findings of this study suggest that four of the five teachers found evolution and the biblical version of creation to be in conflict. One of them, Tapfu, specifically said that he did not believe in evolution and he treated it as science, which in turn he did not believe in. The reason behind this was his religious beliefs. According to this teacher, "*Christianity and science don't click*" (Tapfu, 2012.09.21).

Tapfu was thus a theistic creationist who saw a conflict between science and religion, but showed aspects of 'independence' as well. To him, evolution "*is no match for creation*", and,

> *Personally … to me evolution is … it's not something that I believe in. It's something that I teach. Let me put it like that. It's not something that I believe in. It's something that I teach. I treat evolution like science … only* (Tapfu, 2012.09.21).

He and three others reported experiencing tension between their religious beliefs and the concept of evolution. Seeing evolution at war with their religious beliefs therefore implies a 'conflict' relationship. According to Anderson (2007), people who contribute towards the larger debates between religion and science include theistic religious fundamentalist in one camp and atheistic scientists in the opposite camp. These four teachers were indeed theistic in their beliefs, but the extent of their theism may not be that of fundamentalists such as Biblical literalists. For instance, two of them, Thabo and Mashudu, accepted some aspects of evolution, but had problems when it came to human evolution. They also see evolution as 'independent' from religion, as a result of which they tell their learners to separate the two when learning. These four teachers seemed to be aware that there was a conflict between some religious beliefs and the concept of evolution, but chose to avoid the conflict in their teaching, a stance that Meadows *et al*. (2000, p.103) refer to as 'avoiding conflict'.

David, on the other hand, detached himself from evolution and taught it simply to fulfil his role as a teacher and expose learners to different ways of knowing. He felt that the classroom was not a place for him to 'preach the word [scripture from the Bible]' but to teach about evolution, so that was what he was doing – teaching. David even distinguished between science and religion by stating that one has to be inspired by the Holy Spirit to understand and believe in 'the Word' of God from the Bible, whereas with science, such as evolution, one needs to gather evidence in order to understand the phenomena.

Like the other teachers, James believed that evolution takes place but, unlike the rest, he perceived creation and evolution to be linked. For him, evolution is an extension of creation, and all science provides an explanation and interpretation of what God has done in creating the universe. He saw evolution as part of God's wider plan regarding the origin, existence and diversity of species on earth. The entire universe, therefore, was made by one God, and science, through its observations and investigations, was able to understand what God had made. Therefore, according to James, there was no clash between religion and science. He perceived the relationship as integration, since he used the Biblical story of creation to explain evolution.

The other four teachers stated that evolution was controversial or that there was conflict between it and religion. This, therefore, engendered tension in their learners and in themselves. The

expectation here would have been that the teachers would avoid teaching evolution or select the parts which were perceived to contain no controversy or be less controversial than others. For instance, these four teachers experienced more difficulty teaching about 'human evolution' than they did with other parts of the topic. This would therefore have been an area to avoid in teaching. That this was not in fact the case was also observed in the classes and revealed in the interviews with teachers and learners.

7.3.1.3 Teachers' epistemological beliefs

The beliefs of teachers regarding knowledge and how one comes to know are important. As noted in Chapter 3, these epistemological beliefs have an influence in classroom instruction because they influence teachers' pedagogical beliefs, self-efficacy and content-specific beliefs.

All the teachers in the study were aware that learners had diverse beliefs, and that some of them – whether Christians or adherents of African Traditional Religions (ATR) – because of their religion were likely to experience tension when learning about evolution. These teachers anticipated difficulty in teaching the topic, especially to those learners who could have strong and deeply-rooted religious beliefs. Some teachers even mentioned that evolution was difficult to teach, and that they experienced difficulty explaining it or convincing learners about its validity.

Teachers recognized the importance of allowing learners to express their beliefs and emotions in the classroom and so allowed learners to share their views and beliefs regarding evolution. They did not criticize learners for their opinions but were patient in addressing their concerns and misconceptions. This is behaviour which Kagan (1992) associates with teachers' self-efficacy. It was an interesting observation, particularly considering that some teachers admitted feeling uncomfortable about teaching to young people something in which they did not believe. Perhaps their self-efficacy stemmed from the feeling that they were obliged by their role as teachers to teach the learners what they were expected to know according to the curriculum.

> *You see if you are in a class situation where you are supposed to… they [curriculum developers] are saying teach this things, there is no problem because, you know, I am not forcing anybody to be part of that, you see. It's a matter of knowing that this is what other people are talking about, from there …as an individual you have got a right to choose whatever you want to choose* (David, 2012.02.16).

Teachers were also strongly convinced that they had the ability to influence learning (Settlage *et al*., 2009) positively, and they believed that certain actions could maximize learning and understanding. This was not only reflected in their actions when they tried hard to explain concepts, when they referred learners to textbooks, or when they engaged learners in discussions and presentations on the topic, but also in some of their responses in the research interviews. For

instance, all the teachers believed that their learners would do well on a question about evolution if it came up in the examinations, a sign that they believed they had done well in their teaching about evolution. Some of the strategies they used to engage learners involved encouragement and motivation. For example, Mashudu said the following:

> *Okay, I … sometimes I said to them if, if you don't believe on this evolution* [that it] *is a scientific theory, is a theory, I encourage them okay … 'you have to study so that you may to go and do some research also so that you must come up with evidence and show that this is not what is really happening' …* (Mashudu, 2012.04.12).

And Tapfu:

> *(…laugh…) Yah. Even when you teach evolution, I, you have to advise the learners that, 'evolution, you are supposed to study it, know it, but you are not forced to believe in it* (Tapfu, 2012.09.21).

Teachers were prepared to use strategies that would maximize learning. Since they did not fully accept evolution as a valid concept, the expectation would have been for them to feel less confident about themselves than they did. Some had doubts about how learners would receive evolution, but they had a strong conviction that they could influence learning.

The same strategy of motivation was used to deal with learners who were experiencing tension, which was the case in all the schools. For instance, Tapfu told his learners to focus on passing their examinations, which was a way of asking them to leave aside the personal and religious beliefs as they were perceived to be in opposition to evolution. By focusing on passing, learners were to focus on learning about evolution by not bringing their religious views into that learning. Like David, Tapfu taught about evolution because he had to, but he encouraged his learners to study and understand evolution, and learners were free to choose what they believed after learning about and understanding evolution.

> *… then usually it's not advised to try to divert them from their religion. But they still have to understand the concept of evolution. But the choice of saying we want to believe in evolution is theirs. Or if they want to stick to their religion it's still also their own choice. But as an educator, you just teach them the aspect of evolution.*
>
> *… ah, but, because it's also vital to state to them that for them to pass they need to know evolution … they need to know evolution ... Then for them to also keep their religion they need to know their religion. So, religion by faith, evolution by evidence, I think that's how I take it* (Tapfu, 2012.03.14).

Aware of the learners' predicament with human evolution and the misconception some hold that humans evolved from apes, Mashudu said this:

> *… but the problem that I have seen that one normally we, we, we compare a human being with an ape and telling them okay, which means if we have the similarities, which means we said human come from the ape, not maybe there is the common ancestors*

> *shows the resemblance, I mean the basic plan shows some resemblance, so, what they, what they in their mind they think human being exactly come exactly from ape!* (Mashudu, 2012.04.12).

Some of the misconceptions learners had, according to Mashudu, stemmed from their confusion of evolution with creation. She said, "*... what I have discovered ... the knowledge that they have when we are talking about evolution, they think hore* [that] *evolution is how things are created*". This could highlight the collateral learning described by Jegede and Aikenhead (1999), which involves two or more schemata held simultaneously in long-term memory (p. 52). In this case, learners are having difficulty crossing the border from what they are accustomed to, which is their knowledge of the biblical version of creation, to an unknown, unfamiliar and for them, doubtful concept of evolution. The implication is that, since these learners are familiar with a version of creation which holds that anything that exists does so in the form as created, so creation to them was synonymous with the origins of species, hence their understanding that evolution refers to how things were created. The third scenario could be the one depicted by James, who saw evolution as an interpretation of creation. Maybe these learners also saw evolution in the same way.

7.3.1.4 The influence of teachers' beliefs on teaching about evolution

Except for one teacher, James, the teachers in this study felt uncomfortable with teaching about evolution. James, a Christian pastor who believed in creation that allows evolution to happen, was also a graduate Life Sciences teacher who studied evolution and geography at university. Because of his religious beliefs, he saw evolution as a scientific explanation of what God had done in creating the world and all the species on earth. He appreciated that evolution takes a long time and, because to him a day is like a 'thousand years', he understood why things have been evolving from long ago. The changes have happened on the earth, as observed in continental drift, and even though macro-organisms are not noticeably evolving now, he used examples of mutations in micro-organisms and in viruses such as the Human Immuno-deficiency Virus (HIV) and bacterial infections to illustrate to his learners that evolution is indeed happening. He then uses scripture to convince his learners that evolution does not exclude creation. In James was a teacher who did not recognize a conflict between evolution and creation, but rather saw them as two processes which complemented one another.

Unlike James, Mashudu and Thabo found it difficult to teach about evolution. Mashudu even felt that she sometimes had to defend evolution because she felt as if the learners were denying evolution as a way of protecting their religion, which they felt was under attack. She expressed her predicament in this manner:

> *So it will also force you as a teacher maybe to be defensive because you are trying to make them understand what they are going to write about. So it's not easy to … I find it difficult* (Mashudu, 2012.04.09).

These two teachers believed some concepts supporting evolution, such as natural selection, but did not believe others such as human evolution. The reason given for accepting natural selection was that there was enough evidence to support it, but the reason for not accepting human evolution was because their religion had told them that they had been created by God and that was what they believed in. When teaching, they told their learners not to mix their beliefs with science when learning. They encouraged learners to talk about their views. Learners were allowed to refer to textbooks during lessons in order to learn what was in the books. These teachers taught how scientists worked in order to come up with theories, a strategy employed by James also. In this context they tried hard to explain the evolutionary concepts in order to convince the learners.

David and Tapfu, like Thabo and Mashudu, were aware of the conflict between science and religion, but they tried hard to avoid the conflict in their classrooms. It was interesting to note that David responded that he did not experience any tension when he had to teach evolution, considering that he also indicated that he did not regard evolution to be a valid scientific theory. Perhaps, by stating that there was no tension, David was showing how he manages what could be a conflict for him, which was by separating his beliefs from evolution. The other three teachers admitted to experiencing tension, and they also separated their Christian beliefs from evolution when teaching evolution. However, when learners raised concerns and issues around evolution, these teachers addressed those. They did not believe that evolution took place, especially with humans. They informed learners that evolution was what the scientists were saying, and that they should learn what was said so that they could eventually pass examinations. They also relied on textbooks to provide information to the learners. When arguments arose in class, they facilitated them by arguing from both the religious and naturalist perspectives; the religious perspective used the biblical scripture that God created everything, while the naturalist perspective argued from the view that evolution is a material, physical process. When observing Tapfu, the researcher thought he was a naturalist since he was presenting points to support the naturalist claims. Unlike the other four teachers, Tapfu studied evolution at secondary school and at university as well. But he was a Christian who had deeply ingrained religious beliefs, so he could facilitate discussion from both vantage points. When he revealed his disbelief in science during an interview, it was a surprise because his teaching did not reveal any doubts about science. He did not show any conflict or disturbance on his part when teaching, and was able to argue for evolution and try to convince learners about its validity.

All five teachers of the sample had creationist beliefs, but some also held scientific beliefs to varying degrees. The degree of scientific beliefs in turn affected the teaching, as teachers looked for strategies that would involve and convince learners, yet would not change their beliefs. It seemed that the more that teachers accepted the concept of evolution, the less conflicted they were and the less uncomfortable with teaching about evolution.

7.3.2 Learners' beliefs about evolution

The learners in this study were all African and black and this would suggest that they could also call on African traditional beliefs. The group was highly religious, since only 0.6% of them did not belong to any religious group. Only 0.3% admitted to following some African traditional religion which does not subscribe to Christianity. Therefore, the expectation would be that this sample mainly possesses Christian beliefs, and any influence of their beliefs on their learning about evolution would be mainly from a Christian perspective or worldview.

7.3.2.1 Learners' possible worldviews

It has been argued that all people have a worldview and nobody can live without one (Naugle, 2002, p.29). By professing to be Christian and having Christian beliefs, these learners were professing to a religious – more specifically, a Christian – worldview. As discussed in Chapter 3, the worldview of a people is their way of looking at reality (Kearney, 1984, p. 41). For people with a Christian worldview, this becomes their way of understanding and interpreting the world, and that way has scope and force within Christian thinking. For Christian learners, therefore, a Christian worldview would be their reference point when evaluating and assessing the validity and truth of a claim in explaining their reality.

The findings from open-ended questions in the questionnaires and the interviews show that learners had beliefs ranging from religious to naturalist. Similar findings were reported in South Africa, although from students at a university. For instance, a study by Lawrenz and Gray (1995, p. 566) found that students at the University of the Western Cape fell along naturalism and religion continuum. This means that the students' worldviews in these studies ranged from a position of naturalism at one end to one of religion at the other. The learners in the current study had a similar range of worldviews, although their responses showed more of a religious worldview than a naturalist worldview. Their religious worldview was predominantly Christian, since most belonged to Christian faiths of one sort or another.

7.3.2.2 Learners' acceptance of evolution

One of the interesting findings of this research is a higher than expected level of acceptance of evolution. Even though this study is about beliefs, acceptance was investigated as reflected in the MATE analysis because "belief is a subjective way of knowing which can potentially blur the line between scientific knowledge and religious beliefs" (Sinatra *et al.*, 2003). Analysis of the MATE found that learners in the sample 'moderately' (68.50%) accepted the theory of evolution. This finding is contrary to those from other studies that have found that learners who have deeply rooted religious beliefs have a low acceptance of the theory of evolution (Chinsamy & Plaganyi, 2007). Another interesting finding in support of the current result is that close to half of the respondents (46.91%) regard evolution as valid, while 40.12% regard it as not valid (see Section 5.2.1.3 (a), Tables 5.19 – 5.23). These are interesting results, considering the high level of devotion to religious services in the group as was observed in the biographical data. But the observation could also suggest that it is not the depth of religious beliefs but other factors which affect acceptance of evolution. This would mean that many of the learners who have religious views find the concept of evolution acceptable as a valid scientific theory. The high commitment to attendance of religious services, which could suggest a high level of religiosity of some of the learners, therefore, did not lead to lack of acceptance of evolution. These results are in line with others (Athanasiou *et al.*, 2012), who found that despite a high level of religiosity amongst the Greek students in their sample, only a small percentage (8.4%), agreed with the inerrancy of the scripture. However, religiosity may be different from country to country (*ibid.*), and may be inferred from factors such as frequency of religious activities, or adherence to the literal meaning of the scripture. The particular church that learners attend would also make a difference in the acceptance of evolution, and not so much the religiosity. At present many churches have no difficulty with the concept of evolution.

Alternatively, since it seems that learners' prior ideas did not influence their acceptance of evolution as negatively as would have been expected, one can assume that evolution provides these learners with an acceptable explanation of the world they see. In that case, too, learning about evolution for this group of learners should not be adversely affected. The responses to the open-ended questions and from the interviews showed that learners' beliefs about evolution influenced how they learned about evolution, their experiences during such learning, their feelings and attitudes towards such learning, how they felt about their teacher, the sources they used in such learning and the suggestions they made about improving education involving evolution.

Even though results reveal a moderate acceptance of evolution, for those learners who had entrenched religious beliefs on the matter of creation, it became difficult to accept evolution. This observation has been made by many studies: that learners' deeply ingrained religious beliefs interfere with their ability to view scientific evidence objectively (e.g. Chinsamy & Plaganyi, 2007; Clores & Limjap, 2006; Hokayem & BouJaoude, 2008; Sinclair & Baldwin, 1996). A number of studies conducted overseas and locally have shown that religious beliefs affect the teaching and learning of evolution among high (secondary) school learners and tertiary students (see Chinsamy & Plaganyi, 2007; Dagher & BouJaoude, 1997; Deniz *et al*., 2008; Kagan & Sanders, 2012; Mansour, 2008a; Mansour, 2010; Moore & Kraemer, 2005). As described, factors that are related to accepting evolution include an understanding of evolution (Rutledge & Warden, 2000), epistemological beliefs and thinking dispositions (Sinatra *et al*., 2003), which are often positively correlated with acceptance.

Measuring associations between the acceptance of evolution and some characteristic variables of learners was carried out where the null hypothesis was that there was no association. Some of the items showed that learners' acceptance is associated with some of the variables among these characteristics. Examples of such items were: '*The theory of evolution is capable of being scientifically tested'*; '*Current evolutionary theory is the result of sound scientific methodology*' and '*Organisms on earth came into existence at about the same time*'. Whereas gender and frequency of attendance at religious services did not show any significant association with acceptance of evolution, the characteristics which did were religion, age, the person from whom the learner first heard of evolution, and the number of years since the learner had heard of evolution. Even for the latter items, the p-value was not less than 0.05 at all times, indicating that the null hypothesis could be rejected for some variables but not for others. While the association was not observed with all the MATE items, the findings give an insight into the characteristics of these learners which have an association with evolution acceptance. However, the type of association is not known. Furthermore, the sample was drawn conveniently and this limits the generalisation of this finding to the population.

Dagher and BouJaoude (1997) identified four positions which people could hold against evolution: *for evolution*, *compromise*, *neutral* and *against evolution*, and these four were used in this study. The positions were originally identified from statements made by students (*ibid*.) whereas, in this study, the learners were asked to say whether they were 'for' or 'against' evolution. Not all learners could commit to either 'for' or 'against'. There were still learners who found themselves 'caught in the middle' or who would not commit to an acceptance of evolution and had to compromise by saying they were 'not against' it. Although there were learners in this

study who were confused, none of them said so in response to this question. Instead there were learners who were 'not against'. That therefore highlights the position of 'neutral' (see Dagher & BouJaoude, 1997). Furthermore, a 'neutral' position would indicate someone who is 'not against' but also 'not for', impartial or disinterested. Some of those who were 'not against' felt strongly about both evolution and creation and it was not possible to pick one side. It is possible, however, that some learners found themselves in a corner where they picked a position which would otherwise have been different if such positions were identified from their other responses and not from a direct question.

7.3.2.3 Learners' epistemological beliefs regarding evolution

As noted in the responses to the questionnaire and in the interviews, some learners were so opposed to evolution that they did not even want to learn about it. Lesson observations also came up with learners who were strongly opposed to evolution in four of the five schools where the research was conducted. Some learners, as found out from questionnaires and interviews, even felt that evolution was insulting their God, or that it was setting itself up as another religion; some even stated that, since learning about evolution, their faith was weakening. It seems as if these learners who were so opposed to evolution perceived that there was a conflict between evolution and their religion, or a competition in which one of them – evolution or religion – had to win. It was as if, when a learner aligned herself or himself with accepting evolution, then religious beliefs had to be abandoned. One learner was even unhappy with the teacher because he had the feeling that the teacher was trying to make them believe evolution, perhaps 'convert' them to evolution, as if evolution was a form of religion. Some learners clearly had a feeling that evolution was some form of religion or that it was 'playing God'. Hokayem and BouJaoude (2008, p. 411) mention a conflict described by Roth and Alexander (1997), in which learners thought of both religion and science as absolute forms of knowledge.

In this regard, learners do not seem to appreciate the tentativeness of scientific knowledge and, together with the certainty they apply to their religious knowledge, find the latter more acceptable because the knowledge it provides is perceived to be 'truer' than that of science. Thus learners' perceptions of the epistemological status of both the concept of evolution and the practice of religion is important for making decisions about what they support. Roth and Alexander (1997) describe thinking about both evolution and religion in absolute terms as a stance that might affect the thinker's position regarding evolution. With such a perception, people might feel that it is a matter of 'either/or' where one has to choose between the two, whereas viewing them differently would not demand that choice. Furthermore, another likely perception on the part of the 'unhappy' learners was that they were being 'assimilated' (Jegede

& Aikenhead, 1999) into the 'culture' of evolution, i.e. science. This is critical because a failure to learn science meaningfully calls for the tactics with which learners deal with their conflict and avoid learning. For instance learners might memorize and play 'Fatima's rules', in which learning takes place only to pass examinations.

When learners were asked to give their position regarding evolution by stating whether they were 'for' or 'against' it, some learners showed a clear dilemma when they could not find themselves in either of the two positions. Although the expectation was that learners would simply choose one of the two, the analysis revealed two more positions: of 'compromise' and 'caught in the middle'. The results were somewhat similar to those of previous studies (Dagher & BouJaoude, 1997; Hokayem & BouJaoude, 2008). By saying that they were 'for' evolution, learners indicated that they were accepting evolution, while the 'against' response indicated rejection of the theory. The 'compromise' group included those who felt they had to be fair to both evolution and religion and so present a compromise position. The fourth position, 'caught in the middle', can be taken to be similar to being 'unsure' or 'uncertain' in the other studies. However, 'caught in the middle' is appealing, in that it suggests that something is holding the learner to a certain stance they would rather be out of. Perhaps such learners would have liked to take a position, but maybe their beliefs in this case, or some other factor like understanding, was holding them back.

7.3.2.4 Influence of learners' beliefs on learning evolution

It is argued that, despite learners' high level of commitment to religious activities as demonstrated by high level of frequency of attending religious services, and deeply-rooted religious beliefs, on average the acceptance of evolution by the sample was moderate. As already described, acceptance of evolution has been related to religious beliefs as well as to the understanding of the nature of science and of evolutionary content. This is to say that people who have deeply entrenched religious beliefs do not accept evolution easily, and may not even understand it. In addition, knowledge of the nature of science has been linked positively to an acceptance of evolution, though not so in all cases (see Athanasiou *et al*., 2012).

There were two learners with no religious beliefs, plus four others who were religious but not Christian: one who belonged to the African Traditional Religion, a Rastafarian, a Moslem, and a Jew. However, the views of these learners were not heard in any of the lessons observed, except at one school where the teacher was familiar with the ATR and spoke a lot about it. The Christian views dominated the discussions that went on in the classrooms in the sampled schools.

For learners with entrenched religious beliefs about creation, it became difficult to accept evolution. Although they showed understanding by being able to give correct answers during

lessons, they still uttered their incredulity about evolution and lack of acceptance thereof. For example, learner SCH.D.L8 did not find the evidence of evolution enough to convince him about the validity of the concept. That he did not find adequate evidence for him to accept evolution as valid, could indicate that the teaching did not provide the evidence he needed, or it could be a sign that he simply lacked understanding about evolution. Given that learners were still able to understand something about evolution indicates that knowing about something does not mean that one automatically accepts or believes in it. For instance, some learners who stated categorically that they did not accept evolution, also expressed categorically that they were confident they would perform well in an examination questions on evolution. Similar observations have been made in other studies (Brewer & Chin, 1991 in Sinatra *et al*., 2003). Students understood new theories in the domains of special relativity and quantum mechanics "but failed to accept them" (*ibid*., p. 513), and this was also true in the current study.

In a study by Dagher and BouJaoude (1997), one of the students with a 'good understanding of the theory' did not find the evidence from scientists enough justification to accept evolution and abandon his religion, illustrating that good understanding does not necessarily lead to acceptance of the theory: one may still need to decide whether to accept or to reject a proposition after gaining knowledge and understanding of it (Ertmer, 2005). This implies that the proposition is still to be subjected to further scrutiny and judgement "based on personal convictions, opinions and degree of congruence with other belief systems" (Sinatra *et al*., 2003, p. 512). This observation illustrates the difference between *knowing* something and *believing* in it, or simply, between *knowledge* and *belief* or acceptance. Sinatra *et al*. (2003) further describe belief as a subjective way of knowing, and personal truths as opposed to truths about the world. Beliefs are thus not held in the same epistemic criteria as knowledge, which is referred to as justified 'true' belief, usually based on an objective and rational appraisal of supporting claims (*ibid*. p. 511).

Studies done on the learning of modern science by Western and non-Western learners abroad and in Africa have shown that non-Western learners have difficulty in learning science concepts, and this has been attributed to incompatibility between the non-Western worldview and modern scientific thinking. For instance, researchers such as Aikenhead (2002), Aikenhead and Jegede (1999), Jegede and Aikenhead (1999), Ogunniyi (1988), Ogunniyi *et al*. (1995) have illustrated the difficulty experienced by a non-Western learner in learning modern science. Furthermore, as discussed by Glen Aikenhead and others (Aikenhead, 2002; Aikenhead & Jegede 1999; Jegede & Aikenhead, 1999), for non-Western learners, learning science is similar to learning a new or foreign culture, and hence similar to crossing a border from one life-world to another which is less familiar.

As discussed earlier, cultural border crossings are important for understanding how learners feel when learning science. Characteristic of postmodernism, whereby people are encouraged to live in multiple identities, border crossings enable people to live in these "multiple worlds" (Phelan, *et al*., 1991) and should enable learners to be at home in their life-worlds as well as in the world of science. Using the border crossings typology, one would be inclined to say that learners in this study, who were all African, would fit into three of the categories: 'managed', 'hazardous' and 'insurmountable' or 'impossible', with none experiencing a 'smooth transition' border crossing.

However, the results of this study reveal that most learners felt that they were able to learn about evolution. Only a few of them (4.41%) gave responses showing an 'impossible' border crossing. These would be referred to as 'outsiders' by Jegede and Aikenhead (1999) because their beliefs are highly discordant with evolution. However, 39.01% of the responses indicated a 'hazardous' border crossing, although 42.80% experienced a 'smooth' border crossing. The learners going through the hazardous transition would be referred to as the 'I don't know' learners, and this happens when the cultures are diverse, such as those from family, peers and school worlds, and bring about friction and discomfort. Those with 'smooth' transitions are referred to as 'potential scientists' whose cultures are congruent with science, while the 'other smart kids' found the border crossings 'manageable'. Learning can therefore go from being 'unmanageable' in an 'impossible' border crossing to learners feeling comfortable and at ease in the 'smooth' border crossing. That some learners found it easy to learn about evolution, as they report in their responses, suggests that these learners were comfortable and it can be inferred that the borders were easy for them to cross. Since these learners are non-Western, and cannot be expected to have a Western worldview which is compatible with modern science, then some other factors could have motivated them to learn. But other arguments have indicated that learning difficulties confronting African learners may not be peculiar to non-Western culture alone (Dzama & Osborne, 1999). Besides, the science they learn is not only Western in nature as it has aspects from other cultures. Also, as stipulated in the NCS, the curriculum recognizes other forms of knowing (DoE, 2003a) including that which emanates from their culture.

The results have shown that some learners were affected by their personal beliefs. Learners were influenced in three main ways: 'positively' where they were motivated to learn more or they enjoyed learning evolution, 'negatively' where they felt uncomfortable or even felt forced to learn against their beliefs, and some experienced 'no influence' and felt that they learned evolution in the same way they learned other Life Sciences topics. The learners who were influenced positively include those who felt good about learning evolution and those who wanted to know more about evolution. For these learners, the border crossings were either 'smooth' or

'managed', in that they were possibly able to cross not so much because the borders were permeable but because they were inspired to cross them. But 'managed' learning is included to indicate that the degree might have been different with some crossings being smoother while others were more difficult. Mostly those positively influenced were the learners who were 'for evolution' and found evolution enjoyable to learn. If someone wants to learn more about a concept, the implication is that they are finding it smooth to learn or that they are managing to learn it. The learners who experienced 'no influence' on their learning could have experienced any of the border crossing types, where they did not feel different because they were learning as well as they always had, or because learning science for them is always difficult and evolution was no different. For the learners who were influenced negatively, the possible border crossings are 'hazardous' to 'impossible' because the learners' life-worlds were so different to any which included evolution that it was impossible or almost impossible to learn about it and, as we have seen from the observations, this was due to the learners' religious beliefs.

These results also show that, despite having creationist beliefs and a religious worldview, most learners were still motivated to learn about evolution. From this it can be concluded that the influence on learning was positive, hence the motivation to want to know more about evolution. But care should be taken in making such a claim since there are other factors that can increase a learner's motivation to want to know more. There has been a growing interest in the role of affective constructs in learning and student achievement. It has been argued that knowledge of cognitive and metacognitive strategies is usually not enough to promote student achievement; rather, students must also be motivated to use the strategies as well as regulate their cognition and effort (Pintrich & De Groot, 1990, p.33). Some studies on self-regulated learning (Perry, 2002) and on conceptual change and the role of affective constructs have argued for the importance of considering both motivational and self-regulated learning components in models of classroom academic performance (Pintrich & De Groot, 1990, p.38), that students need to have both 'will' and 'skill' to be successful in the classroom, and that educators and teachers need to integrate these components in models of classroom learning (*ibid*.). The learners in the current study demonstrated a strong will to perform well and even those who had a negative attitude towards evolution did the same. As proposed by Sinatra *et al*. (2003, p. 511), rather than the learning being controlled exclusively by external factors such as the nature of the content or instruction, the learners play a significant role in choosing whether to consider alternative points of view. Bandura (2001, p. 10) has argued that efficacy beliefs "influence whether people think in ways that are self-enhancing or self-hindering" and that beliefs in one's efficacy "play a central role in the self-regulation of motivation through goal challenges and outcome expectations". Even if the motivation for learners to learn is encouraged by the teacher, it is the

learner who in the end makes the decision to learn and who follows that decision through by acting accordingly. Their belief in what they could do, perhaps, motivated by what they expected to achieve, could have also been the motivator for them to learn.

7.3.3 Factors affecting the formation of teachers' and learners' beliefs about evolution

The influence that the beliefs of both teachers and learners exercise on classroom instruction has been discussed in different parts of this thesis. To understand how those beliefs were formed was deemed important, particularly in relation to curricular and instructional design decision-making. Information regarding these beliefs was obtained from questionnaires administere to learners and interviews with both learners and teachers. Some of the field notes compiled during school visits also provided insights into aspects of belief formation by both learners and teachers.

7.3.3.1 Factors affecting teachers

Only five teachers took part in the study. For this reason, data derived was mainly qualitative and was even analysed qualitatively with no correlational analyses performed.

The themes that emerged from the analyses indicate that the teachers considered themselves to be Christian, and therefore their religious beliefs are based on their particular faith. Their religious orientations seem to have been a factor in their acceptance of evolution. Because of their particular deeply entrenched beliefs, teachers did not accept evolution as a valid scientific theory – except for James, who was in fact a pastor in his church. This teacher accepted evolution as valid, even though he pointed out that there were still some gaps in the theory. However, he saw in evolution a concept that complemented that of creation and that, like all science, theories of evolution were a means of interpreting what God had created. He attributed his attitude to the fact that he understood both creation and evolution well enough to see that. The position of accepting evolution, while being at the same time religious is of course not unique, but is common among scientists.

Although it cannot be said that the other teachers who denied some parts of evolution because of their religious beliefs understood less about evolution, it is important that this teacher thinks understanding is necessary in order to make a judgement. Some studies have found a strong positive correlation between an understanding of evolutionary theories and the acceptance of the concept of evolution (Athanasiou *et al*., 2012; Deniz *et al*., 2008). Most, if not all the major Christian churches, accept evolution without difficulty these days.

Although lack of acceptance of evolution was attributed to religious beliefs, in particular Christianity, it is actually not all forms of Christianity that do not accept evolution. It has been shown in earlier discussions (see Chapter 3) the it is mainly the Christian fundamentalists who deny evolution.

Only one teacher was female, while the other four were male, so not much can be said about the influence of gender, especially since in most cases the responses of the female teacher were similar to some of the male teachers' responses.

An interesting point, though, was the factor which related to teacher education on evolution, where the expectation was that the teachers who had not studied evolution in the course of their secondary education would experience more conflict over teaching about evolution than those who had studied evolution at that level. Four of the five teachers had not studied evolution at school; two had studied it at university, and one had studied it from secondary school through to university. The teacher who had studied evolution at secondary school was the one most conflicted by having to teach evolution; in fact, he claimed not to believe in in the whole of science. Another observation is that, of the two teachers who had not studied evolution at all in a formal setting, one was more strongly conflicted, while the other was more accepting of some parts of evolutionary theory. The difference between these two teachers was that the one who was not strongly opposed was more open-minded (Sinatra *et al*., 2003) or 'flexible' (Aikenhead & Jegede, 1999).

7.3.3.2 Factors affecting learners

Having established the characteristics of learners from their biographical data – and the distribution of such characteristics within the sample, as shown in section 5.2 – these variables were then correlated against the acceptance of evolution by learners, as presented in the results for MATE. It was expected that these variables would be significantly correlated to the extent that they would either endorse or constrain acceptance of the concept of evolution. As it turned out, variables like gender and the frequency of attendance at religious services might have an effect on belief formation, particularly where it would affect the acceptance of evolution. The variables which were found to be significantly related to the acceptance of evolution were age, the person from whom the respondent first heard about evolution, the amount of time elapsed since the respondent first heard about evolution, and the religion to which the learner belonged.

With regard to religion, it was found that learners were 'very religious', in that 94.83% of them belonged to some religion, while 93.68% were Christian. Data from the three sources: questionnaires, interviews and school visits, indicated that learners had strong religious beliefs.

This was further corroborated by their creationist views when they referred to the origin of species and to evolution.

Parental social status can influence the beliefs of learners. For instance, Deniz *et al*. (2008) found a strong correlation between the education level of parents and the acceptance of evolution by their offspring. The nature of the parents' education was not investigated in this study, but because the parents of these learners had high academic achievements (tertiary: 69.42%; secondary: 27.83%), it could be assumed that the life-world at home for some learners was somewhat inclined to 'modern scientific'. The modern lifestyle thus attributed to the education level of parents can be corroborated by the fact that some of these learners had heard about evolution from television (12.79%) and books (13.95%) as well as, for a few (1.74%), from the internet. That some had even heard about evolution from their parents is further substantiation of parental influence. However, as seen from the results, a school teacher seems to have been the first person that most learners had learned about evolution from, and possibly this had greater influence because of teachers' role of providing education in the community. Nonetheless, it seems safe to conclude that the person or first source of information about evolution is one of the factors affecting acceptance of evolution.

Another factor, not contextual like others discussed above and which seemed to be related to an acceptance of evolution, even though not correlated statistically, was the thinking disposition of learners. Those learners who were more open-minded in their attitude were more accepting of some or all parts of evolution, even when they stated being against the concept of evolution. Some of them were even happy to have learned about evolution, and wanted to know more about it, which is an indication of open-mindedness. Those who were strongly against evolution did not even want to be in class where evolution was taught. The effect of thinking dispositions on evolution acceptance has been addressed by other researchers (Deniz *et al*., 2008; Sinatra *et al*., 2003). Their studies found that the more open-minded an individual was in disposition, the more accepting of evolution. Thinking disposition could therefore be seen as one of the factors that influenced the acceptance of evolution by learners.

A study by Moore and Cotner (2009) found exposure to the concept of evolution during secondary education to be one of the determinants of the subsequent views of learners about evolution and their acceptance of it. It has been said that the way teaches are taught is one of the factors affecting understanding, misconceptions held, even how teachers teach (Nadelson, 2009). Perhaps, therefore, other factors such as how a teacher was taught and what he was taught in secondary school could have resulted in the tension that some teachers in this study experienced when teaching evolution. Of these five teachers, only one had learned about evolution in

secondary school and he still had difficulty accepting evolution. It cannot be said from this study whether this teacher's secondary education affected his current views, and nothing can be said of the other teachers because they did not learn about evolution at that level.

Another interesting finding was that four of the five teachers in this study felt that there was 'not enough evidence' for evolution. This observation relates to conceptual understanding of evolution or perceptions about the difficulty of arriving at that understanding. It suggests lack of understanding of the role of evidence about science, and in particular about evolution. Such a notion could have resulted from, possibly, poor science education received by these teachers. Since the learners also made the same kind of statement, it may be assumed that such a belief has been passed on to them by their teachers, which would suggest perpetual transmission of misconceptions by those who teach.

Some learners – 14.79% in the questionnaires and 33% of those interviewed – suggested the removal of evolution from the curriculum. A similar suggestion was encountered by De Villiers (2011), where students in his study perceived evolution to be difficult and more than 34% of them wanted it to be replaced in the curriculum, indicating a dissatisfaction with the idea of evolution on the part of school learners. If the student teachers who feel this way leave teacher education with such views, how will they deal with it in schools?

7.3.4 Teaching and learning strategies in evolution instruction

The research findings and earlier discussions indicated that teachers' beliefs influenced the strategies they used in the classrooms. Teachers' pedagogical beliefs, for instance, were influenced by epistemological beliefs as well as their efficacy beliefs. Teachers' religious beliefs and their worldviews influenced their understanding and acceptance of evolution and, more importantly, influenced their expectations of the learning and teaching processes.

7.3.4.1 Strategies to achieve meaningful learning

In the interviews, teachers stated that they planned for teaching about evolution differently to the way they did for other topics. Since they recognized the importance of prior knowledge when teaching, it was deemed essential to determine learners' preconceptions regarding evolution before giving instruction about it. In view of the fact that these preconceptions were perceived as important, teachers felt that if not handled properly, they could interfere with meaningful learning about evolution. To avoid this, the knowledge of those preconceptions was used in planning the content sequence and other instructional strategies.

Mostly, teachers used strategies that incorporated learners' beliefs in discussions which sometimes turned into arguments, in an attempt to reduce any conflict with those beliefs. This was done with caution, however, where the teachers directed the discussions and intervened when matters got out of hand and learners' emotions became heated. Some learners stated that they enjoyed the discussions and felt evolution widened their knowledge about the world, while others hated being in the classroom and wished they had the choice not to learn about evolution. Some felt that teachers were trying to assimilate them into a new understanding. Jegede and Aikenhead (1999, p.47) give two possible outcomes of assimilation: alienation of learners from their life-worlds, or the playing of the school games called Fatima's Rules which utilizes memorization and leads, mostly to rote learning. Considering that 94.83% of the learners belonged to some religion and that some of those learners were against the idea of evolution, as observed in their arguments and the sentiments they expressed, is there a possibility that even the learners who professed enjoying learning about evolution were simply going through the motions and playing these games? Jegede and Aikenhead (1999) show that even teachers can play by such rules, particularly if their goals and those of the learners are similar, and passing is the main goal. Teachers and learners will do whatever it takes to achieve that, even though no meaningful learning will be taking place. This is what happens when learners do not want to assimilate new knowledge, or when teachers do not feel convinced about this new knowledge.

Mashudu summed up the intentions of the teachers when she passionately showed how much she wanted her learners to learn meaningfully in the way she responded in the following vignette.

> Interviewer: *I noticed that your learners were arguing a lot in class and you allowed them the space to argue and raise their own views. I was wondering why you were using that strategy.*
>
> Mashudu: *... I don't want my learners to cram* [memorize]. *I want them to understand what they are supposed to learn. And they must analyse* [and] *they must interpret the information. If they cram, they will fail to answer.*

Returning to learning about evolution and the matter of border crossings, the role of the teacher is found to be different for different types of learners. For instance, as stated by Jegede and Aikenhead (1999), in order to achieve collateral learning teachers can act as 'coaching apprentices' for potential scientist learners, act as 'travel-agent culture brokers' for 'other smart kids', or as a 'tour-guide culture broker' for the 'I don't know learners' as well as for the 'outsiders'. To understand how the learners in this study coped with learning, we revisit the four kinds of 'collateral learning', which is the cognitive explanation of what goes on in border crossings as described by Aikenhead and Jegede (1999) and Jegede and Aikenhead (1999). In collateral learning, learners, particularly 'potential scientists', "construct scientific concepts side-

by-side with minimal interference from the indigenous concepts" (Aikenhead & Jegede, 1999, p.276). These authors identified four types of collateral learning as being: parallel, secured, dependent, and simultaneous, described in the following discussion.

Some learners in this study seemed to have managed to learn about evolution despite the conflict they experienced with their religious beliefs. For those learners where the conflict was not resolved, 'parallel' learning occurred. This type of learning takes place when the conflicting schema do not interact at all, or when the science concept is added to the long-term memory from which it will be retrieved when needed, such as during examinations. The strategy is also called the 'compartmentalization' technique or what Cobern (1996) referred to as 'cognitive apartheid'. Other learners were probably aware that they held both schema, the scientific schema concerning evolution and the religious schema concerning creation, and could use either one when it was convenient. These learners could have managed this by being open-minded (Sinatra *et al*., 2003) or by being playful, and flexible (Aikenhead & Jegede, 1999) which could have led to 'secured' collateral learning where the conflicting schemata interact. Such learners are aware that they are shifting between both worlds and hold on to each schema securely. This can also explain why many learners were confident that they would do well in examinations but still maintained their religious beliefs. There were some learners whose beliefs changed from being creationist to being naturalist after learning about evolution. These learners could have had a schema from the naturalist worldview or the domain of science challenging a schema from the religious worldview, whereby they were forced to modify their existing religious schema and restructure their religious worldview radically, leading to dependent collateral learning. But there were also learners who achieved 'simultaneous' collateral learning since they used their understanding of evolution from an indigenous perspective, that is, what was being communicated from their communities (humans coming from monkeys), to understand evolution from the scientific perspective (humans and monkeys having a common ancestor). This is achieved when the understanding of a concept in one domain of knowledge, such as in this case an indigenous one, is used to facilitate understanding of the same concept in a different domain, such as a scientific one. It has to be noted, however, that this process led to the misconception that humans evolved from monkeys or apes, found among learners who had difficulty in learning about evolution, some of whom even hid their beliefs during the learning process.

7.3.4.2 Strategies to manage tension and conflicts

It is acknowledged that the teaching and learning strategies which were meant to enhance learning, discussed in section 5.5.4.1, might overlap with what is covered in this section. The

strategies for managing tension and conflict are nonetheless discussed separately as a way to highlight the conflicts that teachers and learners experienced in the classrooms.

(a) Teachers' strategies

Although one of the teachers stated categorically that he experienced no tension because of his beliefs, the other four teachers had to find ways of managing the conflict they perceived existed between their beliefs and the concept of evolution. For the teachers who experienced tension, either within themselves or with their learners, or whose learners experienced such tension, the teaching strategies employed were meant to avert the conflict or ease the tensions when they arose.

Meadows *et al*. (2000) found four types of teachers in their study. Two of those types included teachers who were unaware of the conflict between religious beliefs and evolution and those who were aware of the conflict but consciously avoided the discrepancy by not being willing to confront it. This latter group chose to keep their religious beliefs separate from their knowledge about evolution. The relationship between evolution and religion could be that of 'conflict' or 'independence' in Barbour's (2000) typology – conflict because the two are viewed to be at war, or independence because they are viewed to be 'non-overlapping magisteria' (NOMA) as suggested by Gould (1999). The third and fourth categories represent, respectively, those teachers who were disturbed by the conflict and those who were managing it.

Teachers in the third category ask questions about which one prevails between their cognitive demands and religious beliefs, and perceive that choosing one is done at the expense of the other, leaving them in "real, deep and often emotionally painful conflict" (Meadows *et al*., 2000). Barbour (2000) sees such as being in conflict, hence the relationship – 'conflict' where evolution and religion are at war and incompatible. What makes it disturbing for them is starting to question their personal religious beliefs in line with their newly-found understanding of evolution, and as they begin to doubt their own beliefs, they experience deep and painful emotional disturbance. Teachers in this category may deal with their disturbance by either avoiding evolution, as in category 2, or they may be able to manage the conflict, as in category 4 of Barbour's (2000) typology. The implication here is that since these categories do not clearly show independence, a teacher in one category can slip into others. For instance, a teacher in conflict may fall into the independence strategy as they emphasise the positions of both evolution and creation in relation to the natural phenomena they are both trying to explain.

Teachers in the fourth category, aware of the conflict, "attempt to manage it by constructing mental models incorporating selected elements of evolutionary theory with a biblical

understanding of creation … a strategy that helped them to manage the conflict between their religious beliefs and evolutionary concepts" (Meadows *et al*., 2000). Teachers in this category include those who will accept some parts of evolution, such as non-human evolution, or the micro elements of evolution but not the macro elements. Even though they are managing the conflict, not accepting some parts of evolution is indicative of being disturbed. This category corresponds to the 'dialogue' or the 'integration' relationships of Barbour (2000) – dialogue because the teacher uses either religion or science to explain the other, or even tries integration so as to seek a closer partnership between the two, such that each needs the other to understand the phenomena they are both trying to explain. These two categories also do not show a clear distinction between them. In this sense teachers in *dialogue* category may easily fall in the *integration* category, or vice versa, because in each of these categories, there is some form of dialogue and some form of integration. Meadows *et al*. (2000) recognize that the degree to which teachers will manage the conflict depends on their personal theories, since some of them may be comfortable learning about evolution while others remain uncomfortable.

Hermann (2008) has described the various approaches that teachers use to cope when teaching controversial topics. His model also shows four approaches, described in Chapter 3. One of the approaches, 'affirmative neutrality', entails teaching from different vantage points without emphasizing what the teacher supports.

Teachers sometimes felt the tension, but they found ways of coping with their own conflicts and the learners' unwillingness to learn. For instance, Mashudu said the following:

> *With my own beliefs, how do I manage to deal with my own belief? … Umm I'm not that person who become who can, who become so emotional, I don't use my feelings, yah. Maybe I think it helps because, I just go I … I just see the work schedule and what I'm supposed to do, and try to find the strategy which I can use, what is the main focus? Why are we teaching … I try to, to have this question; why are we teaching it evolution? Then when I study the, the module, the … or the information then I think okay what is it important that learners at the end of this module must be able to understand* (Mashudu.2012.04.12).

In earlier discussion, Mashudu was depicted as a progressive creationist whose perception of the relationship between evolution and religion was one of independence. Mashudu revealed in the first interview that she felt very strongly against making her own beliefs known to the learners, because she felt that knowing her position might affect their learning.

Mashudu thus demonstrated 'affirmative neutrality' since she was approaching evolution from the scientific perspective, but also trying to do so from a religious perspective, yet she did not want to reveal her standpoint. Hermann suggests three other strategies: 'avoidance', where the

teacher avoids teaching evolution for one reason or another; 'advocacy', where the teacher moves student thinking to be scientific and accepting of evolution without discussing other alternative views; and 'procedural neutrality', where teaching involves eliciting students' views. The other teachers thus maintained neutrality in their teaching, since none of them avoided teaching about evolution or the controversial parts of it, such as human evolution and speciation, as none used the 'avoidance' strategy, and none were 'selective' (Griffith & Brem, 2004) – they taught everything as it is prescribed by the syllabus. Being selective also entails highly structured strategies (Griffith & Brem, 2004) with little room for learner input. The neutrality of these teachers was manifest when they elicited perspectives on evolution from the learners; otherwise they were also inclined to advocacy in that they were moving learners' thinking towards the scientific view as described by Hermann (2008) although none showed signs of being scientists (Griffith & Brem, 2004) and they only taught aspects of science. Teachers who tend to be neutral also do so because they are still conflicted (Griffith & Brem, 2004), although they are being respectful (Smith, 2010b) to their learners and learners' views about the topic; this is what all but one of these teachers were doing.

Although this strategy was suggested as 'conflicted' by Griffith and Brem (2004), it seems that teachers in this study were more 'respectful' in the strategy that they used, revealing their conflict, hence we adopt Smith's (2010b) 'respectful' category for this sample of teachers. Teachers were very careful not to hurt learner feelings, because they were also still affected the by some denialism. This was observed in lessons where teachers were careful when explaining the concepts, but it was also confirmed by the teachers, who indicated that they did not want to change the learners' views.

(b) Learners strategies

Among the learners, despite their having such entrenched religious beliefs, there were some who felt strongly that they wanted to learn and know more about evolution. To do this, when learning they separated their beliefs from the subject. Some even stated in interviews that they left their religious beliefs outside when they entered the evolution classroom. There were some learners who were still so confused that they did not know what to believe any longer.

Barbour's (2000) categorization can be used to assess the strategies used by learners and teachers alike, in dealing with the conflict between their religious beliefs and evolutionary concepts. In one interview, a learner stated that the religious beliefs she had before learning evolution had weakened since she opened up and understood about evolution. This learner, however, had always had some unanswered questions regarding the biblical story of creation, and she felt that

the concept of evolution gave her answers to those questions. She showed painful emotional disturbance. Although she had started with creationist beliefs, as she stated, now that she had learned about evolution, she felt it provided the answers.

> *Ya, I believe that the Bible says that people were created by God, and then ya, people were created by God. And how did God create those people? Because Adam and Eve just come on earth, we don't know where they are coming from, why can't people nowadays be created like Adam and Eve? So that's why I believe that evolution take place* (SCH.E.L7).

This learner had indicated earlier in the interview that she believed in evolution. However, her supporting statement came with a misconception about dinosaurs being ancestors of all the other species.

> *Mmm, I now believe in evolution. I believe that every species come from a dinosaur, and then, when times goes on, when they moved to different places, they tried to adapt at that situation, that's why they we changed to different kinds of animal all around the earth* (SCH.E.L7).

She includes another misconception: that people arose from apes, although this is a mistake that is easier to make, the distinction between 'apes' and 'ape-like' being quite subtle.

> *Ya, they have conflict, evolution is talking about people are risen from apes, and the Bible talks about people being created by God the way they are* (SCH.E.L7).

To illustrate the disturbance she was going through, this learner felt she had to choose between evolution and religion. Although she believed that she started out as a creationist, now that she had learned something about evolution, she felt she had to choose it over creation, and that was not an easy decision for her to make.

In spite of the conflict experienced by some learners which led to the disturbance in others, some learners showed a strong motivation to learn about evolution and perform well in its assessment. As discussed earlier, this motivation could have stemmed from learners' efficacy about what they were capable of doing. Bandura (2001, p. 11) has shown that "the likelihood that people will act on the outcomes they expect prospective performance to produce depends on their beliefs about whether or not they can produce those performances". That some of these learners showed a willingness to learn and stated that they were going to perform well in assessment on evolution gives a sense of their efficacy. According to Bandura, "a strong sense of coping efficacy reduces vulnerability to stress and depression in taxing situations and strengthens resiliency to adversity". Even though learning about evolution might not have been as deeply taxing a situation for many of the learners in this group, yet for those who were affected but still

believed they would perform well, perhaps they had efficacy beliefs that provided means for coping and remaining spirited in their learning.

7.4 DISCUSSION OF THE RESEARCH QUESTIONS

The findings presented in Chapters 5 and 6 indicate the beliefs that teachers and learners in this study have in relation to evolution. Also indicated is how these beliefs influence the way the teaching and learning of evolution takes place. Further, the strategies that teachers and learners used during instruction in evolution have been described. In the following sections, the findings for research questions are presented.

7.4.1 Teachers' beliefs and their influence on teaching and learning about evolution

As already reported, all the five teachers in the study were Christians and had corresponding religious beliefs. Despite these beliefs, these teachers were able to teach evolutionary theory and did not attempt to avoid the topic or any parts of it. They encouraged and motivated learners, and did not seem to be so affected by contrary beliefs that they could not teach. They did mention creation in their classes. However, except for James, these teachers insisted that evolution and creation were different and that learners should not confuse their beliefs with evolution. James, on the other hand, sometimes referred to the Bible to show his learners that evolution and creation were complementary, an indication that he believes science and religion complement each other. There was an attempt on the part of the other teachers to separate what they believed, which was creationist, from what they had to teach, which was scientific. The use of this strategy suggests that these teachers believe science and religion are separate and should be treated as such by the learners. However, as some of the teachers stated, this was done to avert any potential conflict which would result if the two were treated together, and as one of them – Thabo – stated, evolution is 'controversial'. To these teachers, therefore, evolution is a controversial issue, a suggestion that it poses challenges for teaching. To cope with the controversy, they separated their religious beliefs from evolution and some even encouraged their learners to do likewise. While this strategy might have helped them to cope, Sanders (2010) warns that it is denying both learners and evolution a fair deal.

The teaching strategy of 'discussion' prevailed in all the five schools. These teachers allowed learners to express their views, even when those views were against the concept of evolution. The use of this strategy suggests that the teachers had convictions about the educational relevance of such activities (Reis & Galvão, 2009), particularly when the topic taught is regarded as being controversial. It would also seem that, epistemologically, the teachers in this study

believed that knowledge 'was not only out there' but that learners could be part of the knowledge they were trying to construct and learn. These teachers handled learners who did not accept evolution by allowing them to voice out their opinion, and allowing learners generally to interact with each other on the topic. This strategy points the teachers to having approached the teaching of evolution with respect for learners' beliefs. By allowing learners to share their views, they showed a 'respectful' (Smith, 2010b) or 'conflicted' (Griffith & Brem, 2004) coping strategy, where they even assured learners that they were not trying to change their views.

The teachers also tried hard to present evidence that would convince learners that evolution was a valid scientific theory. Unfortunately, the evidence is only available to them by way of the textbooks, and was thus seen as not as concrete and as convincing as was required by the learners. These textbooks do not claim to constitute the necessary and sufficient evidence. The use of textbooks, therefore is limiting, since the evidence of evolution is abundant in places outside of the books. The role of the textbooks should be to point to the users, both teachers and learners alike, where evidence is available and what resources they need to access it. But, since another book, the Bible, is treated as evidence, they might not look any further than the textbooks for evidence. Regardless of how they approach this matter, that they try to produce evidence is an indication of a belief, on the part of the teachers, that concrete evidence can make learning more manageable and meaningful, and also about what constitutes 'concrete' evidence. In addition, by saying that there is not enough evidence or proof to support evolution, some of these teachers show lack of understanding and a misconception about evolution. For these teachers, they find it difficult to believe if they have not seen, which amounts to a model of science which according to Blancke, Maarten, Braeckman, De Smedt and De Cruz (2011), derives from a view that science is about doing experiments in laboratories and making direct observations.

Although some aspects of evolution were 'easier' for these teachers to teach, in that there were no chants of disbelief or disagreement from their learners, one area which was particularly contentious was that of human evolution. It was interesting to observe the teachers trying to convince their learners that humans also evolved, when they themselves did not believe such a thing. Although these teachers were creationists in their beliefs, they did not avoid teaching about evolution, nor did they teach only some parts and leave out others.

7.4.2 Learners' beliefs and their influence on learning about evolution

Since almost all the learners in this study were Christian they had creationist beliefs. The expectation was that these learners would find difficulties in learning about evolution because of

the perception held by the fundamentalist Christians that evolution contradicts the theory of creation as related in the Book of Genesis, which they believe to be true. Some of them were affected, even feeling that their God was being insulted by the concept of evolution. Some were torn apart and did not know what to believe. Some felt that their teacher was trying to persuade them to abandon their Christian beliefs and to accept evolution.

All the same, learning went on and some learners were even motivated to learn about evolution. However, this happened for different reasons. For some learners, learning more about evolution meant understanding science and passing in the examinations. For others, understanding more about evolution would enable them to prove that evolution was wrong and not valid, while creation as narrated in the Bible was the correct explanation of the origin and diversity of species. So, even with entrenched religious beliefs, learners found reasons to want to learn more and understand about evolution.

Despite their deeply-ingrained religious beliefs and difficulty in accepting the concept of evolution, the learners in this study still managed to learn about it. It can thus be said, from the findings of this study, that being religious or having a religious worldview does not mean one cannot understand and accept evolution – just as much as understanding and accepting evolution does not mean one should abandon religious beliefs.

7.4.3 Factors that influenced learners' and teachers' beliefs

For teachers and learners in this study alike, it seems that their background has been instrumental in the formation of their beliefs. That they referred to the Bible when making assertions during their arguments indicates that religion has been very important in the formation of their beliefs. While this is an obvious observation, it also shows that other factors have been responsible, including the factors that brought religion to the learners and teachers. Such factors include church, family and community. For example, the beliefs of James who is a pastor in a Christian church, and David who is an elder in a Christian church, are strongly influenced by their respective churches and their role as religious leaders in their communities. David was careful to say that he was not a preacher at school, but a teacher. As a teacher, his role was to tell learners what they needed to know, and they would choose what to believe after that.

As also discussed earlier, the kind of science education received seems to be contributing to the formation of beliefs. The perception from both teachers and learners who did not accept evolution, that there was not enough evidence for evolution may be indicative of the kind of

science education they received, where the role of evidence in science was either not emphasised or simply ignored.

7.4.4 Dealing with potential conflict

For teachers and learners alike, some tension was experienced with regard to approaching the subject of evolution. As a result, some teachers were not very open about their own beliefs, mainly concentrating on the delivery of the relevant curriculum content concerning evolution. This was particularly true for Mashudu, who would even try to discourage learners from discussing creation. To avert potential conflict, the teachers asked learners for their views regarding evolution. They encouraged learners to focus on learning about evolution as supported by science, and not to dwell on their religious beliefs. Teachers emphasized the nature of science to the learners, explaining how scientists come up with knowledge and thereby trying to justify the validity of evolution to the learners. During lessons they stressed that evolution was a scientific concept derived from observations and experimentation and therefore based on evidence, and they would use pictures in textbooks to show the evidence which existed in, for instance, fossils. In some instances this did not help much, as learners indicated that they did not believe what they were shown, some even saying scientists lie. One teacher, Tapfu, told learners they could not use beliefs when learning about evolution. As he told them, science and evolution were accepted through evidence, while the biblical version of creation and religion in general required the use of faith. David would remind learners that they were in a science lesson, not church. Therefore, learners were discouraged from trying to understand evolution based on their religious beliefs. This separation of religion and science was a strategy used by four teachers. The one teacher who found creation and evolution complementary approached the lessons by showing this complementarity. The learners in this teacher's class did not seem to be experiencing tension. They did have the opportunity to bring into the discussions their religious beliefs and the beliefs of their grandparents which were not based on Christianity but on African knowledge systems.

Perhaps learners also used the same strategy when they were studying on their own outside class, but during class they certainly expressed their beliefs. There were some learners who argued and quoted from scripture, especially the book of Genesis in the Bible, to support their arguments, showing that they were using their religious knowledge and beliefs in judging the information they were being given about evolution. But for most of them, rather than dwelling on the conflict, the willingness to pass in the examinations became a motivator for learning.

The strategies used in teaching could have been affected by the beliefs that these teachers and learners had about evolution, about how it should be taught and learned in order to maximize learning. We have seen that the scientific model of evolution has some connection with the biblical version of creation, in that they explain the same phenomena but from different vantage points: one from a scientific perspective, and the other as an issue of faith.

7.4.5 The use of multiple methods

As shown in previous sections, data for this research were obtained by multiple approaches. The use of measurement to establish acceptance of evolution by learners and then using open-ended questions and interviews to find out their views and beliefs about evolution enabled the corroboration of findings from one source. The interviews enabled us to understand how a group of learners which seemed to be as religious as revealed in the biographical information, could show moderate acceptance of evolution. Factors such as motivation to learn and pass examinations, change from creationist beliefs - probably from literal interpretation to a position where evolution could be accepted, were unravelled during the interviews. The strategies that both teachers and learners use in teaching and learning of evolution, and for some to deal with conflict, were also observed from the observations, and clarified in interviews. There were instances where data from observations seemed to be refuted by what was said in interviews. For instance, Tapfu, who had taught evolution by inviting learners' views and explained evolution to convince the learners, showing how scientists worked to come up with evolution, convinced me, as a non-participant observer in the class that he accepted evolution and understood the nature of science. However, he revealed in interviews that he did not believe in science and said that evolution was impossible and nobody knew was certain of it because it talks of things that happened when none of the present-day scientists were around. This is a completely different picture from that received in the classroom. However, this gave a picture of his beliefs as a Christian, but also how he coped with his own conflict during teaching, which he did by not showing his beliefs to the learner. It also gave a better understanding of the phenomena than if only observations were used as source of information.

7.5 SUMMARY

The majority of the participants in this study were Christians who held strongly to their religious beliefs. Beliefs are about what is perceived to be real and true. Truth and reality are determined for everyone by particular worldviews. These worldviews are determined by what people have been exposed to as they matured and learned more about their existence, the existence of the world and all that is in it – the whole universe, so to say. As stated by theorists, "worldviews

themselves … are a response to the problem of existence and meaning of the world, and at least sketch a subliminal answer to the ultimate question of existence" (Naugle, 2002, P. 61).

It seems that the teachers and learners in this study were looking for answers regarding existence. With two seemingly competing theories available to them, they felt they had to find one to accept or to believe in. Given that they were exposed first to the biblical version of creation, which gave them answers regarding their existence on earth, hearing about evolution brought conflicts and doubts to some, as it was not mentioned in the Old Testament and seems to present a different version of creation. They were faced with a choice to make and, because of initial exposure and belief in the biblical version of creation, they evaluated the validity of evolution in terms of their own religious perspectives or worldview. As already found in many studies (e.g. Clores & Limjap, 2006; Dagher & BouJaoude, 2005; Sinclair & Baldwin, 1996; Trani, 2004), the deeply-rooted religious beliefs of people interfere with their ability to view scientific evidence and appreciate the validity of scientific theories and concepts in an objective way. In one study, Mansour's (2008b, p. 1624) findings established that early and teacher education 'formative experiences' were interpreted initially by individual teachers through their religious beliefs. According to Mansour, the personal religious beliefs of teachers in his study were used as a filter for new experiences, working as criteria or bases for interpretations of new experiences. One may, therefore, reject a proposition as untrue simply because the basis for judging its validity is in an opposing worldview. Rejection of evolution on seemingly rational grounds was observed by Dagher and BouJaoude (1997) when students in their study rejected the theory of evolution for reasons that demanded proof. Similarly, learners and teachers in this study who were sceptical about evolution, would not accept evolution or who rejected it did so for what they considered to be lack of evidence, referring to evolution as a 'guess', a 'myth', 'not valid', 'not true' or 'not real'. These statements may be sentiments calling for proof that evolution is true, valid, real, not a myth and not a guess, without including an acknowledgement that proof may indeed be available.

For the teachers who believed in the creation by God of all species in their existing form, and for whom it was difficult to accept any other explanation regarding the origin and diversity of species, teaching evolution was a duty that they had to perform like any other. Some did occasionally feel frustrated, not knowing how to explain and convince learners, particularly when learners would not accept the idea of evolution, but argued strongly against it.

Although the study was not meant to compare schools, some of the observations reveal that the teacher had some influence on the way learners dealt with evolution in class. For instance, James, the teacher who stated that there was no conflict between evolution and creation, taught

his learners in a manner that they would also not see any conflict. During the interviews, learners from the same school were not as conflicted as some of those from the other schools. While the other teachers did not say that there was a conflict to the learners during teaching, they however did not bring the issue of biblical creation to class, but would instead try to dissuade learners from bringing their creationist beliefs to evolution discussions. Perhaps this perpetuated whatever conflicts learners were experiencing.

There were learners who considered that individual organisms would evolve, in their lifetimes, in response to environmental discomforts. It is true that environment affects evolution, as described by Darwin and Wallace in their theories. Also, environment affects development of individual organisms, including humans. The idea from the learners, though, has an element of environmental determinism, where the environment is thought to set limits to the development of humans, determining how they develop in their lifetimes. This idea suggests that individuals evolve out of choice, an idea resembling Lamarckism. It also suggests acceptance of evolution of individual life forms at, or below species level, but is silent on the evolution at the larger scale, or macroevolution, where a species can evolve into another. If only the micro elements of evolution are recognized by the learners, this can lead to disapproval of the macro elements and the denial that species can evolve into others, such as denying that humans and apes have evolved from a common ancestor that was of a different species, though ape-like.

What is indicated in this study is that evolution remains problematic for many science teachers (Nehm, 2009; Sanders & Ngxola, 2009), since they experience internal and external conflict over teaching it (Griffith & Brem, 2004). For science teachers, the classroom they operate in represents an intersection of science and society, challenging them to plan with, around, or through any controversy that may surface during instruction (Hildebrand *et al*., 2008, p. 1044). This necessitates an understanding of evolution by teachers as well as the ability to select and apply the appropriate pedagogy to enable learners to learn about evolution meaningfully. An explicit approach to teaching about evolution has been found to influence students' views of the nature of science by guiding them in the process of interpreting historical narratives within alternative perspectives (Abd-El-Khalick, 2001). Natural scientists are perhaps better able than lay people to understand the use of the term 'theory' because of their familiarity with the nature of science and the role that the methodologies of science have played and continue to play in the development of theories such as those which support evolution. Teachers of Life Sciences in South Africa, however, are not necessarily natural scientists. Nonetheless, for those who experience difficulty with understanding the nature of science, training may help them appreciate it and teach it to their learners. In this way, the appreciation of scientific theories – such as those

concerning evolution – for what they are would be achieved, and the understanding of core concepts enhanced. A similar suggestion has been made by Abrie (2010) who found that, when students' understanding of the nature of science improved, their understanding of what was meant by a theory and what constitutes as evidence in science improved.

Even though the 'creation-evolution debate' has not been experienced with the same depth in South Africa as it has been in other places, the current exposure to the concept of biological evolution at school level is likely to bring such debates to the fore. The discussions and arguments witnessed in the classrooms observed in the course of this study, and the comments from both teachers and learners, are indicative of tensions that are experienced by those who have deeply-rooted religious and personal beliefs. This study has confirmed what has been stated by Le Grange (2008a), that learners in South African science classrooms experience cognitive dissonance when learning about certain scientific phenomena. This has been true with evolution instruction in this study. Because teachers also have their personal philosophical dispositions about evolution, they seem to be experiencing some form of cognitive dissonance with regards to evolution, as their learners do. They have stated experiencing tension between their religious beliefs and the approach to evolution which affected the way they taught. This situation is possible in South Africa because teachers have been shown to lack sufficient understanding of evolution due to their entrenched beliefs (Chinsamy & Plaganyi, 2007). This lack of understanding may in turn affect their efficacy and how they plan and execute instruction about evolution. Teachers also relied heavily on textbooks which, and this could have resulted from lack of understanding. If flawed, the textbooks are likely to perpetuate the transmission of such flaws to the learners. It may also stifle teachers' creativity in terms of pedagogy and content delivered in evolution classrooms. Perhaps teachers were aware of such shortcomings when they suggested workshops or some form of training on how to teach evolution meaningfully.

In addition, the resilience of personal beliefs affected teachers and learners alike. As has been suggested, this resilience may be attributed to the fact that such beliefs are logical and valid within people's own paradigms (Ogunniyi, 2012). So, whatever else that one learns which does not fit into those paradigms is seen as illogical. This suggests that, if evolution does not fit into learners' paradigms, learning it is likely to "evoke inner tension, cognitive conflict and/or temporary retirement of students' active participation" (Schilders *et al.*, 2009) as was observed with some of the learners in this study. It was interesting, though, to notice that teachers were well prepared for the possibility that their learners would experience cognitive or psychological conflicts during learning, perhaps as a reflection of their own personal experiences. Whether the strategies they implemented in the classrooms stimulated meaningful learning or whether

learners simply played 'Fatima's rules' remains to be checked. All in all, however, these teachers felt they had done their best to prepare learners for examinations, and learners also felt that they were ready to tackle an evolution question if it cropped up in the Life Sciences examination. After all, this seems to be the ultimate goal: to have learners pass the high-stakes Grade 12 examinations at the end of their school career. The question of whether to 'know' or to 'believe' as a goal of evolution education is irrelevant, as the teaching of this topic is implemented in the schools and the curriculum elements are the important ones. It would seem that the ultimate implementers, the teachers, are left to resort to their own wits as they deal with this dilemma when preparing and implementing lessons in their classrooms. The question would be how well the individual teachers interpret the curriculum, and to what extent they implement it as expected. This issue touches on sufficiency of their training and not so much on their beliefs. But there is a possibility that teachers' religious beliefs influence the interpretation and how they carry out their teaching. If teacher's knowledge was insufficient, the issue of learner performance would not relate to beliefs of teachers and learners only. The way teachers prepare and teach the topic, how they align curriculum expectations to learners' activities and to assessment may also affect that performance.

Learners are at a stage in their lives when they are likely to ask questions about the purpose of life in general, the purpose of their own lives, where they originate and where they will end, as individuals and as people. Whereas religion provided answers to some or all of these philosophical and metaphysical questions, there obviously are other ways of understanding that origin, that purpose and that destiny. What remains is that teaching and learning about evolution does influence and have an effect on the way teachers and learners think about truth and reality, and the way in which they learn. When a topic such as evolution is surrounded by controversy in some parts of the world and it is introduced in the curriculum, it becomes a challenge to curriculum developers to avert possible problems with its instruction. The challenge for some teachers is two-fold: (1) lack of acceptance; and (2) teaching the topic to learners who do not believe in it, when teachers are in the same situation themselves and trying to convince learners to learn it. Seemingly, teachers as implementers and learners as recipients of the curriculum are affected by the change.

As has already been said by others, the purpose of teaching about evolution – or science for that matter – should not be to change people's beliefs, but to aim at bringing about an understanding of the concepts. Smith (2010a) even questions "the propriety of changing beliefs as a goal of public instruction in a democratic society". Otherwise educators could be accused of assimilating learners into a foreign culture (see Aikenhead & Jegede, 1999; Jegede & Aikenhead, 1999) or of

indoctrination (Smith, 2010a) or of making them to abandon that which is meaningful to them (Cobern, 1996). The teachers in this study tried to teach learners to understand how scientists work in order that they could appreciate that evolution is based on valid scientific theory. It would seem that teachers were teaching learners to 'know' and not so much to 'believe' evolution. This approach is in agreement with what has been stated by some writers that when it comes to evolution: the stance that belief is not an issue as long as learners know what it is they are learning and know how it works is the only one realistically possible (Anderson, 2007, p. 674). When teachers encourage their learners to leave their beliefs aside when learning about evolution, and when learners decided to do that, they were perhaps consciously or unconsciously avoiding a situation where they would use their beliefs to evaluate the validity of evolution. Instead, teachers were encouraging learners to evaluate evolution as a scientific concept, on empirical evidence – a stance that could enhance an understanding of the nature of science in a Life Sciences classroom. Regrettably, teachers did this amidst a dearth of resources.

All the same, within the limitations of the available resources and, to some extent, their own understanding of evolution, teachers tried to assist learners to understand the concept and to prepare them to do well in examinations. Teachers felt strongly that their role was not to change the beliefs of learners, but mainly to expose learners to the concept of evolution as another way of explaining the origin and diversity of species. This is in line with the notion that the goal of science education should not be to change the beliefs of learners but to promote knowledge and understanding (Cavallo & McCall, 2008; Clores & Limjap, 2006; Smith & Siegel, 2004). The choice to accept or to 'believe in' evolution was left to the learners. After all, the teachers themselves remained entrenched in their own religious beliefs. However, they wanted to teach learners in accordance with the curriculum, and felt they needed to be trained so as to be skilled to do so.

The results of this study thus indicate that evolution is problematic for some Life Sciences teachers, and have concerns about teaching it, a finding similar to Sanders and Ngxola (2009). Teachers therefore need to be trained in the teaching of topics like evolution, as has been suggested by others (Tatina, 1989; Nadelson & Nadelson, 2010). What should be included in teacher preparation programmes is a systemic approach in order to holistically address their content knowledge, which should look into their conceptions and misconceptions, their teaching strategies (Nadelson, 2009) as well as their own personal beliefs. One of the teachers asked me a number of times, in one of the interview and the discussion sessions when I visited the school: *"What should I do? … You know I really don't know what to do sometimes… Should I tell them* [learners] *about my beliefs, or should I not tell them? … Will it not affect their learning if I tell*

them what I believe in?" These questions and other similar ones mainly highlight the plight of teachers who want their learners to learn, but who are conflicted because of their own personal beliefs and are aware that the learners are conflicted in turn because of their personal convictions and beliefs, but do not know how to deal with the situation.

7.6 LIMITATIONS OF THE STUDY

Although the aim of the research was to describe accurately how the beliefs of teachers and learners influence the teaching and learning of evolution in schools, there were limitations to the design of the study. These may have had an effect on the external validity of the study, making it difficult to extrapolate the results to the rest of Vhembe District and beyond. These limitations relate to the choice of theoretical framework, the methodology used to collect data, including sample size, the questions asked in soliciting information from the participants, as well as to the procedures used in the analysis and interpretation of the data.

Where methodology is concerned, the first set of limitations can be discerned in the sampling techniques used, in which the participants volunteered to be in the study, and individuals with different information could have been missed out.

- Firstly, non-probability sampling techniques were used because of their convenience for selecting the samples for this study. This limited representativeness of the study sample of the rest of the population and hence limited generalizability of results.

- Secondly, the results of this study cannot be generalized to secondary school learners in other grades because only Grade 12 learners participated. Despite their being concepts related to evolution in the curricula of earlier grades, such as Grade 10, in South Africa the use of the term 'evolution' first appears in the Grade 12 syllabus (see DoE, 2003a). For this reason, only Grade 12 learners were selected to participate in the study, as it was assumed that they would be the best learner group from which to obtain the required information.

- Thirdly, learners who took part in the study were all of 'Bantu' (locally known as 'black') African descent. They belonged to the main cultural groups in Limpopo Province, being mostly VhaVenda, and they were mostly Christian. Similarly, all the teachers were black and Christian and only one of the five was not Venda.

As noted by Van der Riet and Durrheim (2006), generalizability is limited to the population from which the sample of a study is taken. This means that the other groups within the population that were not Christian or African or Venda, might have yielded different outcomes in this study.

- Fourthly, the selection of the sample from only five schools in the Vhembe District meant that not all the schools took part. Generalizability would depend on how representative the five schools were or how similar they were to the others. Since this representativeness was not established in the study, generalizability would again have been limited, especially where contexts of human interaction vary from those of the study sample. However, since this study used mixed meanings, this aspect of limitation was therefore countered by the fact that the interpretive approach to the study notes that meanings are highly variable across varying contexts.

The second set of limitations arises out of the data collection procedures. For instance, the study involved observations of lessons of which teachers were informed beforehand, being told that the purpose was mainly to observe how they normally teach evolution. However, the 'Hawthorne effect' might have resulted, as the teachers could have given special attention to the topic of evolution and treated it differently during the observations. A 'Hawthorne effect' occurs when subjects in a study change what they do in response to being observed. Similarly, the learners could have behaved differently simply because their behaviour was being captured by a 'stranger' in their classroom – 'stranger' because I only met the learners for the first time when I came to observe them. Since the study dealt with people's beliefs which reflect their social or cultural background, to some extent, the expectations I might have had of the participants might have affected their performance. As a researcher, I might have had certain expectations from these groups by virtue of their background and my own, and unwittingly passed on cues that influenced their responses, especially during interviews. Alternatively, the participants might have had expectations due to that background, their standpoint, the standpoint of the researcher, or other variables.

Still concerning data collection, another factor that could be a threat to the validity and trustworthiness of the results could have arisen from 'demand characteristics', which refer to the perceptions participants may have about the demands of the research. This could have resulted from the perception that I expected participants to be either pro- or anti-evolution, even though I did not consciously make my own position regarding evolution known to the participants before or during the research.

The third possible source of limitation is the questions asked in the course of data collection. As a Christian, a former secondary school Life Sciences teacher and currently a lecturer teaching Life Sciences student teachers, my personal bias may have had an impact on the design and content of the questions asked. Although the instruments were scrutinized by other people, it is

possible that I might have "inadvertently tip[ped] the scales" (Krathwohl, 1998, p. 521) in the choice and wording of questions, and by giving unintended cues for certain responses during interviews.

Lastly, the above mentioned limitations could further have been compounded by the choice of theoretical framework, which was informed by the worldview theory, and thus looked at beliefs as an indication of participants' worldviews. People's beliefs were presumed to be part of the participants' prior ideas and views which would influence instruction and learning effects in the approach to evolution. The theories chosen influenced my analyses and interpretation of the data, whereas employing a different framework with different presumptions could have given rise to a different outcome.

7.7 CONTRIBUTIONS OF THE RESEARCH

Despite the fact that the study had limitations, as outlined above, particularly affecting the extent to which the findings may be generalized, significant contributions may have been made in relation to education in South Africa about evolution. This study was conducted in the Limpopo Province, where such a study had not been conducted before. While studies of evolution education in South Africa had obtained information from secondary school teachers (see Sanders, 2010; Sanders & Ngxola, 2009) and prospective Life Sciences teachers in universities (see Abrie, 2010; Chinsamy & Plaganyi, 2007), some (Kagan & Sanders, 2012; Lawrence & Sanders, 2012), including this one, worked with secondary school learners. However, this study is the first has focussed on what happens in the classroom during instruction about evolution, juxtaposing the teaching and learning strategies to understand the dynamics of an 'evolution' classroom.

This research has revealed that the teachers and most learners in the study were practising Christians. Findings from the qualitative data from both learners and teachers reveal that both possessed creationist beliefs. Where such beliefs stemmed from the cultural background of the individuals, they were not expressed as such in classrooms, and were only revealed during interviews with some. These religious beliefs were based mainly on fundamentalist Christianity and a literal interpretation of the Old Testament.

Since the study explored the influence of the beliefs of teachers and learners on the teaching and learning of evolution, the high prevalence of fundamentalist Christian beliefs among the participants meant that the study actually investigated the influence of these beliefs. These particular beliefs dominated the discourse of the research, since the 'loudest voices' Chilshom (2002, 2003) were heard from the fundamentalist Christian believers in the study. Other beliefs

which learners mentioned in the questionnaires and some interviews, were not the basis for arguments against evolution.

Previous research has found that some Christians, particularly the fundamentalists, experience conflict over evolution and do not accept its validity. It was therefore not much of a surprise to find that both teachers and learners in this study experienced some conflict with evolution.

In this study, the influence of these religious beliefs manifested itself in teaching strategies, where teachers were encouraging learners to separate their beliefs from evolution. This happened despite the fact that teachers would sometimes make a point about religion or about divine creation. With regard to learning, the influence manifested itself in the refusal by some learners to accept the notion of evolution. However, the lack of acceptance did not always impede learning about evolution, as some learners became curious to know more about it, even though they were not prepared to accept it.

A surprise finding was the almost total abandonment by the participants of African traditional beliefs, and the uptake of Christianity. Although this result reflects the picture in the Limpopo Province, where it was reported in Chapter 2 that 1.4% of the population professed to belong to African religions during Census 2011 (Statistics SA, 2012), the expectation was that their views would reflect African traditional beliefs. In instances where traditional beliefs were mentioned, it seemed as if they were referred to as the beliefs of the past, which existed with 'grandparents'. Perhaps acceptance of Christianity suggests leaving behind the life of the past where traditional beliefs dominated, and embracing a new and modern way of life.

It has been mentioned throughout the report that beliefs influence the way teachers teach and the way learning takes. What makes this study original, is that it has explored the beliefs of teachers and learners in the Vhembe District of the Limpopo Province in relation to evolution education. The context is therefore different from other studies which investigated beliefs in relation to evolution education. For instance, the study by Kagan and Sanders (2012) took place with Jewish learners. As shown by the results of national censuses, the population in Limpopo consists of people who have diverse beliefs. In the study, the samples consisted of Black people only. The expectation was that these people would show a strong inclination to African Traditional belief systems. While the study does not say this is not the case in some affairs of these people, a surprise finding has been that the people in this study mostly declared belonging to the Christian faith. It was these Christian beliefs that were affecting how the teaching and the learning of evolution went. It was interesting to find that the teachers who experienced a conflict between their beliefs and evolution approached its teaching by separating their beliefs from evolution and

encouraged their learners to do the same. On the other hand, the teacher who, though declaring to be a Christian like the others but not finding evolution contradictory to his Christian beliefs, incorporated learners' and his own religious views when teaching. Learners of this teacher did not seem to be experiencing conflict between evolution in the same way as those from other schools. The teaching strategies that teachers use therefore, are influenced by their beliefs about evolution, such as whether they regard it as true, real or valid. This confirms that a teacher is a significant factor and perhaps a strong influence into how learners deal with evolution. It has emerged from the study, therefore, that religious backgrounds of the teachers and learners have a significant impact on their beliefs regarding evolution and on the way the teaching and learning of the concept is approached. Another factor that seems to have had a significant impact on the beliefs of these people regarding evolution was the way it was brought to them for the first time.

Another interesting finding from this study was that, despite experiencing a conflict between an acceptance of evolution and their religious beliefs, some of these teachers and learners did not avoid dealing with evolution in the classrooms. Motivation for teaching evolution on the part of the teachers seems to have stemmed mainly from their perceived obligation to meeting the requirements of the curriculum, while learners' motivation to learn had varyious origins.

7.8 RECOMMENDATIONS

Arising from what was observed in all the classes: teachers using discussions and allowing arguments, and the reports of both learners and teachers as to the value of these discussions, the question that comes to one's mind is how much authority learners had at the time of engaging in such activities – authority on their content as well as authority on what to say and how to say it.

Recent developments in science education include looking at argumentation as a strategy that can be used to facilitate learning in the science classrooms (see Ogunniyi, 2007a; 2007b; 2012). Perhaps there is need to investigate the argumentation strategy in teaching evolution. What was mainly happening in the discussions in the classrooms included arguments sometimes, as observed in this study. Learners would argue for and against evolution, and the arguments sometimes would go on until the bell went to indicate the end of the lesson. While such arguments were going on, teachers would sometimes wait and watch – careful, it would seem, not to take any side lest they alienate one side and strengthen any existing barriers to learning, if not create new ones.

Considering that the learners and teachers who participated in this study were all Africans, one would have expected that African traditional beliefs would dominate the discussions around the origin and diversity of species on earth. However this was not the case. The dominant worldview

in this sample was the Christian one, with a belief in one God who has created the entire universe and all that is found in it, with the fundamentalist view that nothing changed after creation took place, based on a literal interpretation of the Book of Genesis. Christianity came to South Africa with Western missionaries before and during colonization. It was therefore imported in a way similar to the way in which Western science was imported. It seems that Christianity was well adapted to African worldviews, perhaps one might say, more than modern science has been. The one teacher and the few learners who mentioned their indigenous beliefs in this study were quick to state that they did not adhere to such beliefs, but to Christianity instead. In the end, the tension that was observed in this study emanated not from the African traditional or indigenous beliefs but from Christian beliefs. From this one can assume that the philosophy behind Christianity was not as different from the African traditional beliefs as is modern scientific thinking. In that case, it would seem that it was easier for the learners in this study to learn and accept Christianity than it was to learn and accept science. Further investigations may help to clarify this assumption, and to highlight the areas where belief and judgement differ. In addition, the fact that Christian beliefs dominated the classroom discourse where beliefs were concerned could be a suggestion that Christianity has superseded African religions. Discussions for and against this point have been advanced but will not be addressed in this thesis. Regardless, investigating a possible ascendency by Christianity and other religions like Islam over African religions should provide an insight into the trends.

Furthermore, this study confirms the notion that religion –, whether of Western, African or other origin – is discordant with modern scientific thinking. Interestingly, Africans have been described as monistic, their view of the world and reality being one of a unified whole, while Europeans are dualistic, viewing the world as either spiritual (sacred) or secular, and seeing the two as separate. Without being overinvolved with this generalisation, investigating the nature of the influence by beliefs would be useful so as to understand at what point beliefs feature as a teacher prepares to teach evolution. This could help us understand if teachers are merely not able to interpret the curriculum, whereupon what they believe would not affect what or how they teach, or if their beliefs affect the way they judge and make meaning of the concept and how it is to be taught.

Jegede and Aikenhead (1999) have suggested a strategy that can assist with the learning of science in the African context: the ecocultural paradigm, a term they borrowed from Lugones (1987). This paradigm involves teaching science with the aim of enabling learners to be at ease in each culture: the culture of modern science and the culture of the learners' indigenous life-worlds. In the light of the outcomes arrived at in this study, this ecocultural paradigm may be

investigated for learners with a religious worldview, where it might be given a name other than ecocultural. The argument here is that all learners will learn with ease in their life-worlds, whether they be Western, African indigenous, or religious. The 'ecocultural' paradigm may thus be investigated within the religious or Christian setting.

This study did not include an investigation into the nature of science, although it was implied in the classroom behaviour and in the teachers' and learners' comments. There have been concerns regarding this area in the literature, where lack of understanding of the nature of science is said to affect the understanding of scientific concepts. It would be worthwhile thoroughly to investigate the extent to which teachers understand and teach the nature of science in their Life Sciences classrooms in South Africa, and the extent to which a proper understanding of the nature of science can enhance the acceptance and understanding of controversial issues like evolution. This is important and relevant since learners are expected from the curriculum to understand the nature of science. A similar suggestion was made by Abrie (2010) that teacher education programmes should not focus only on conceptual understanding but also on improving an understanding of the nature of science and dealing with conflicts in the classrooms. Investigations in this case could include the perceptions of teachers about the nature of science and its usefulness in science learning, as well as the extent to which an approach to the nature of science is incorporated in classrooms.

Some of the suggestions the teachers put forward to improve the teaching of evolution relate to teacher education and the curriculum. One such suggestion is for the Department of Education to hold workshops for teachers in order to assist them with regards to the teaching and learning of evolution. The importance of preparatory teacher programmes (Mansour, 2010; Rutledge & Mitchell, 2002) and continuing teacher education has been highlighted (Nadelson & Nadelson, 2010) in relation to evolution. This is relevant in South Africa in order to assist those teachers who may lack understanding about evolution, experience personal conflicts with the concept, or have difficulty in teaching the topic. This may require revisiting curricula at this level so as to emphasise the importance and centrality of evolution to Life Sciences. With regards to curricula at school level, considerations may be made on when and how evolution should be learned. As some teachers have suggested starting it in lower school grades, it would be worthwhile to investigate the feasibility of doing so.

With the cultural diversity found in South Africa, the extent to which knowledge being produced is reflective of the true diversity of knowledge and heritage (Odora-Hoppers, 2002) needs to be investigated. In other words, is the knowledge generated representative of the cultures of the

country? This question requires a stringent approach to an investigation of the diversity when generating knowledge that will accommodate all cultures and learners in the learning process.

7.9 CONCLUSION

The evolutionary theory has now been on the curriculum in South African schools for more than five years, having been examined in the secondary schools' final examinations for the past five years. Evolution is one of the concepts in the Life Sciences examinations in which performance is poor.

This study has perhaps highlighted some of the challenges that could be facing the teaching of this concept in South African secondary schools. With scientists agreeing that evolution is the major unifying concept in Life Sciences and other sciences, it is important that it is treated as such, not only in the curricula but in the classrooms as well. What is crucial is not only that the concept is taught, but that it is taught as a central theme. It seems that the teachers in this study teach evolution because it is in the curriculum. In that sense, although these teachers linked evolution to other topics such as genetics and environmental studies, it is not clear whether they make these connections because they consider it to be a unifying framework in the Life Sciences. The use of other topics seems to be mainly to support evolution and to enhance its understanding. For instance, one of the teachers stated the importance of teaching 'nucleic acids' before evolution as this would improve the understanding of evolution. Teaching evolution to explain the diversity of life forms existing on Earth was not noticeable. If one believes that all living individuals are created as they are, she/he might not use evolution to explain the diversity of life. Generally, evolution is mainly treated as a topic to be learned and passed in examinations without using it to enrich understanding of much of biology.

People in this country have diverse beliefs, some of which are strongly-entrenched religious and cultural beliefs. As reflected in the attitudes expressed by teachers and learners in this research, religious beliefs bring the theistic worldview, the idea that God exists and is creator of everything to the classroom where the content being taught bears a naturalistic worldview, in that it explains evolution as a scientific process and not through the involvement of the supernatural. According to one of the teachers, learners with theistic beliefs have a perception that their religion is under attack from the naturalistic evolutionary content of the curriculum, and thus feel that they have to defend their religion. Martin-Hansen (2008, p. 319) points that, in such classrooms where attack is being perceived, the "theistically minded students have become afraid, nervous and defensive". Life Sciences teachers may not have any control over the beliefs of learners who come to their classrooms. However, as planners of instruction, they need to be

aware that religious learners will have theistic beliefs, some of which may be perceived to be contradictory to evolution, affecting its acceptance and meaningful learning. The cultural or any borders that need to be crossed in order for evolution to be learned meaningfully need to be identified in the South African context, and strategies to smooth these borders should be found so that the learners can cross them with ease.

Although the study has been about beliefs, it does not attribute poor learners' performance in evolution education to beliefs of teachers and learners. An association was established between some characteristic variables of learners and acceptance of evolution. The type of association cannot be explained from this study. Regardless, in all strategies geared at enhancing the teaching and learning of evolution, the learners' views and beliefs, as well as those of the teachers, cannot be overlooked and need to be recognized, acknowledged and respected, so that learners and teachers alike may be empowered to be responsible for their own learning and actions. After all, the way teachers and learners have been socialized in the end contributes to what happens in the classroom.

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APPENDICES

APPENDIX 1: LEARNERS' INTERVIEW SCHEDULE

The influence of the beliefs of teachers and learners on the teaching and learning of evolution

1. Before learning about evolution at school, what were your views about the origin of species on earth?
2. How did these views affect your learning of evolution?
3. What are your views now? Ref. questionnaire: *Question 13.*
4. Please describe how you felt during the learning of evolution. *Ref. Q. 15, 17.*
5. Please describe your opinion regarding the inclusion of evolution in public schools' curriculum in South Africa.
6. Are you for or against the teaching of evolution?
7. How do you think you will perform in a question on evolution in the examinations?
8. What are your future career plans?

THANK YOU FOR YOUR TIME

APPENDIX 2: LEARNERS' QUESTIONNAIRE

The influence of the beliefs of teachers and learners on the teaching and learning of evolution

Dear Learner

In the Questionnaire that follows, I am interested in finding out your beliefs about theories of biological evolution and how your beliefs influence education in this area in schools.

Evolution is one of the topics in the Grade 12 syllabus which accounts for about 25% of Life Sciences Paper 2 marks in Senior Certificate examinations. The findings from my research will assist in the design of curricula and teacher education programmes.

In ***Section A*** you will be required to indicate your answer by circling an appropriate number in a shaded box.

In ***Section B*** you will be required to read a Statement and then circle a number in a shaded box on a scale from Strongly agree to Strongly disagree.

In ***Section C***, you will be required to write your responses in the space provided below each question.

There is also an opportunity for you to be interviewed.

You should understand that ...

- your participation in this research is *voluntary*, and that you can withdraw from it at any time.
- in line with the regulations of the University of Pretoria regarding the code of conduct for proper research practices for *safety in participation*, you will not be placed at risk or harmed in any way by participating in this research.
- your *privacy* with regard to confidentiality and anonymity as a respondent will be protected at all times and your answers will be bulked with those from other learners for statistical analysis.
- the research information gathered will be used for the *purposes of this inquiry only*.
- your *trust* will not be betrayed in the research process and in dissemination of its published outcomes, and you will not be deceived in any way.

You are requested to give your consent to participate in this research.

I hereby declare that I give my *informed consent* for participation in the research.

My name is:

Signature: _____

Date: _____

<u>If you would like to be interviewed please tick the box</u> ☐

Ms 'Mamotena Mpeta

1

For Office Use

Learners' Questionnaire: ***Exploring the influence of teacher and learner beliefs on evolution education***

Respondent number V1 [ ][ ][ ] 1

Please answer each question by drawing a circle around a number in a shaded box or by writing your answer in the shaded space provided

Section A: ***Biographical Information***

1. What is your gender?

Male	**1**	V2 [ ] 5
Female	**2**	

2. What was your age at your last birthday?

	V3 [ ][ ] 7

3. What is your religion? *(Please select a single answer)*

Christian, Catholic	**1**	V4 [ ][ ] 10
Christian, Pentecostal	**2**	
Christian, Protestant	**3**	
Christian, Zionist	**4**	
Muslim	**5**	
Hindu	**6**	
Jewish	**7**	
No religion	**8**	
Other (specify):		

4. How frequently do you attend religious services? *(Please select a single answer)*

more than once a week	**1**	V5 [ ] 13
once a week	**2**	
once a month	**3**	
once a year	**4**	
Never	**5**	

5. With whom do you attend religious services? *(Please select a single answer)*

alone	**1**	V6 [ ] 15
with your family	**2**	
with your friends	**3**	

Question 6 ***follows on the next page ...***

6. What is your cultural group? *(Please select a single answer)*

Afrikaans	**1**	V7	17
English	**2**		
Ndebele	**3**		
North-Sotho	**4**		
South-Sotho	**5**		
Swasi	**6**		
Tsonga	**7**		
Tswana	**8**		
Venda	**9**		
Xhosa	**10**		
Zulu	**11**		
Other (specify):			

7. How would you describe the community you come from? *(Please select a single answer)*

Rural	**1**	V8	20
Urban	**2**		
Suburban	**3**		
Other (specify):			

8. What is the highest educational level of your more educated parent/guardian? *(Please select a single answer)*

Tertiary	**1**	V9	22
High School	**2**		
Primary School	**3**		
Other (specify):			

9. From whom or where did you first hear about evolution? *(Please select a single answer)*

Parents	**1**	V10	24
Sister	**2**		
Brother	**3**		
Other relatives	**4**		
Friends	**5**		
School teacher	**6**		
Religious leader	**7**		
Television	**8**		
Books	**9**		
Magazines	**10**		
The Internet	**11**		
Other (specify):			

Question 10 ***follows on the next page ...***

10. How many years ago did you first hear of evolution? *(Please select a single answer)*

1 to 2 years ago	**1**	V11	27
3 to 4 years ago	**2**		
5 to 6 years ago	**3**		
7 to 8 years ago	**4**		
9 to 10 years ago	**5**		
More than 10 years ago	**6**		

11. What is **your single most important comment** about evolution?

V12 30

Section B: ***Rating of statements on Evolution***

12. Please **read each** statement below **carefully** and indicate your **answer** by **circling** an appropriate **number** in a shaded box for each statement.

	Strongly agree	Agree	Disagree	Strongly disagree		
Organisms existing today are the result of evolutionary processes that have occurred over millions of years.	**4**	**3**	**2**	**1**	V13	33
The theory of evolution is capable of being scientifically tested.	**4**	**3**	**2**	**1**	V14	35
Modern humans are the product of evolutionary processes that have occurred over millions of years.	**4**	**3**	**2**	**1**	V15	37
The theory of evolution is based on speculation.	**4**	**3**	**2**	**1**	V16	39
The theory of evolution is based on valid scientific observation.	**4**	**3**	**2**	**1**	V17	41
The theory of evolution is based on valid scientific testing.	**4**	**3**	**2**	**1**	V18	43
Most scientists accept evolutionary theory to be a scientifically valid theory.	**4**	**3**	**2**	**1**	V19	45
The available data are clear as to whether evolution actually occurs.	**4**	**3**	**2**	**1**	V20	47
The age of the earth is less than 20,000 years.	**4**	**3**	**2**	**1**	V21	49
There is a significant body of data that supports evolutionary theory.	**4**	**3**	**2**	**1**	V22	51
Organisms exist today in essentially the same form in which they always have.	**4**	**3**	**2**	**1**	V23	53
Evolution is a scientifically valid theory.	**4**	**3**	**2**	**1**	V24	55
The age of the earth is at least 4 billion years	**4**	**3**	**2**	**1**	V25	57
Current evolutionary theory is the result of sound scientific research.	**4**	**3**	**2**	**1**	V26	59
Current evolutionary theory is the result of sound scientific methodology.	**4**	**3**	**2**	**1**	V27	61
Evolutionary theory generates testable predictions with respect to the characteristics of life.	**4**	**3**	**2**	**1**	V28	63
The theory of evolution can be correct since it agrees with the Biblical account of creation.	**4**	**3**	**2**	**1**	V29	65

Section B: ***continues on the next page ...***

Section B: (cont.)

12. Please **read each** statement below **carefully** and indicate your **answer** by **circling** an appropriate **number** in a shaded box for each statement.

	Strongly agree	Agree	Disagree	Strongly disagree			
Humans exist today in essentially the same form in which they always have.	4	3	2	1	V30		67
Evolutionary theory is supported by factual historical data.	4	3	2	1	V31		69
Evolutionary theory is supported by laboratory data.	4	3	2	1	V32		71
I believe that evolution is the best explanation for the way the world has come to exist in its present form.	4	3	2	1	V33		73
Much of the scientific community accepts that evolution occurs.	4	3	2	1	V34		75
The theory of evolution brings meaning to the diverse characteristics observed in living forms.	4	3	2	1	V35		77
The theory of evolution brings meaning to the diverse behaviours observed in living forms.	4	3	2	1	V36		79
Organisms on earth came into existence at about the same time.	4	3	2	1	V37		81
Evolution is the best explanation for how the world of today has come to exist as we experience it.	4	3	2	1	V38		83
Evolution is the best explanation for how the organisms of today have come to exist in their current form.	4	3	2	1	V39		85

Section C: ***Open ended questions***

13. What is your **belief** about evolution?

V40			87
V41			90
V42			93
V43			96
V44			99

Question 14 ***follows on the next page ...***

14. Describe what you believe regarding the **origin of species** on earth.

V45			102
V46			105
V47			108
V48			111
V49			114

15. Describe how your **beliefs** influence your learning of evolution.

V50			117
V51			120
V52			123
V53			126
V54			129

Question 16 ***follows on the next page ...***

16. What is your **attitude** towards learning evolution in school?

V55			132
V56			135
V57			138
V58			141
V59			144

17. Describe **your experiences** with regards to learning evolution.

V60			147
V61			150
V62			153
V63			156
V64			159

Question 18 ***follows on the next page ...***

18. Indicate the **sources** you use to enrich your knowledge about evolution.

V65			162
V66			165
V67			168
V68			171
V69			174

19. Describe how you **feel** about the way your Life Sciences teacher is teaching evolution.

V70			177
V71			180
V72			183
V73			186
V74			189

Question 20 ***follows on the next page ...***

20. Provide **suggestions** you wish to make regarding the **teaching** of evolution in schools.

V75			192
V76			195
V77			198
V78			201
V79			204

Thank you for your time and co-operation

APPENDIX 3: TEACHERS QUESTIONNAIRE

The influence of the beliefs of teachers and learners on the teaching and learning of evolution

Dear Teacher

In the Questionnaire that follows, I am interested in finding out your beliefs about theories of biological evolution and how your beliefs influence education in this area in schools.

As you are aware, Evolution is one of the topics in the Grade 12 syllabus which accounts for about 25% of Life Sciences Paper 2 marks in Senior Certificate examinations. It is hoped that the findings from my research will assist in the design of future curricula and teacher education programmes.

You are requested to indicate your chosen answer by circling an appropriate number in a shaded box.

There is also an opportunity for you to be interviewed.

You are respectfully to understand that ...

- your participation in this research is *voluntary*, and that you can withdraw from it at any time.
- in line with the regulations of the University of Pretoria regarding the code of conduct for proper research practices for *safety in participation*, you will not be placed at risk or harmed in any way.
- your *privacy* with regard to confidentiality and anonymity as a respondent will be protected at all times and your answers will be bulked with the answers of other teachers so that appropriate statistics may be obtained.
- as a research participant, you will at all times be *fully informed* about the research process and purposes.
- the research information gathered will be used for the *purposes of this inquiry only*.
- your *trust* will not be betrayed in the research process and in dissemination of its published outcomes, and you will not be deceived in any way.

You are hereby requested to declare that you give your *informed consent* for participation in the research.

I give my informed consent to participate in the research of Ms M Mpeta

My name is: _____

Signature: _____

Date: _____

If you would like to be interviewed please tell me.
Ms M Mpeta (Cell: 084-305-7914)

***Teachers' Questionnaire*: The influence of the beliefs of teachers and learners on the teaching and learning of evolution**

For Office Use

Respondent number — V1 [ ][ ][ ] 1

Please answer each question by drawing a circle around a number in a shaded box or by writing your answer in the shaded space provided

1. What is your **gender**?

Male	**1**	V2 [ ]	5
Female	**2**		

2. What **was** your age **at your last birthday**?

	V3 [ ][ ]	7

3. What is your cultural group? *(Please select a single answer)*

Afrikaans	**1**	V4 [ ][ ]	10
English	**2**		
Ndebele	**3**		
North-Sotho	**4**		
South-Sotho	**5**		
Swasi	**6**		
Tsonga	**7**		
Tswana	**8**		
Venda	**9**		
Xhosa	**10**		
Zulu	**11**		
Other (specify):			

4. What is your religion? *(Please select a single answer)*

Christian, Catholic	**1**	V5 [ ][ ]	13
Christian, Pentecostal	**2**		
Christian, Protestant	**3**		
Christian, Zionist	**4**		
Muslim	**5**		
Hindu	**6**		
Jewish	**7**		
No religion	**8**		
Other (specify):			

5. How frequently do you attend religious services? *(Please select a single answer)*

For Office Use

more than once a week	**1**	V6		16
once a week	**2**			
once a month	**3**			
once a year	**4**			
never	**5**			

6. Besides being a Teacher, **what other role** do you perform in your **community**? *(You may select multiple answers)*

Religious leader	**1**	V7		18
Community leader	**2**	V8		20
Member of a non-governmental non-profit organization	**3**	V9		22
Business operator	**4**	V10		24
School Governing Body member	**5**	V11		26
Other (specify):		V12		28

7. What is your **highest** academic **qualification**? *(Please select a single answer)*

Senior Secondary Certificate / Matric	**1**	V13		31
Post School Certificate	**2**			
Post School Diploma	**3**			
Bachelor's Degree	**4**			
Post graduate Certificate in Education	**5**			
Post graduate Diploma in Education	**6**			
Honour's Degree	**7**			
Master's Degree	**8**			
Doctor's Degree	**9**			

8. For how many **years** have you been **teaching**?

	V14		33

9. For how many **years** have you been **teaching Life Sciences**?

	V 15		36

10. For how many **years** have you been **teaching Life Sciences in Grade 12**?

	V16		39

11. What is your **teaching experience** of **evolution** in **years**?

	V17		42

***Question 12** follows on the next page …….*

For Office Use

12. At what **stage** in your **own education** did you **study evolution**?

I have never studied evolution	**1**	V18		45
At High School	**2**			
At College	**3**			
At University	**4**			

13. How would you describe the **location** of the **school** you are now teaching at? *(Please select a single answer)*

Rural	**1**	V19		47
Urban	**2**			
Suburban	**3**			

14. From whom or where did you **first hear** about evolution? *(Please select a single answer)*

Parents	**1**	V20			49
Sister	**2**				
Brother	**3**				
Other relatives	**4**				
Friends	**5**				
School teacher	**6**				
Religious leader	**7**				
Television	**8**				
Books	**9**				
Magazines	**10**				
The Internet	**11**				
Other (specify):					

15. How many **years ago** did you **first hear** of **evolution**? *(Please give a single answer)*

		V21			52

16. What was your **main reaction** when you **first heard** of evolution?

	1	V22			54
	2				
	3				
	4				
	5				
	6				

Question 17 follows on the next page .....

For Office Use

17. What is your main feeling when you teach evolution now?

	1	V23			56
	2				
	3				
	4				
	5				
	6				

18. What is your **single most important comment about evolution**?

	1	V24			59
	2				
	3				
	4				
	5				
	6				

Thank you for your time and co-operation

APPENDIX 4: TEACHERS' INTERVIEW SCHEDULE

Interview questions

1. What do you understand by evolution?
2. Please indicate the sources you use to enrich your knowledge about evolution.
3. Please describe what you believe regarding the age of the earth.
4. Please describe what you believe regarding the origin of species on the earth.
5. What do you think of evolution as a scientific theory?
6. How do you feel when you have to teach evolution?
7. Please describe how your beliefs influence your teaching of evolution.
8. Please describe your experiences with regards to teaching evolution.
9. Please describe how you deal with learners who do not accept evolution as a valid explanation of the existence of organisms in the earth in their present form.
10. Please describe your opinion regarding the inclusion of evolution in public schools in South Africa.
11. Please describe how you think your learners will perform in questions on evolution in the final examinations.
12. What concerns are there regarding the teaching of evolution at your school?
13. Do you experience inner tensions between your beliefs and having to teach evolution? Please explain.
14. Do your learners ever experience inner tensions between their beliefs and having to learn evolution? Please explain.
15. Do you find that you plan differently for evolution than for other topics?
16. Do you try and find what ideas learners have about evolution before you start teaching it? If so, how does that help? If not why?
17. Please provide suggestions regarding the teaching of evolution in schools.

THANK YOU FOR YOUR TIME

APPENDIX 5: CLASSROOM OBSERVATION SCHEDULE

School: (*pseudonym*) _____ Teacher: (*pseudonym*)_____Date _____Time_____

Class observed _____Lesson number _____ Number of Learners _____

Topic of the lesson:_____

Lesson objective(s):_____

_____

_____

_____

Comments by the researcher:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Teacher's activities	Ticks	Learners' activities	Ticks	Notes / Comments
Classroom organisation				
• Teacher teaches from the front of class				
• Arrangement of learners				
Lesson introduction				
• Teacher reviews previous work				
• Teacher gives overview of lesson content				
***Teaching methods:* Teacher**				
• reviews learners' everyday knowledge related to evolution				
• provides well-designed materials (hand-outs, pictures, models, etc.)				
• employs learner-centred approaches (small group discussion, learner-led activities)		Learners participate in the group activities		
• invites class discussion		Learners initiate discussions		
• uses teaching media (technology, computer, video, overheads)				
• asks questions		Learners respond to questions		
• invites questions		Learners ask questions		
• answers questions				
***Teacher-Learner interaction:* Teacher**				
• solicits learner input		Learners are involved		
• involves a variety of students		Learners actively involved		
• varies strategies to suit different learner needs				
***Content:* Teacher**				
• Appears knowledgeable				
• Content is well organised				
• Explains evolution and related concepts clearly				
• Relates concepts to learners' experience		Learners bring a variety of experiences		
• Uses learning experiences appropriate to level of learning		Learners relate to evolutionary concepts		
• includes concepts on creation				
Other points (post observation)				

• English language used in discussions				
• Relevant content in evolution covered				
• Meets the curriculum expectations: -dealing with diversity -dealing with conflict				

APPENDIX 6: PACESETTER FOR LIFE SCIENCES GRADE 12, 2012

Pacesetter for Life Sciences Grade 12
2012

DATE	WK	STRAND	CONTENT	FORMAL ASSESSMENT	Date Complete	Signature
18/01 -20/01 (3 days)	1	Life at Molecular, Cellular & Tissue Level (6 weeks)	Nucleic acids: •DNA: structure, coding, replication, DNA profiling	Practical Investigation (Hands-on): •Conduct an investigation •DNA Extraction/Dissection •Preparing a wet mount/Using microscope •Scientific Report ;Drawing •Poster/pamphlet/Table •Graph		
23/01-27/01	2		•RNA; Protein synthesis; Gene mutation; DNA sequencing			
30/01-03/02	3		Meiosis & role of chromosomes ; Gametogenesis (revision); Genetic variation ; Genetic abnormalities; polyploidy ; Comparison of mitosis & meiosis			
06/02-10/02	4		Genetics: Terminology; Mendel's Laws; Mutations			
13/02-17/02	5		Genetics: Monohybrid genetic crosses			
20/02-24/02	6		Genetics: Genetic engineering, ethics & legislation			
27/02-02/03	7	Diversity, change & continuity (5 weeks)	Evolution: Origins; Early theories of evolution	Informal Assessment: Research: Report/ Poster •A genetic disease/ disorder •Genetic Engineering of a particular crop (GMO)		
05/03-09/03	8		Evolution: Natural Selection & speciation in terms of present knowledge			
12/03-16/03	9		Evolution: Evidence for Evolution: Fossils; Modifications by descent; biogeography; genetics			
19/03-23/03 (4 days)	10		Evolution: Human Evolution, Evolution in present times/ alternative explanations	**Controlled Test 1** (100 marks): Life at Molecular Level; Diversity, (up to wk 10) **Date:28/03/2012**		
26/03-30/03	11		Controlled Tests			
			HOLIDAY			
10/04-13/04 (4 days)	12	Life Processes in Plants & Animals (9 weeks)	Plant responses to the environment: Hormones; defence mechanism	Preparation & submission of CASS for Term 1 moderation		
16/04-20/04	13		Animal responses to Environment	Assignment: A short task (1 to 1 ½ hours) •Translation activities •Analysis and interpretation of data •Drawing/justifying conclusions. At least **2 skills** must be assessed during an assignment task. •Table •Graph •Calculation •Translation •Concept Map •Essay-writing •Case studies •Drawing		
23/04-26/04 (4 days)	14		Nervous system Central; Peripheral; Autonomic			
02/05-04/05 (3 days)	15		Structure & functioning of nerves; reflex arc			
07/05-11/05	16		Receptors/Sense Organs: Human eye			
14/05-18/05	17		Receptors/Sense Organs: Human Ear			
21/05-25/05	18		Endocrine System: Chemical coordination;			
28/05-01/06	19		Medical disorders			
04/06-08/06	20		Asexual vs. Sexual reproduction; Reproduction in Plants: Life Cycles, alternation of generations; Metamorphosis in Insects			
11/06-15/06	21	Mid-year Examinations:	Examination	**Paper 1**: • Life at molecular, cellular... (60%) • Diversity, change & continuity (40%) 150 marks; 2½ hrs **Paper 2:** Life Processes in Plants & Animals (wk 12 – 20) 150 marks; 2½ hrs		
18/06-22/06	22		Examination			
			WINTER HOLIDAY			
16/07-20/07	23	Life Processes •Reproduction (4 weeks)	Reproduction in flowers; importance of seeds; reproductive strategies	Finalisation and submission of CASS marks (Term 2) for Moderation		
23/07-27/07	24		Human Reproduction: Reproductive structures; Gametogenesis; Ovulation &Menstrual Cycle	Practical Investigation: Hypothesis testing Frac •Design an experiment •Germination investigation •Dissection of reproductive organs •Mark-recapture simulation •Line/ belt transect/quadrate sampling •Scientific report •Questionnaire/survey/ interview •Table •Graph		
30/07-03/08	25		Human Reproduction: Fertilization; Implantation; Gestation, Birth, Contraception; STI's;			
06/08-08/08 (3 days)	26	Environmental Studies: Population & Community Ecology (3 weeks)	Introduction & terminology: Species, Population, Community, Competition; Factors influencing the size of a population			
13/08-17/08	27		Population size; Human population; Social Organisation			
20/08-24/08	28		Community Structure (Symbiosis); Community change over time (Ecological Succession)			
27/08-31/08	29		Revision	**Controlled Test 2** (100 marks): Life processes: 60% Environmental Studies: 40% (wk 23-wk 28) **Date:24/08/2012**		
03/09-07/09	30		Preparatory Examination	Compilation of CASS marks for Term 3		
10/09-14/09	31		Preparatory Examination	**Paper 1:** DNA Genetics (60%); Evolution (40%) **Paper 2:** Life processes (60%); Environmental Studies (40%)		
17/09-21/09	32		Preparatory Examination			
25/09-28/09 (4 days)	33		Preparatory Examination			
			SPRING HOLIDAY			
08/10-12/10	34	Revision: All strands	Revision; preparing for the end of the year examination	**Paper 1:** (150 marks; 2½ hrs) •DNA Genetics (60%); •Evolution (40%); **Paper 2:** (150 marks; 2½ hrs) •Life processes (60%); •Environmental Studies (40%)		
15/10-19/10	35					
22/10-26/10	36					
29/10-07/12	37 - 42	Examinations	*Formal assessment: End of year Examinations*			

APPENDIX 7: PERMISSION FROM THE LIMPOPO PROVINCIAL DEPARTMENT OF EDUCATION

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION
OFFICE OF THE HEAD OF DEPARTMENT

Enquiries : Nemalili Eastern(Manager: Office of the HOD)
Tel Ext. : (015) 290 7702

Date : 17 December 2010

Mrs.M.Mamotena
University of Venda
Private Bag X5050
Thohoyandou
0950

Cell: 0843057914
Mamotena.Mpeta@univen.ac.za

Dear Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH: VHEMBE DISTRICT

1. Thank you for your e-mail dated the 15 December 2010 of which the content is noted. We are indeed humbled by the interest displayed by yourself on matters affecting our education system.
2. Your request to conduct research in Vhembe District for your Doctoral degree with the University of Pretoria is hereby granted. It is however important to indicate that prior arrangements to conduct the latter should be arranged in advance so that our work flow is not sacrificed.

1

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700 Private bag X9489, POLOKWANE, 0700
Tel.; (015) 290 7602/7655, Fax:; (015) 297 0937, E-mail: mnisivv@edu.limpopo.gov, ramukhadim@edu.limpopo.gov

The heartland of Southern Africa - development is about people!

3. Once more, we wish you all of the best in your studies and assure you of our cooperation in this regard.

Yours Sincerely

.....

17 December 2010

Benny Boshielo
Head of Department-Education
Limpopo Province

Cc: Senior General Manager: Mr.M.J.Thamaga
District Senior Manager: Dr.N.G.Rambiyana

2

APPENDIX 8: PERMISSION FROM THE VHEMBE DISTRICT EDUCATION OFFICE

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

VHEMBE DISTRICT

Ref: 14/7R
Enq: Ravele N.P.
Tel: 0159621029

DEPARTMENT OF EDUCATION
VHEMBE DISTRICT
DSM'S OFFICE
2010 -11- 10
PRIVATE BAG X2250, SIBASA 0970
TEL. 015 962 1313/4
LIMPOPO PROVINCE

Mrs. Mamotema Mpeta
Faculty of Education
University of Pretoria
0002

PERMISSION TO CONDUCT RESEARCH IN SOME HIGH SCHOOLS IN VHEMBE DISTRICT.

1. The above stated matter refers.

2. Your application for permission to conduct a research in some High Schools in Vhembe District on teaching and learning of the biological topic "Evolution" has been granted.

3. Before you embark on your research consider the following:

3.1. The Circuit offices and the schools should be notified well in advance before the visits.

3.2. Your research should be conducted outside school contact sessions in order to avoid disruptions of lessons

4. Wishing you all the best in your studies.

..... 10/11/2010

DISTRICT SENIOR MANAGER **DATE**

Thohoyandou Government Building, Old Parliament, Block D, Private Bag X2250, SIBASA, 0970
Tel: (015) 962 1313 or (015) 962 1331, Fax: (015) 962 6039 or (015) 962 2288

The heartland of southern Africa - development is about people!

APPENDIX 9: LETTER TO SCHOOL PRINCIPALS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

PRETORIA 0002
Cell: 084-305-914
Office: 015-516-2042
Email: m.mpeta@univen.ac.za
mbmpeta@yahoo.co.uk
19-03-2011

Dear Principal,

My name is 'Mamotena Mpeta and I am a PhD student at the University of Pretoria. I am carrying out a research on the teaching and learning of the biological topic 'Evolution' in schools in the Vhembe District. The main purpose of the research is to explore how the beliefs of teachers and learners influence the teaching and learning of this topic. I have been granted permission to conduct this research in Grade 12 classes in the Vhembe schools by the Limpopo Education Department and the Vhembe District Education Department.

I am requesting your permission to conduct this research in your school. The research will involve Grade 12 Life Sciences teachers and learners. Data will be collected from 2011 to 2012 in the following manner:

- **Two (2) interviews with each teacher participating in the research.** The first interview of about 45 minutes will be conducted immediately after the first lesson observed to access teachers' beliefs, views and past experiences with the topic. The second interview will be conducted after going through data from the first interview and the lesson observation to clarify issues emerging from the data and enable teachers to articulate the information. Interviews will be audio taped.
- **Classroom observations for lessons on Evolution.** During the observations, I will not take part in the activities of the lessons in any way.
- **Questionnaires for learners in the classes observed.** Responding to the questionnaire should take about 30-40 minutes.
- **Individual interviews with 6 learners from the school.** Each interview will take about 20-30 minutes. Interviews will be audio taped.

Participation in this research is entirely on voluntary basis. This means that everyone is free to accept or to refuse to take part. If one agrees to take part, but later changes her/his mind, she/he will be allowed to withdraw from the research at any stage without being asked any questions.

Participation of your school in this research will not harm the school or the participants in any way. The researcher will not interfere with normal activities in the classrooms, and there are no foreseeable physical injuries that could result to anyone from her/his participation. The

interviews will be conducted privately between the researcher and the individual participant in a private area. This will provide a safe and comfortable environment where the participant will be free to express his/her views. Any views expressed will be used for the purpose of this research only.

In addition, the identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorized user. To ensure the confidentiality, learners responding to questionnaires will be asked not to write their names or any information that will give their identity linking them to the questionnaire. The questionnaires will be coded with numbers which will be given to the learners to remember. Those who will be selected for interviews will be identified using these numbers and will be invited individually for the interviews at different times.

If you still have any questions regarding the purpose, procedures and activities of this research, please do not hesitate to contact me at any of the above-mentioned telephone numbers or email addresses. Should you wish your school to participate in this research, please sign in the form in the next page as a declaration that you give permission for the research to be conducted in your school.

Yours sincerely,

_____ _____

'Mamotena Mpeta (Mrs.) Date

Supervisor

_____ _____

Dr JJR de Villiers Date

INFORMED CONSENT DECLARATION

In terms of the ethical requirements of the University of Pretoria, I now request you to complete this form as an indication of your permission for Grade 12 Life Sciences teachers and learners at your school to voluntarily participate in this research:

I, _____(Principal) have read this letter and understand the terms involved. I confirm that I have been fully informed about and understand the purpose, procedures and activities of this research. The rights of teachers and learners regarding their participation have been fully explained to me.

With the understanding that participation in this research is voluntary, and that at any time of the research I may pull out my school, or any of the participants are free to pull out without any repercussions; and

on condition that the identity of my school and of the participating teachers and learners, and the information provided by the teachers and learners, are treated as confidential at all times, and that the participants will not be harmed in any way and there will be no risks involved with their participation, 1 hereby freely (**Mark what IS applicable**)

☐ **grant** permission

☐ **do NOT grant** permission

for Mrs. M. Mpeta to conduct the research in my school.

Signature: _____ Date: _____

Researcher's signature: _____Date: _____

Thank you for your time.

APPENDIX 10: LETTER TO LIFE SCIENCES TEACHERS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

PRETORIA 0002
Cell: 084-305-914
Office: 015-516-2042
Email: m.mpeta@univen.ac.za
mbmpeta@yahoo.co.uk
19-03-2011

Dear Grade 12 Life Sciences teacher,

My name is 'Mamotena Mpeta and I am a PhD student at the University of Pretoria. I am carrying out a research on the teaching and learning of the biological topic 'Evolution' in schools in the Vhembe District. The main purpose of the research is to explore how the beliefs of teachers and learners influence the teaching and learning of this topic. I have been granted permission to conduct this research in Grade 12 classes in the Vhembe schools by the Limpopo Education Department, the Vhembe District Education Department and the principal of your school.

I am inviting you to volunteer to take part in this research. The research will involve Grade 12 Life Sciences teachers and learners. Data will be collected from 2011 to 2012 in the following manner:

- **Two (2) interviews with each teacher participating in the research:** The first interview of about 45 minutes will be conducted immediately after the first lesson observed to access teachers' beliefs, views and past experiences with the topic. The second interview will be conducted after going through data from the first interview and the lesson observation to clarify issues emerging from the data and enable teachers to articulate the information. Interviews will be audio taped.
- **Classroom observations for lessons on Evolution:** During the observations, I will not take part in the activities of the lessons in any way.
- **Questionnaires for learners in the classes observed:** Responding to the questionnaire should take about 30-40 minutes.
- **Individual interviews with 6 learners from the school:** Each interview will take about 20-30 minutes. Interviews will be audio taped.

Participation in this research is entirely on voluntary basis. This means that you are free to accept or to refuse to take part. If you agree to take part, but later change your mind, you will be allowed to withdraw from the research at any stage without being asked any questions or giving any reasons.

Your participation in this research will not harm you or other participants in any way. The researcher will not interfere with normal activities in the classrooms. You participation will

involve only answering of questions and there are no foreseeable physical injuries that could result to anyone from her/his participation.

The identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorized user. To ensure privacy and confidentiality, you will not be asked to reveal your identity during the interviews or to give any information that could give away your identity. The interviews will be conducted privately between the researcher and the individual participant in a private area. This will provide a safe and comfortable environment for you to be free to express your views. Any views expressed will be treated in a strictly confidential manner and will be used for the purpose of this research only.

However, if you feel there is important information you want to share but to which you do not wish to be linked, feel free to write it down and put in the research box that will be in the school during the research period. Do not write your name or anything that could give away your identity. The personal information such as your age, religion, culture is not meant to identify you but to gather information that will enable the researcher to understand if and how such factors affect people's views and opinions about evolution.

Learners responding to questionnaires will be asked not to write their names or any information that will give their identity linking them to the questionnaire. The questionnaires will be coded with numbers which will be given to the learners to remember. Those who will be selected for interviews will be identified using these numbers and will be invited individually for the interviews at different times.

If you still have any questions regarding the purpose, procedures and activities of this research, please do not hesitate to contact me at any of the above-mentioned telephone numbers or email addresses. Should you wish to participate in this research, please sign in the form in the next page as a declaration that you voluntarily accept to take part in this research.

Yours sincerely,

_____ _____

'Mamotena Mpeta (Mrs.) Date

Supervisor

_____ _____

Dr JJR de Villiers Date

INFORMED CONSENT DECLARATION

In terms of the ethical requirements of the University of Pretoria, I now request you to complete the following section as an indication or your voluntary acceptance to take part in this research:

I, _____ have read this letter and fully understood what the study is about. I understand that

- my participation in this research is *voluntary*, meaning that I can choose to take part or not to take part from the beginning; and that if I take part, I am free to withdraw from the research at any stage without being asked any questions or having to explain anything.
- in line with the regulations of the University of Pretoria regarding the code of conduct for proper research practices for *safety in participation*, I will not be placed at risk or harmed in any way by this research.
- my *privacy* with regard to confidentiality and anonymity as a human respondent will be protected at all times, meaning that my identity will not be made known to any unofficial user and whatever I say will remain confidential.
- as a research participant, I will at all times be *fully informed* about the research process and purposes.
- research information, including the information I give during the research, will be used only for the *purposes of this research*
- my trust will not be betrayed in the research process and in dissemination of its published outcomes, and I will not be deceived in any way.

1 hereby declare that I (**Mark what IS applicable)**

☐ **give** my *informed consent* for participation in this research.

☐ **do NOT give** *informed consent* for participation in this research.

Signature: _____ Date: _____

Researcher's signature: _____Date: _____

Thank you for your time.

APPENDIX 11: LETTER TO PARENTS AND GUARDIANS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

PRETORIA 0002
Cell: 084 305 7914
Email: m.mpeta@univen.ac.za
19-03-2011

Dear Parent/Guardian,

(Only for learners who are below the age of consent, that is, below 18 years of age)

I am requesting your consent to have your child in Grade 12 as a participant in the research I am currently doing in schools in the Vhembe District. I am investigating how the beliefs of teachers and learners about the biological topic 'Evolution' influence the teaching and learning of this topic. I have been given permission to do this research in the school your child goes to by the **Limpopo Education Department** and the **Vhembe District Education Department**.

Data will be collected from 2011 to 2012 in the following manner:

- 2 interviews with one teacher for each class.
- Classroom observations for lessons on Evolution.
- Questionnaires for learners in the classes observed
- Interviews with 3 learners from the school.

You are assured that the identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorized user. I will also not interfere with any class activities during classroom observations. Participation in this research will not cause any risks to your child. Furthermore, participation is by choice and your child is free to pull out at any stage of the research without fear of any harm.

Yours sincerely,

--- ---

M. Mpeta (Mrs) Date

Supervisor

--- ---

Dr JJR de Villiers Date

In terms of the ethical requirements of the University of Pretoria, you are now requested to complete the following section:

I, _____ have read this letter and understand the terms involved.

On condition that the information provided by my child is treated as confidential at all times, that the research will not cause any risk to my child, and that participation is voluntary and my child is free to pull out at any time during the research without any effects, 1 hereby (**MARK what IS applicable**).

☐ **give** consent for my child to participate in the research.

☐ **do NOT** give consent for my child to participate in the research.

Signature:_____ Date _____

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

University of Pretoria
PRETORIA 0002
Cell: 084 305 7914
Email: m.mpeta@univen.ac.za
19-03-2011

Vhabebi / Vhaundi,

Ndi humbela thendelo yavho kha u shumisa nwana wavho a re kha gireidi ya 12 u vha tshipida tsha thoduluso ine nda khou I tshimbidza zwikoloni zwi re fhasi ha tshitiriki tsha Vhembe. Tsedzuluso iyo yo disendeka kha zwine vhadededzi na vhana vha tshikolo vha tenda uri zwi vha na thuthuwedzo kha thero ya Biology/Life Sciences nga ha thero ya ivolushini. Ndo wana thendelo I bvaho kha muhasho wa pfunzo fhano Limpopo na kha tshitiriki tsha Vhembe.

Thoduluso I do itwa u bva nga 2011 u swika nga 2012 nga ndila I tevhelaho:

- Inthaviwu luvhili na mudededzi muthihi wa kilasi
- U lavhelesa kufunzele nga u tou dalela kilasirumu musi hu tshi khou funzwa nga ha ivolushini
- Mbudzisotholi dza vhana vho dalelwaho kilasini hu tshi khou funzwa
- Inthaviwu na vhana vhararu kha tshikolo

Vha fulufhedziswa uri dzina la nwana wavho a li nga buliwi nahone mafhungo ayo a do vha tshiphiri. Nne-vho , mutodulusi a thi nga dzheneleli kha tshifhinga tsha ngudo dza vhana. Hone-ha, u vha tshipida tsha thoduluso a si khombe-khombe, Nwana u a tendelwa u litsha naho thodisiso dzi saathu u fhela hu si vhe na vhukando vhune a nga dzhielwa.

Wavho a fulufhedzeaho

_____ _____

M. Mpeta (Mrs) Date

Supervisor

_____ _____

Dr. JJR deVilliers Date

THENDELANO

U ya nga ha ndzudzanyo ya maitele a zwithu a Univesithi ya Pretoria, ndi humbela uri vha dadze tshipida tshi tevhelaho:

Nne, …….ndo vhala lunwalo nda pfesesa thodea dzothe. Ndi tenda fhedzi arali mafhungo ane nwana wanga a do netshedzwa a tshi do dzula e tshiphiri tshifhinga tshothe. **Ndi vhea luswayo fhethu ho teaho**:

☐ Ndi **nea** nwananga thendelo uri a vhe tshipida tsha tsedzuluso iyi.

☐ A **THI NEI** nwananga thendelo ya u vha tshipida tsha thodisiso iyi.

Tsaino ……. Datumu ……

APPENDIX 12: LETTER TO LEARNERS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

PRETORIA 0002
Cell: 084 305 7914
Email: m.mpeta@univen.ac.za
19-03-2011

Dear Grade 12 Life Sciences learner,

My name is 'Mamotena Mpeta and I am a PhD student at the University of Pretoria. I am carrying out a research on the teaching and learning of the biological topic 'Evolution' in schools in the Vhembe District. The main purpose of the research is to explore how the beliefs of teachers and learners influence the teaching and learning of this topic. I have been granted permission to conduct this research in Grade 12 classes in the Vhembe schools by the Limpopo Education Department, the Vhembe District Education Department and the principal of your school.

I am inviting you to volunteer to take part in this research. The research will involve Grade 12 Life Sciences teachers and learners. Data will be collected from 2011 to 2012 in the following manner:

- **Two (2) interviews with each teacher participating in the research.**
- **Classroom observations for lessons on Evolution:** During the observations, I will not take part in the activities of the lessons in any way.
- **Questionnaires for learners in the classes observed:** The questionnaire should take about 30-45 to give answers to.
- **Individual interviews with 6 learners from the school:** There will be one interview with learners which will take about 20-30 minutes. Interviews will be audio taped.

Participation in this research is entirely on voluntary basis. This means that you are free to accept or to refuse to take part. If you agree to take part, but later change your mind, you will be allowed to withdraw from the research at any stage without being asked any questions or giving any reasons.

Your participation in this research will not harm you or other participants in any way. The researcher will not interfere with normal activities in the classrooms. You participation will involve only answering of questions and there are no foreseeable physical injuries that could result to anyone from her/his participation.

The identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorized user. To ensure privacy and confidentiality, you will not be asked to give your identity during the interviews or to give any information that could give away your identity. The interviews will

be carried out between the researcher and the individual participant in a private area. This will provide a safe and comfortable environment for you to be free to give your views. Any views you give will be treated in a strictly confidential manner and will be used for the purpose of this research only.

However, if you feel there is important information you want to share but to which you do not wish to be linked, feel free to write it down and put in the research box that will be in the school during the research period. Do not write your name or anything that could give away your identity. The personal information such as your age, religion, culture is not meant to identify you but to gather information that will enable the researcher to understand if and how such factors affect people's views and opinions about evolution.

When answering the questionnaire, you will not be asked to write your name or any information that will give your identity and link you to the questionnaire. The questionnaires will be given numbers. You will asked at the end of the questionnaire if you also want to take part in the individual interview. If you show that you wish to be interviewed show by filling a form at the end of the questionnaire. Please remember your questionnaire number if you wish to be interviewed. Those who will be selected for interviews will be identified using these numbers and will be invited for the individual interviews.

If you still have any questions regarding the purpose, procedures and activities of this research, please do not hesitate to contact me at any of the above-mentioned telephone numbers or email addresses. Should you wish to participate in this research, please sign in the form in the next page as a declaration that you voluntarily accept to take part in this research.

Yours sincerely,

_____ _____

'Mamotena Mpeta (Mrs.) Date

Supervisor

_____ _____

Dr JJR de Villiers Date

INFORMED CONSENT DECLARATION

In terms of the ethical requirements of the University of Pretoria, I now request you to complete the following section as an indication or your voluntary acceptance to take part in this research:

I, _____ have read this letter and fully understood what the study is about. I understand that

- my participation in this research is *voluntary*, meaning that I can choose to take part or not to take part from the beginning; and that if I take part, I am free to withdraw from the research at any stage without being asked any questions or having to explain anything.
- in line with the regulations of the University of Pretoria regarding the code of conduct for proper research practices for *safety in participation*, I will not be placed at risk or harmed in any way by this research.
- my *privacy* with regard to confidentiality and anonymity as a human respondent will be protected at all times, meaning that my identity will not be made known to any unofficial user and whatever I say will remain confidential.
- as a research participant, I will at all times be *fully informed* about the research process and purposes.
- research information, including the information I give during the research, will be used only for the *purposes of this research*
- my trust will not be betrayed in the research process and when giving out the research outcomes, and I will not be deceived in any way.

1 hereby declare that I (**Mark what IS applicable)**

☐ **give** my *informed consent* for participation in this research.

☐ **do NOT give** *informed consent* for participation in this research.

Signature: _____ Date: _____

Researcher's signature: _____Date: _____

Thank you for your time.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	**CLEARANCE NUMBER :**	SM 11/02/01
DEGREE AND PROJECT	PhD The influence of the beliefs of teachers and learners on the teaching and learning of evolution	
INVESTIGATOR(S)	Mamotena Mpeta	
DEPARTMENT	Science, Mathematics and Technology Education	
DATE CONSIDERED	29 May 2013	
DECISION OF THE COMMITTEE	APPROVED	

Please note:

For Masters applications, ethical clearance is valid for 2 years

For PhD applications, ethical clearance is valid for 3 years.

CHAIRPERSON OF ETHICS COMMITTEE Prof L Ebersohn

DATE 29 May 2013

CC Jeannie Beukes
Liesel Ebersohn
JJR de Villiers
WJ Fraser

This ethical clearance certificate is issued subject to the following conditions:

1. A signed personal declaration of responsibility
2. If the research question changes significantly so as to alter the nature of the study, a new application for ethical clearance must be submitted
3. It remains the students' responsibility to ensure that all the necessary forms for informed consent are kept for future queries.

Please quote the clearance number in all enquiries.