Exploring Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies when mediating learning of evolution in Namibia

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not been previously submitted at any other university for degree purposes. Where I have drawn on the words or ideas of others, these have been acknowledged using complete references according to Departmental Guidelines.

Signature:  Date: 07 April 2017

Abstract

The Namibian Senior Secondary Certificate Examiners' Reports (2013) shed light on the topics in which learners often perform poorly and evolution is one of such problematic topics. Anecdotal reasons include religious views of teachers, opposition by learners to the topic, and inadequate understanding of the subject content knowledge. I have not come across any literature on evolution in Namibia that formally look closely at this problem. We do not have a clear idea of what is going on in Namibian science classrooms, when evolution is taught. We do not have a clear idea of the factors at play in the teaching of evolution in these classrooms, either when it is done well and completely or when it is not so. It is against this background that I was inspired to engage in this study which examined teachers' conceptions, dispositions and pedagogical strategies that they use when teaching evolution.

The study is underpinned by an interpretive paradigm, which afforded me an opportunity to understand the teachers' worldviews in relation to evolution. It also allowed me to gain insight on the pedagogical strategies that teachers use when mediating learning of the topic of evolution and its related concepts. Within the interpretive paradigm, a case study approach was adopted, using a mixed-method design generating both quantitative and qualitative data. Teachers from two regions, namely, the Hardap region and Khomas region, participated in the study. Data were generated using questionnaires, semi-structured interviews and lesson observations. Fifteen questionnaires were completed and from those questionnaires, the sample included six teachers (40%) from the Hardap region while nine teachers (60%) were from the Khomas region. For the interview, the sample included two teachers – one from each region. For the observations, I observed five teachers teaching evolution.

I presented quantitative data in tables and graphs, whereas the qualitative data was analysed inductively using Vygotsky's (1978) socio-cultural theory as a theoretical framework. In addition, I used Ogunniyi's (2006) Contiguity Argumentative Theory (CAT) as an analytical framework. These theories were used as lenses to interpret and make sense of the qualitative data, which I colour coded to form sub-themes. Thereafter, overlapping sub-themes were combined to form themes, which were linked to the research questions and in relation to literature/theory. Similarly, overlapping themes were combined to form analytical statements.

It emerged from the study that religious views did not play a large role in most teachers' views and attitudes towards the teaching of evolution. Instead, it emerged that lack of content knowledge on evolution is the main factor that influences teachers' views and attitudes towards teaching evolution in schools. This is quite profound, as the assumption is that when teachers are religious, the likelihood is that they would object to the teaching of evolution. In light of this, the study recommends that there is a need for professional development and support of science teachers, so that they are able to properly mediate the learning of evolution.

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CHAPTER ONE
SITUATING THE STUDY

1.1 Introduction

This chapter introduces my research, in which I explored Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies that they use when mediating learning of evolution in the Hardap and Khomas regions in Namibia.

It describes the context of the research and explains why I decided to pursue the study. A statement of the problem, research goal and research questions are provided. A brief summary of the theoretical frameworks and analytical tools used follow the background information. This is followed by the data gathering process and its justification in this study. I also elaborate on the significance of this study. Concepts relevant to the study are defined to ensure the reader has a clear understanding of what they entail. Finally, the chapter ends with some concluding remarks.

1.2 Namibian education system and demographic information

According to the Namibian National Planning Commission (2011), Namibia's population was estimated to be 2,147, 585 in the year 2011. This estimate explicitly takes into account the effects of excess mortality due to HIV/AIDS, which can result in lower life expectancy, higher infant mortality rates, higher death rates, and lower population growth rates. Namibia is a middle-income country, the considerable successes of which, rest on a strong multiparty parliamentary democracy that delivers sound economic management, good governance, basic civic freedom, and respect for human rights.

Upon its independence in 1990, Namibia inherited well-functioning physical infrastructure, a market economy, rich mineral resources, and a relatively strong public administration. However, the social and economic imbalances of the former apartheid system have left Namibia with a highly dualistic society. The structure of the economy has made job creation difficult, and poverty and inequality remain unacceptably high. These key challenges are at the top of the government's development agenda (Namibia. Ministry of Environment and Tourism [MET], 2002).

According to the United Nations Development Plan (2007), Namibia has made significant progress in addressing structural problems. For instance, access to basic education has become more equitable and primary health care services are widely available. Access to safe water and sanitation has improved, and sound public policies are helping to lay the foundation for gender parity. Additionally, new programmes have been launched to protect the country's environment and natural resources. Namibia not only maintains a social safety net for the elderly, disabled, orphans, vulnerable children, and war veterans, but also has a Social Security Act that provides maternity leave, sick leave, and medical benefits for the population. Nonetheless, human development challenges persist. Although Namibia is on track to meet the Millennium Development Goals for education, environmental, and gender issues, it faces daunting challenges in combating the HIV/AIDS epidemic, making it especially challenging to meet Millennium Development Goal Six.

1.3 Research site

Namibia is on the Atlantic coast of southern Africa. It is divided into 14 political and educational regions, namely: Hardap, Oshana, Kavango West, Kavango East Omaheke, Kunene, Ohangwena, Omusati, Karas, Erongo, Otjozondjupa, Oshikoto, Khomas and Kavango (see Figure 1.1 below).

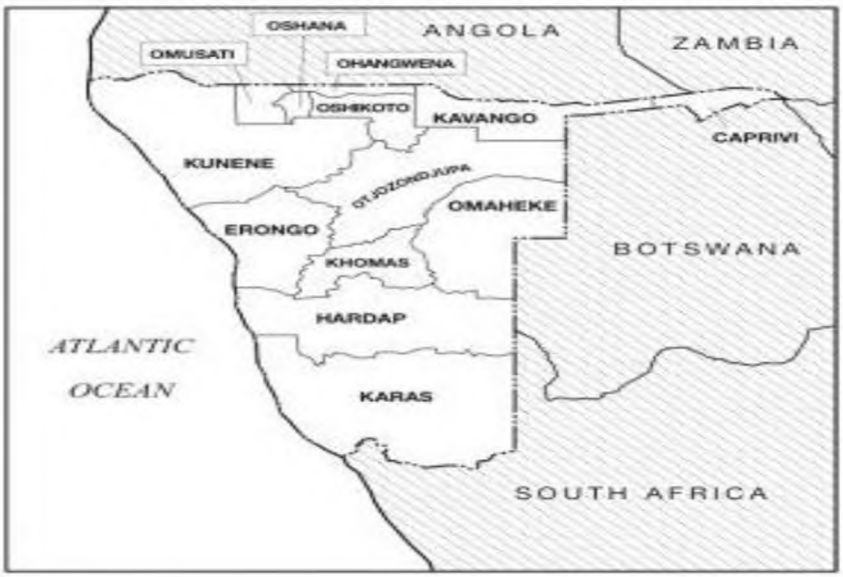

Figure 1.1: The Namibian map showing the different political regions

(Retrieved on the 12 July 2016 from https://www.google.co.za/search)

This study was conducted in two different regions, Hardap and Khomas. Hardap is situated towards the southern part of Namibia and its capital town is Mariental. It spans the width of Namibia, from the Atlantic Ocean on the west to the border with Botswana and South Africa on the East. The Hardap region is still developing economically and financially. Trade sectors in Hardap occupy 5.2% of the land of Namibia, and it has a population of about 79 000. The majority of people live in urban areas, are poor and thus have a lifestyle that is below standard. There are about 1 508 schools in Namibia, of which about 102 are privately owned. The Hardap region has 55 public schools and two private schools.

The Khomas region is located on the Khomas Highlands plateau, in the central part of Namibia, and contains the national capital, Windhoek. The Khomas region has well-developed economic, financial and trade sectors and occupies about 4.5% of the land of Namibia, but has an estimated population of 250,262. The majority of people in the Khomas region live in urban areas. The children are well taken care of and are given adequate education compared to other regions. Furthermore, the Khomas region has one of the highest employment rates compared to other regions of Namibia. The lifestyle of the people in the Khomas region is of a higher standard in relation to the Hardap region (Namibia. MoE, 2009). Due to its size, relative to other Namibian cities, Windhoek is the social, economic and cultural centre of the country, to a greater extent than many other national capitals. Nearly every national enterprise is headquartered there. The Khomas region has 104 public schools and 23 private schools.

This research was conducted at different schools in the Hardap region. I decided to conduct my study in this region because it is where I have been teaching for the past five years at a particular school where I came across the research problem. There are six secondary schools in this region, two of which participated in this study. The teachers from the other schools did not take part due to various reasons, such as them being overloaded with work.

Furthermore, this study was conducted in the Khomas region, which is situated in the central part of Namibia, because it is close to the Hardap region, and it was easy for me to move between the two research sites. It also has many secondary schools – Grade 8 to 12 – with enough Biology teachers that I could ask to assist me in the research study.

Biology is a compulsory subject in all the secondary schools in these regions. However, a small number of schools do not offer Biology on a higher level. From my experience, those schools are faced with the challenges of not having qualified teachers or not having the necessary equipment such as laboratories to conduct their practical sessions, which is part of the higher level syllabus.

Subject allocation for the teachers is done by the principal and the heads of department, and in some cases teachers are forced to teach subjects or grades that they are not comfortable with. This can be a problem as teachers do not teach effectively when they are uncomfortable with the topic. According to Shulman (1986, 1987), teachers' subject matter (content) knowledge and their general knowledge of instructional methods (pedagogical knowledge) are paramount for effective teaching. Pedagogical content knowledge is suggested as a third major component of teaching expertise. Therefore, teachers should teach subjects or topics in which they have sufficient content knowledge. This is very important as teachers teach most effectively when they are able to express themselves well.

In some of the schools such as Maryland Secondary School (pseudonym), in the Hardap region, learners can choose whether they want to do Biology or not, while in other schools they are forced to do the subject as it forms part of all the subject combinations. From my experience as a Biology teacher, I have found that the learners that are forced to do subjects that they do not like, tend to perform poorly in those subjects.

1.4 Significance of the study

Conducting this study may provide a better understanding of some of the factors that are shaping the teaching of evolution in Namibia, which could be of interest to science teachers, those involved in teacher development, and those managing science teachers and curriculum or textbook writers.

1.5 Research goal and questions

The main goal of this study was to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies that they use when mediating the learning of evolution. The study also aimed at examining possible enablements and/or constraints when Grade 12

Biology teachers mediate learning of evolution. To achieve this goal, the following questions guided the study:

1.5.1 Main question:

What are Grade 12 Biology teachers' conceptions, dispositions and pedagogical strategies that they use when mediating learning of evolution?

1.5.2 Sub-questions:

1. What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
2. What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
3. What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?
4. What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?

1.6 Theoretical frameworks and analytical framework

This study is informed by Vygotsky's (1978) socio-cultural theory (see Section 3.2) in conjunction with Ogunniyi's (2006) Contiguity Argumentation Theory (CAT) (see Section 3.3) as an analytical framework.

The social cultural theory of Vygotsky is used in this study as a lens to look at the pedagogic strategies the Grade 12 Biology teachers use when mediating learning of evolution. The theory was useful in this regard as mediation is central to it. Socio-cultural theory assisted me to shape thinking around mediation in the classroom. The socio-cultural theory also assisted me to identify the enablements and constraints, when it comes to the teaching of evolution.

On the other hand, I used Ogunniyi's Contiguity Argumentation Theory (CAT) as an analytical framework, which helped me to identify teachers' views and attitudes towards the teaching of evolution. CAT deals with the nature of interactions between distinctly different thought systems in the context of this study, *science* and *creationism*. According to Ogunniyi (2006), five cognitive states occur within an individual, when there are two or more

competing thought systems (in this case teaching of evolution in schools by possible Christian teachers). For this study I adopted Ogunniyi's (2006) five discernible cognitive states, namely, the dominant, suppressed, assimilated, emergent and equipollent (see Table 3.3).

1.7 Data collection techniques

In this study, I used the following data gathering techniques:

- Survey questionnaires;
- Semi-structured interviews; and
- Observations.

I used various data generation techniques to increase the validity and trustworthiness of the data; this is called triangulation (Cohen, Manion, & Morrison, 2011).

1.8 Definition of key concepts

Biology: The study of life and many living organisms. The syllabus content emphasises a broader scope than the basic science evident in the subject (de Klerk, 2010).

Evolution: The process by which different kinds of living organisms are believed to have developed from earlier forms during the history of the earth (de Klerk, 2010).

Conceptions: Different categories of teachers' ideas behind their descriptions of how they experience the teaching (Atallah, Bryant, & Dada, 2010).

Dispositions: A pattern of behaviour, thinking, and interaction towards something (Atallah et al., 2010).

Mediation: The process that involves a more knowledgeable other in the context of the study (Biology teachers) to help and guide learners to access and make sense of subject content (Vygotsky, 1978).

ZPD: The difference between learners' actual developmental level and their potential developmental level (Stott, 2016).

1.9 Thesis outline

This thesis documents data and findings from the different selected secondary schools in the Hardap and Khomas regions. It consists of seven chapters.

In Chapter One, I contextualise the study and briefly reflect on the reasons for selecting this specific research topic. I also highlight the significance of the study, the research goal, research questions and methodology. I briefly mention the theoretical and analytical frameworks that underpin the study and the methods used for gathering the necessary data for this case study are stated.

In Chapter Two, I present a review of all relevant literature to the study. The literature review is sub-divided into sub-units covering aspects of the literature on teachers' conceptions and dispositions towards the teaching of evolution.

In Chapter Three, I present the theoretical and analytical frameworks underpinning my study. Vygotsky's (1962) socio-cultural theory and Ogunniyi's (2006) Contiguity Argumentative Theory (CAT) were used as theoretical and analytical frameworks respectively. In this chapter, I explain the features of both theories and how they are linked to my study.

In Chapter Four, I present the methodology used in this study. I discuss the various data-generating techniques used in the study. In addition, I provide an overview of the research sites, research participants, ethical considerations, the trustworthiness and validity of the data, and the limitations of the study. I also explain how the two theories - Social Cultural Theory and the Contiguity Argumentation Theory - assisted me during my data collection.

Chapter Five presents, analyses and discusses the quantitative data from the survey questionnaires. These data sets are based on teachers' views and attitudes and is presented in graphs and pie charts. These data are mainly in reference to research sub-question 1, which is on teachers' views and attitude towards the teaching of evolution. I further present, analyse and discuss the qualitative data from the survey questionnaires (open-ended questions). This chapter also presents the data on the Biology teachers' conceptions, dispositions and pedagogic strategies when mediating learning of evolution. It then presents the data on enablements and/or constraints towards effective teaching of evolution. The data are in reference to all four of my research sub-questions.

In Chapter Six, I present, analyse and discuss qualitative data from the semi-structured interviews and the classroom observations. The data are in reference to four research sub-

questions. Data from these two data gathering techniques were colour coded to form sub-themes. I then combined the overlapping sub-themes into themes.

Chapter Seven summarises my findings and provides recommendations with regards to the teachers' conceptions and dispositions towards the teaching of evolution, and pedagogic strategies when mediating learning of evolution. It also discusses the limitations of the study and suggests areas for future research.

1.10 Concluding remarks

This chapter started by providing a detailed description of the context of the study. The chapter further provided the demographics and history of the research site and the underlying factors that informed this research. I presented the research goal and research questions. Finally, the chapter provided a brief overview of the study as a whole, outlining the different chapters of this research report. In the next chapter, I discuss literature relevant to my study

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The goal of this study was to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogical strategies that they use when mediating learning of evolution. This chapter thus reviews the literature in relation to teachers' conceptions and dispositions towards teaching the topic of evolution and their pedagogic strategies that they use when teaching evolution.

I explore various international perspectives regarding teachers' conceptions and dispositions towards teaching the controversial topic of evolution. The idea is to explore and identify different perspectives on the teachers' views and attitudes toward teaching evolution, and the factors that influence these. I also discuss literature on the topic of evolution, and its importance in the science curriculum. Furthermore, I review literature on the teaching of evolution, and the pedagogical approaches or strategies that can be used by teachers to enhance the learning of this topic. Finally, I explore the need to include evolution in the science curriculum (or not) and the effective pedagogical strategies for teaching evolution.

This chapter takes the following structure: I start by contextualising my research topic within the Namibian curriculum expectations. Then, I explore the teachers' conceptions and dispositions towards teaching evolution and highlight the importance of including evolution as a topic in the curriculum. Finally, I identify appropriate pedagogical strategies and discuss their effectiveness for teaching the topic of evolution, according to the different authors.

2.2 Background of the study

It is widely recognised that scientifically and technologically based world knowledge has become critical in understanding the world, in order to make good and well-informed decisions. Science education helps develop not only skills needed by the economy of modern societies, but also an awareness of many of the broader issues confronting society, such as climate change, natural hazards, natural resources, and evolution – which is the focus of this study – to mention a few. So, learners need to be taught science in order for them to become

familiar with modes of scientific inquiry, rules of evidence, ways of formulating questions, and ways of proposing explanations. Science also provides citizens with the tools needed for rational debate and sound decision-making based on scientific knowledge (National Research Council, 1996).

Science education is a priority in most countries, but it faces many challenges in the areas of teaching and learner performance. Learners in South Africa as shown by the Trends in International Mathematics and Science Study (TIMSS), for instance, performed poorly (Howie, 1997; Howie, 2004; Reddy et al., 2015). The TIMSS is a series of international assessments of mathematics and science knowledge of learners around the world. According to the TIMSS report of 2011, three countries (Botswana, South Africa and Honduras) continued to perform at the lowest end in both mathematics and science. This serves as evidence that learners' performance in science education is not at a desired level. Similarly, the Examiners' Reports in Namibia revealed a similar picture of lower than desired performance in science in Namibian schools. This begs the question as to why this is happening.

Research studies need be carried out, with particular reference to Namibia, to identify the main causes of the poor performance in science education, and in individual topic areas in particular. A number of Namibian studies on teaching and learning in individual science and mathematics topic areas, have already been conducted by Rhodes University Masters and PhD students. For example, there have been studies on how teachers scaffold learners in Biology (Kanime, 2015), improving pedagogical studies (Enghono, 2013) and the importance of practical activities in teaching Biology (Frans, 2015), to mention just a few. All these studies were conducted to try to better understand the causes and possible methods of improving learner performance in Biology.

The 2013 and 2014 Namibian Senior Secondary Certificate (NSSC) Biology Examiner's Report concluded that, ''some teachers are not teaching or covering certain parts or topics of the syllabus'' (p. 17) and that some topics were better covered than others. However, in this case the report is not specific as to the problem areas. In other Examiners' Reports problem topic areas in science education in Namibia were identified. In Biology, I can report that a Biology workshop in 2014 that was attended by about 30 Namibian teachers who explored

the teaching of the subject and the use of 'practicals' in the subject. Some time was also spent sharing views and opinions on the challenges in the teaching of evolution.

Conversations with various teachers at this event revealed that they felt that there were religious concerns, the topic was complex, and some felt they did not have mastery of the content. One indicated that he tried to avoid teaching the topic while another Biology teacher said that he did not have a problem with teaching the topic, although he does not believe in evolution. He indicated that he is also teaching it for a colleague at his school who refuses to teach evolution because of its conflict with her religious beliefs.

In addition to this, as a Biology moderator for Grade 11 and 12 question papers, I have noticed that some teachers include few questions on evolutionary concepts when they set the examination question papers. I have also noticed when I moderate Grade 12 Biology marked scripts that many learners omit or skip evolution-related questions. This suggests that there might be a problem with the topic of evolution.

These seem to be some of the factors at play, making the teaching of evolution problematic in some Namibian classrooms; clearly inviting the topic to be researched in greater detail so as to better understand how it is actually being taught and some of the factors at play. The quality of education received by the learners is determined by, among others, the conditions of schools, the training of teachers and improved methods of teaching and learning (Namibia MoE, 2009). This has contributed to the choice of this study to investigate the constraints and enablements of evolution education in schools.

2.3 Curriculum expectations

The Namibian Senior Secondary Certificate of Education (NSSCO) syllabus for Biology is designed as a two-year course leading to an examination after completion of the Junior Secondary Certificate. The syllabus is designed to meet the requirements of the Curriculum Guide for Formal Senior Secondary Education for Namibia and has been approved by the National Examination, Assessment and Certification Board (NEACB). It is composed of many different topics including evolution – which is the focus of this study – that is covered during the Grade 11 and 12 academic years. Teachers are obliged to teach all the topics appropriately and effectively to the learners. As a result, the curriculum spells out that no

topic should be skipped or ignored, as the learners should learn everything that is in the syllabus. The curriculum requires the learners to be assessed on everything that is covered in the syllabus, as the aim of education is to develop and increase learners' knowledge.

The Namibian Senior Secondary Certificate (NSSC) adds that Biology aims at increasing the learners' knowledge and understanding of the physical and biological world of which they are a part. In Namibia, the teaching of evolution is compulsory, as the topic forms part of the syllabus. The Biology syllabus for the Namibia Senior Secondary Certificate [Higher] (NSSC) [H] clearly states in the general objectives, that learners should know that the transmission of genetic information from generation to generation leads to continuity of, and variation within, a species. The syllabus also places emphasis on what evolution is and further requires learners to explain how natural selection leads to evolution. The syllabus therefore includes many evolutionary concepts that the learners need to learn and understand.

According to the curriculum requirements, learners develop knowledge, skills and attitudes to be able to lead a healthy life. They learn to manipulate and relate to the natural environment in the value-framework of the sustainable use of matter, energy and processes of living and non-living things. The Natural Sciences learning area thus comprises Environmental Learning (Pre-Primary); Environmental Studies (Grade 1-4); Natural Science and Health Education (Grade 5-7); Elementary Agriculture (Grade 5-7); Life Science (Grade 8-10); Agriculture (Grade 8-12); Biology (Grade 11-12); and Physical Science (Grade 8-12), in Namibia. The way this learning area is arranged is very important and beneficial, as it allows the learners to build on existing knowledge. The learners can use their prior knowledge they gained in the lower grades, to develop or learn new concepts.

2.3.1 Prior knowledge

The teacher's work of facilitating students' learning never ends. In order to facilitate learning, one of the fundamental principles teachers should employ, is understanding learners' prior knowledge. It is well known that learners build on what they already know and come to understand or learn, through formal and informal experiences. So, it is important for Biology teachers teaching evolution, to assess prior knowledge very early in the semester, since the knowledge learners possess may either promote or hinder their learning.

Through assessment, the teacher may come to know the extent to which learners' prior knowledge is accurate or inaccurate. When prior knowledge is inaccurate, the teacher may need to spend some time helping the learners to come to terms with their misconceptions, before they can go on to help the learners build new knowledge. The ease or difficulty of such a task may lie in learners making a conscious or unconscious decision to hold on to such misconceptions. In such a case, the inadequate and inaccurate prior knowledge will tend to hinder learning. As indicated earlier on, the teacher may benefit from spending some time to determine the extent and nature of learners' prior knowledge and skills. This may ensure that the learners develop their prior knowledge by linking it with the new knowledge, which is one of the values of the Namibian National Curriculum Guidelines.

The Namibian National Curriculum Guidelines recognise and promote the following values:

- Recognise that learning involves developing values and attitudes as well as knowledge and skills;
- Self-awareness and an understanding of the attitudes, values and beliefs of others in a multilingual and multicultural society;
- Encourage respect for human rights and freedom of speech;
- Provide insight and understanding of crucial global issues in a rapidly changing world, which affect quality of life: the AIDS pandemic, global warming, environmental degradation, distribution of wealth, expanding and increasing conflict, technological explosion, and increased connectivity.
- Recognise that as information in its various forms becomes more accessible, learners need to develop higher cognitive skills of analysis, interpretation and evaluation to use information effectively; and
- Seek to challenge and motivate learners to reach their full potential and to contribute positively to the environment, economy and society.

To this end, the syllabus aims at providing well designed studies of experimental and practical science – a worthwhile educational experience for all learners, whether or not they are going to study science beyond this level NSSC [H] (2010). In particular, it enables them to acquire sufficient understanding and knowledge. The syllabus also aims to prepare the learners for studies beyond the NSSCO [H] level in pure sciences, in applied sciences, or in

science-dependent vocational courses (ibid). Learners thus need to be taught the different topics in Biology, including evolution, so that they can have a clear mind about different biological topics, in order for them to be able to decide on their future careers. It further aims at developing learners' attitudes towards the subject (Biology in the context of this study). This is very important as Biology covers different topics that may be controversial and this can influence the learners' attitudes towards the subject.

Lastly, the syllabus informs the learners that scientific theories and methods have developed, and continue to do so. As a result, learners need to learn and understand the different theories and concepts, for examination purposes. It is acknowledged, however, that all these aims can be achieved when the teachers are teaching the learners all the topics effectively, by using well thought out and appropriate teaching strategies that can promote learning of all these topics. If teachers teach only certain topics that they are comfortable with and omit some, this will affect the learners' performance. This corroborates with Sanders and Ngxola (2010) who state that learners omit or skip questions in examinations, when they are not taught about that topic in school. They further say that markers for the Life Sciences matriculation examination paper in 2008 in South Africa, reported that learners from a number of different schools had simply omitted evolution-related questions, although these made up about half of the second paper – suggesting that the topic of evolution had not been taught in their schools. In the next section, I discuss the teaching and learning of evolution.

2.4 Teaching and learning of evolution

The teaching and learning of evolution raises public disagreements in many countries. In 2002 there appeared to be a creation and evolution disagreement in the United Kingdom, where this public disagreement made headlines in the national press and on television (Williams, 2008). The public disagreement arose from the statement that creationism was being taught by a certain school (Williams, 2008). In a similar vein, Wiles (2008, p. 54) describes a "burning issue" where teachers in America said that they "won't, don't or can't teach evolution properly". In the editorial of The American Biology Teacher, Wiles (2008) states that 12% of Biology teachers in Oklahoma would rather teach creationism than evolution. In a survey done by the National Science Teachers Association (NSTA) in the United States (NSTA, 2005), 30% of the teachers surveyed indicated that they felt coerced by their communities to overlook or downplay evolution and the related topics when teaching. A

further 31% of teachers felt that they had to include alternatives to evolution in their teaching of evolution (NSTA, 2005).

The situation in South Africa is similar to that in the United States in that most of the teachers are against the teaching of evolution (Stears, 2006). The previous curriculum, influenced by Christian Nationalist Education, did not require that evolution be taught as a biological concept, because it conflicted with the religious beliefs of the then government (Lever, 2002). In contrast, the present curriculum requires that evolution be taught as a biological concept, and this has raised concerns among many South African teachers. The religion/evolution controversy is one source of anxiety highlighted by Sanders and Ngxola (2010) in their study, and affects teachers' views and attitudes toward the teaching of evolution. In the next section, I discuss why evolution ought to be taught.

2.4.1 Why teach evolution?

About forty years ago, geneticist Theodosius Dobzhanksy, a major contributor to the foundation of modern biology wrote the now famous words, that nothing in biology makes sense, except in the light of evolution (Dobzhansky, 1973). At that time, Dobzhansky was encouraging Biology teachers to teach evolution to their learners, in spite of religiously motivated opposition. In my view, this statement about evolution is as valid now as it was then.

Essentially, evolution explains biodiversity, illustrating that an abundance of different organisms inhabit the earth. It accounts for the fact that certain organisms that look different to each other are related and that other organisms that appear to look alike are only very distantly related. Evolution can provide an explanation for the appearance of humans on the earth and our biological connections to other organisms. Evolution also explains how we humans acquired our traits and how groups of humans are related to one another. Evolution tells us why the living world appears the way it does (Farber, 2003). It provides us with an understanding of these aforementioned questions. It also addresses questions such as, why do organisms have highly specialised functions that permit them to live in hostile environments (hot springs), or in extraordinarily limited environments.

Learners need to learn the importance of preserving and conserving our environment as proposed by the National Research Council (1996). Evolution is regarded as a cornerstone for

education in Biology, and is incorporated into the standards for grade school Biology recommended by the National Research Council and the Next Generation Science Standards (Dobzhansky, 1973; National Research Council, 1996; NGSS Consortium of Lead States, 2013). Evolution has long been considered an important part of scientific literacy (American Association for the Advancement of Science, 1990, 1993), and it is considered integral in higher education in the biological sciences (Alters & Nelson, 2002).

Miller, Scott and Shinji (2006) state that evolution informs practice and progress in areas from medicine and biotechnology, to environmental policy and public health, which makes the widespread rejection of evolution a serious public concern. Petto (2008) maintains the belief that the teaching and learning of evolution has immense practical value that extends beyond just understanding our world. According to him, the principles of evolution underlie improvements in crops, livestock, and farming methods. The natural selection for instance, accounts for the rise in pesticide resistance among agricultural pests and informs the design of new technologies to protect crops from insects and disease. Evolution is also further intended to help learners to develop testable questions that can be answered by scientific investigation. This encourages critical thinking among the learners. Petto (2008) concurs with Miller et al. (2006), and posits that the understanding of evolution is necessary to learners, as it might help the learners to develop an understanding of medicine.

The International Society for Evolution, Medicine and Public Health emphasises that understanding evolution is central to the advancement of medicine. Indeed, the entire field of evolutionary medicine is devoted to using the principles of evolution, to study and treat human illnesses and diseases (Nesse & Stearns, 2008). Concepts such as adaptation and mutation inform therapies and strategies, to combat pathogens including influenza (*ibid.*). Knowing the evolutionary relationships among species, allows scientists to choose appropriate organisms for the study of diseases, such as HIV/AIDS. Scientists are even using the principles of natural selection to identify new drugs for detecting and treating diseases such as cancer (Nesse & Stearns, 2008).

Agreeing with Nesse and Stearns (2008) on the significance of application of evolution in the field of medicine, Newton (2011) accentuates reasons why evolution should be included in the syllabus and why it should be taught to the learners in schools. Firstly, according to him, evolution helps us understand the origin of HIV; because we know that HIV shares a

common viral ancestor, this opens other avenues of research into ultimately defeating HIV. Secondly, evolution makes sense of the need for a new vaccine every year, and points the way towards developing it. Thirdly, the origin of antibiotic-resistant organisms is a textbook example of natural selection. Patients infected with a diverse population of bacteria are given an antibiotic that wipes out almost all the bacteria. If they start to feel better and do not finish the full course of antibiotics, what is left behind are those bacteria most resistant to the drug. Those survivors then become the nucleus of a new, resistant population. Understanding this evolutionary process is an important part of modern public health, and thus learners should gain knowledge of this so that they can know and understand the importance of completing or finishing their medication, even if they feel recovered. This is all useful information that learners can gain from learning evolutionary concepts and that is why this topic should be included in the syllabus and be taught appropriately to Namibian learners as well, as omitting or removing evolution could deprive learners of fundamental biological knowledge.

Removing evolution from the science classroom or allowing it to be compromised, not only deprives learners of a fundamental tenet of biology and medicine, but will undermine their understanding of how scientific knowledge is amassed. For this reason, teachers should understand that evolution is a very important topic that should be taught to learners. Teachers should accept evolution and teach the concepts appropriately to the learners, as the topic is very relevant.

In light of the above-mentioned, teachers as mediators of learning are obligated to teach the concepts of evolution, to help learners reach their Zone of Proximal Development (ZPD) as proposed by Vygotsky (1978). Teachers should teach these concepts despite their personal beliefs and attitudes towards the topic of evolution.

2.4.2 The controversy associated with the teaching of evolution

According to Branch and Scott (2007), despite the obvious need for teaching evolution, there is still much controversy in America whereby science teachers are on the front line of the evolution war. This war according to these scholars, are being fought on two fronts: in the courtroom and in the classroom. Thus, there is enormous pressure being placed on some teachers in some American classrooms, to include creation science or intelligent design as alternatives to evolution (Branch & Scott, 2007; Clough, 1994; Sharpes & Peramas, 2006).

Research done amongst certain groups of teachers in America revealed that there were some teachers whose lack of belief in evolutionary theory affected their teaching, to the point that they taught evolution superficially or did not teach it at all (Aguillard, 1999; Rutledge & Warden, 2000; Trani, 2004; Wiles & Branch, 2008). Over the years, many surveys and polls have been administered to the general public in order to assess teachers' acceptance of evolution (Kight, 2012). Results from these studies indicated that more than half of all Americans reject evolution and favour alternative explanations, such as intelligent design (*ibid.*).

There are several reasons why evolution and its teaching constitute a controversial issue in many countries (Miller et al., 2006; Nehn & Schonfeld, 2007). For example, evolution is believed to contradict some religious beliefs, which affect teachers' attitudes toward evolution (Miller et al., 2006). In addition, surveys have found that many high school Biology teachers reject evolution and instead identify with creationism (Moore, 2007). This then influences the teachers' views and attitudes negatively towards the teaching of evolution. Studies (Aguillard, 1999; Rutledge & Mitchell, 2002) have shown that religious beliefs and subject knowledge are the factors that influence teachers' conceptions and dispositions towards the teaching of evolutionary concepts. Rutledge and Mitchell (2002) emphasise that religious beliefs are the dominating factors that influence many teachers' views and attitudes towards the acceptance and teaching of evolution.

In many countries, there are still problems around the acceptance of evolution being taught in schools, by some members of the community (Rutledge & Mitchell, 2002; Mohlala, 2007). In the United States for instance, a group of Christian parents instituted legal action in 2005 to challenge the implementation of teaching evolution in schools, because they felt that it undermined their notion of God (Mohlala, 2007). This shows how religion, which is one of the factors that influence teachers' conceptions and disposition towards the teaching of evolution, also influences parents. Miller et al. (2006) maintain that American adults, including teachers who pray regularly and believe in God, were more likely to reject evolution. In their analysis of Zoology learners in South Eastern Louisiana University, Sinclair and Pendarvis (1997) found that the religious beliefs of learners interfered with their ability to be objective regarding scientific evidence. They also established that learners who were very religious rejected evolution, and they felt that there was a dichotomy between religion and the acceptance of evolution.

In addition, research done amongst learners revealed that some teachers had strong prejudices against evolution, often because of their religious beliefs (McKeachie, Lin & Strayer, 2002; Blackwell, Powell, & Dukes, 2003). Furthermore, research has indicated that the negative attitudes of teachers towards learning about evolution, affects their willingness to teach it. A high proportion of teachers who do not believe in evolution omit or do not teach the topic – this results in learners performing poorly in this topic (McKeachie et al., 2002; Sanders & Ngxola, 2010). In the United Kingdom there is an increase in the number of Muslim teachers in schools and this has also impacted on the learning of evolution (Ashrif, 1998). There is an increase in the number of teachers that do not accept evolution in the United Kingdom and learning of evolution by the learners has become increasingly difficult (BBC news, 2007). Miller et al. (2006) state that acceptance of evolution in Islamic countries like Indonesia, Pakistan, Egypt, Malaysia, Turkey and Kazakhstan is 40% lower than it is in the United States of America. One of the reasons provided by the authors for the lower acceptance of evolution in Islamic countries is that evolution is aligned with atheism (lack of belief in the existence of God).

This concurs with several authors (Aguillard, 1999; Rutledge & Mitchell, 2002; Trani, 2004) who state that religious beliefs are one of the dominating factors that influence teachers' views and attitudes towards the teaching of evolution. Another reason given by Miller et al. (2006) is that Biology is taught in a highly religious environment – so much so that Biology textbooks in Pakistan contain Islamic verses from the Koran. There is no specific reference in the Koran that opposes evolution, but evolution is presented as more of a social and cultural threat, than a religious threat (Hameed, 2008). For this reason, some Christian teachers do teach evolutionary concepts despite their religious views towards the topic. According to Ogunniyi's (2006) CAT theory, these teachers hold an equipollent cognitive state or view (see Section 3.3). That is, these teachers hold both views together, as both views have equal cognitive power and co-exist without logical connection. As a result, these teachers teach evolution to their learners, despite the fact that evolution is believed to contradict or attack their religious beliefs.

The National Academy of Science released a book on Science, Evolution and Creationism, a third edition of a publication that addresses science and religion (NAS, 2008). There is a section entitled ''Isn't belief in evolution also a matter of faith?'' Within that section, the NAS states, ''Acceptance of evolution is not the same as religious belief. Evolution is

accepted within the scientific community because the concept has withstood extensive testing by thousands of scientists for more than a century" (NAS, 2008, p. 49). Scientists do not necessarily believe in evolution, but they only accept it as a theory, the best explanation available in accordance with a systematic evaluation of the evidence (Scharmann, 2005). Scharmann (2005) further argues that the primary goal of evolution education is an understanding of evolution, not a belief in evolution.

Teachers as mediators of learning need to have a good understanding of evolutionary concepts. Sufficient subject or content knowledge about the subject that they teach, is a very important aspect of being a good mediator. As stated earlier by several authors (Aguillard, 1999; Rutledge & Mitchell, 2002; Trani, 2004), a lack of subject knowledge on evolutionary concepts, can influence the teachers' views towards the teaching of evolution.

A teacher with adequate subject knowledge on evolutionary concepts, may be able to teach the concepts effectively to the learners, while the opposite may happen when a teacher lacks subject knowledge on evolution. Sanders and Ngxola (2010) maintain that teachers with a limited understanding of evolution, tend to spend less time teaching the topic to the learners. They believe that subject knowledge on evolution is the key to effective and appropriate teaching of evolutionary concepts. Vygotsky (1978) stresses that a mediator needs to have more experience in order for him/her to assist and guide the learners, so that they can reach their ZPD. This suggests that the teacher should have more knowledge on evolutionary concepts in order to be able to guide the learners appropriately.

For this reason, it is obvious that if you are going to teach evolutionary concepts, you need to know a lot about it (Heggart, 2016). Affirming the importance of subject knowledge towards effective teaching are Sinatra, Southerland, McConaughy and Demastes (2003), who state that teachers' own beliefs and dispositions influence their understanding and acceptance. This is especially more so, when teachers' initial understanding about biological evolution is limited. In other words, teachers who have limited content knowledge on evolution may not accept and teach evolution (Sinatra et al., 2003). Although subject knowledge is of significance towards teaching, it should be accompanied by pedagogical content knowledge in order for effective and appropriate teaching to take place.

Shulman (1986) emphasises the importance of pedagogical content knowledge in teaching, referring to the particular content-appropriate approaches that are best suited to teaching specific topics, so that pupils understand the concepts involved. Not only should teachers have a thorough knowledge of the content they are to teach, but they must be aware of the typical difficulties that learners are likely to experience when learning that topic, specific misconceptions commonly held by learners about the topic, and pedagogies (teaching approaches) that are suitable for teaching that particular topic.

In the case of evolution, such approaches include strategies for dealing with potential controversies, including the need to develop attitudes of open-mindedness and tolerance of other viewpoints. Trani (2004) agrees with Shulman (1986), and says that a lack of understanding of the concept, and consequently the ability to teach the topic competently, are the problems with regards to the acceptance and teaching of evolution. Tatina (1989) further emphasises that studies have found that teachers' attitudes and views about subject matter, can also influence their curricular and instructional decisions. Teachers' content knowledge can influence their attitude towards the effective teaching of evolution. In the next section I discuss the different pedagogical strategies that teachers can employ, when mediating their learners.

2.5 Pedagogical approaches to teaching science (evolution)

Teachers need to use effective and appropriate pedagogical strategies during mediation of different Biology topics, including evolution. Different pedagogical approaches are used and applied in the teaching of the different topics, to make the learners understand the concepts easier. The science education community has made a significant effort to improve the effectiveness of evolutionary teaching in schools. A primary focus of this endeavour has concerned the development of curricula and instructional strategies that foster learners' learning of evolutionary concepts. Many of these efforts emphasise the lines of evidence supporting evolutionary theory and the theory's scientific validity in light of science as a method of inquiry (National Academy of Science, 1998). These strategies may be particularly effective because they equip learners to make informed decisions about the scientific validity of evolution, by focusing on the evaluation of evidence within the framework of the discipline, rather than presenting information as facts that should be memorised or by

focusing on religious belief (Clough, 1994). Determining the effectiveness of these novel instructional strategies, remains an important challenge of evolutionary biology education.

Scharmann (2005) indicates that the implementation of science education demands a review of current epistemological and pedagogical practices. He adds that there is a need to interrogate the possible epistemological and pedagogical practices for promoting effective evolutionary education in our schools. The point remains that teachers as mediators should use appropriate and effective teaching strategies when teaching evolution, to ensure that learning takes place meaningfully. Thus, teachers should use different teaching strategies to try and enhance the learning of evolution. The key dilemma is that some Biology teachers continue to teach evolution ineffectively, as most teachers use traditional ways of teaching. Successful learning in the Biology curriculum will therefore depend on teachers' chosen methods for teaching and learning.

According to Kostova and Atasoy (2008), successful learning depends on the teaching and learning methods used. They note that it is no longer enough for the teacher to know a lot, or to be able to explain concepts in a simple and interesting way. Instead, the teacher should be able to facilitate learning by stimulating learners to ask questions, reacting to their answers, helping them accept challenges and disagreements, discuss contradictions, think critically and offer creative solutions. Jensen and Schnack (2006) further argue that teachers should help learners to develop action competence, a point which Silo (2009) agrees with. She emphasises that the teacher is responsible for strengthening learner participation during the lessons, as this will help the learners to learn and develop well. Silo (2009) further reveals that efforts to engage learners, develops tensions and contradictions between participants, which in turn develops competent learners through their participation. This gives rise to an elusive object of learner participation, as the purpose for their participation in these activities is not clear. Ketlhoilwe (2003) supports the use of learner-centred, participatory and active learning methodologies when facilitating science in formal education.

When learners are engaged with others in conversation or with the teacher, they can learn and develop well. Mortimer and Scott (2003) accentuate that the concept of the communicative approach is central to the socio-cultural theory (see Section 3.2) so that teachers can develop learners' ideas. They highlight four aspects of the communicative approach, namely,

dialogic/authoritative and *interactive/non-interactive*, which I use to analyse my observation data in this study (see Section 4.7.3).

He, like Kostova and Atasoy (2008) argues that a combination of teaching and learning methods oriented towards agency, capabilities, social and structural changes, are likely to achieve science education objectives.

Examples of these methods are: role play, active learning, investigation or experiential learning, group work, presentations, discussions, debates, field work, homework studies, demonstrations, observations and collaboration. Loubser (2008) emphasises that effective learning has to move away from teaching and learning approaches based solely on the transmission of knowledge. It has to move towards approaches which encourage development of qualities, such as initiative, reflection and responsibility in relation to science. It has to foster values and attitudes which influence behaviour and action. Thus, he also supports learner-centred approaches for stimulating and maintaining learners' interest in science education.

Rosenberg (2008) indicates that learner-centred approaches to education are being interpreted in problematic ways, resulting in empty, superficial or incoherent learner activities with little content. She adds that teachers trained in the Bantu Education system have not been prepared to integrate everyday knowledge with schools or formal knowledge. Many teachers find it difficult to use available content-rich resource materials effectively, to plan and support lessons.

Though the learner-centred approach is favoured by many education systems, such as the South African education system (Sanders & Ngxola, 2010, p. 122), it sometimes requires that learners have space to move around or work in small groups. This might be challenging in overly large classes, and teachers will need to be creative to ensure that teaching and learning is learner-centred. The conclusion that learners' misconceptions should be dealt with systematically can be difficult for teachers who are teaching evolution, since much of the learners' resistance is framed in religious terms and one might be reluctant to address religious ideas in classrooms. These applications are developed in detail and are intended to be sufficient to allow others to use these approaches in their teaching. Teachers should thus implement these approaches in their classes when teaching the topic of evolution.

Hake (1998) assembles the most impressive data set illustrating the effectiveness of alternative pedagogical strategies in schools and colleges. The data are for key concepts in introductory biology. Hake defines traditional teaching of Biology as relying primarily on lectures given to passive learners, and exam problems, while interactive engagement methods are those designed at least in part, to promote conceptual understanding through interactive engagement of learners in heads-on (always) and hands-on (usually) activities, which yield immediate feedback through discussion with peers and/or instructors. Interactive engagement methods range from inquiry labs without lectures (Law, 1997) to large classes in which mini-lectures alternate with conceptually focused multiple-choice questions that learners answer individually and then discuss with their neighbours for two minutes, before answering the questions again (Crouch & Mazur, 2001). This approach is considered to be more effective compared to the traditional teaching approach (Nelson, 2008).

Donnelly (2014) opposes the idea that traditional teaching strategies are ineffective. Based on a recent study of classrooms in the UK and China and the recent UK report titled, *What makes great teaching*?, there is increasing evidence that these new-age education techniques lead to under-performance. This entails teachers facilitating instead of teaching and praising learners on the basis that all are winners, in open classrooms, where what children learn is based on their immediate interests. He further states that enthusiasm for discovery learning is not supported by research evidence, which broadly favours direct instruction. He believes that teachers need to be explicit about what they teach and make better use of whole-class teaching, especially in areas like English, Mathematics and Natural Science. He further states that initial instruction when dealing with new information and concepts, should be explicit and direct. Thus, when teachers are teaching evolution to the learners for the first time, it is important for them to explain the concepts directly to the learners. When education is teacher-centred, the classroom remains orderly, learners are quiet, and the teacher retains full control of the classroom and its activities. This will help the learners to understand the concepts and make sense out of them.

Many in Australian education believe children are only really learning when they are active (Donnelly, 2014). As a result, teachers are told it is wrong to sit learners at their desks and ask them to listen to what is being taught. Again, the evidence proves otherwise. The UK

report on teaching methods suggested that even when sitting and listening, children are internalising what is being taught. Learning can occur whether they are 'active' or 'passive'.

Nelson (2008) states that for the last three decades, the evidence has been quite strong that traditional teaching is not very effective in school and university classes, in science and other disciplines. Additionally, the problem is that while traditional methods are 'not ineffective' and work for some learners, they are not nearly as effective as some well documented alternative approaches. Essentially, Nelson is more concerned with how evolution is being taught in schools and tertiary institutions. To this end, Nelson identifies pedagogical strategies that can make a large difference in learners' understanding and acceptance of evolution. These strategies are the extensive use of interactive engagement, and a focus on critical thinking in science. Using these two strategies during mediation will help the learners to actively compare their initial conceptions (and publicly popular misconceptions) with more fully scientific conceptions.

Vygotsky's (1978) socio-cultural theory which sees mediation as happening with the assistance of signs and that this gives it quality and this resonates well with Nelson 2008. Hence, the use of teaching aids such as signs, graphs and posters in classrooms is important. He points out that mediation does not only create ZPDs (Stott, 2016) of new mental processes, but also creates ZPDs of new activities of learners, through the conversion of their goals into motives and actions into activities (Karpov, 2005). This encompasses the social and cultural qualities of the relationship between the teacher and the learners (Moll, 2004).

Lee's (1997) research findings indicate that in Hong Kong, many teachers continue to use exposition methods and rely on textbooks and the syllabus when they are teaching science topics. As highlighted in this study, the teachers' main concern is fear of "not covering the syllabus" (Lee, 1997, p. 200). They also found that teachers find the syllabus and the textbook to be overburdened with information that makes it difficult to find time for innovative methods. This resonate with Shulman (2004), who assumes that most teaching is initiated by some form of 'text': a textbook, a syllabus, or an actual piece of material.

Also looking at the same context, Stimpson (1997) observes that on average, teachers' teaching styles are more teacher-centred and teachers place more emphasis on teaching knowledge, less on attitudes and the least on skills. He further found that lectures and

experiments are the most popular teaching methods and that some teachers occasionally use other methods such as informal discussions and group projects. Computer-assisted learning activities, field trips, outdoor activities and role-play were teaching methods that teachers have not used because of constraints but would like to use. Many teachers would like to take their learners for field trips but cannot do so due to constraints such as finance. Karpov (2003) maintains that traditional approaches of teaching are good, and emphasises that empirical learning, which is the traditional way of learning that is employed in many schools, is often problematic because it leads to misconceptions. He suggests that rote learning prevents the child from applying the knowledge at hand because rote learning is inflexible, meaningless and non-transferable. Karpov describes it as "pure verbal knowledge which is inert" (2003, p. 70).

Newman, Griffin and Cole (1989) posit that unlike more traditional forms of schooling in which the teacher is dominant and rote learning is the general mode of teaching, the ZPD approach places the emphasis on interactive knowledge acquisition with the teacher appropriating the child's contributions into their understanding of the task at hand. In this way the learning remains meaningful to the child and they engage with the material being taught. In light of this, many education systems support the learner-centred approaches more than the teacher-centred approach (Hogan, 2008). For this reason, in Namibia, teaching methods have shifted from early positivist approaches, towards methods which are learner-centred. In the next section I will discuss pedagogical approaches in more detail in the Namibian context (Ministry of Education, 2009).

2.5.1 Pedagogical approaches for science education in Namibia

In Namibia, teaching methods have shifted from early positivist approaches, where science education was about transferring information and raising awareness, towards participatory methods based on social constructivism, influenced by the learner-centred education policy in Namibia. New methods are now emerging which are ontologically situated, for example, the inquiry-based method.

In the Namibian context, the curriculum builds on learner-centred education in accordance with the 'Towards Education for All' policy (Namibia. MEC, 1993). Learner-centred education is a Namibian conceptual policy framework, which encourages learner participation and involvement in pedagogy. With regard to evolution education, learner-

centred education may promote critical thinking and problem solving skills in learners. Learner-centred education sees a learner as an active, inquisitive human being, eager to learn, to investigate and make sense of his/her surrounding world. The learner brings knowledge from home, the community and environment to school, which should be utilised and drawn into teaching and learning. Learner-centred education takes into account that learners are individuals with their own needs. The Namibian Ministry of Education (2009) thus emphasises that in the classroom, attention should be given to individual differences through differentiation of teaching methods and teaching materials. Kanyimba (2002) highlights that this is often a challenge for most teachers, as in the implementation of evolution education it promotes progressive constructivist pedagogy, integration of disciplines and use of everyday knowledge, related to disciplinary knowledge and structure.

Mubita (1998) highlights that learner-centred education focuses on the learner and not the teacher. This has implications on the role of the teacher and the teaching approach in terms of teaching and learning for instructional materials, and the way teaching is organised. A teacher in learner-centred education guides the learners in acquiring new knowledge and skills. This does not mean that the teacher is the source of knowledge, but rather that she/he facilitates the learning processes of the learners. The learners are to be empowered to think and take responsibility not only for their own, but also for other people's learning and development. The classrooms should stimulate learning, allow for problem solving and encourage cooperative learning.

However, Mubita (1998) explains that the teacher, the learners, the curriculum and the community should be considered in learner-centred education. He adds that this will bridge the gap between society and school. This will help both parents, schools, teachers, learners and curricula unit planners to become one society or community with one goal in educational development. He adds that it takes more than one person to educate a child towards becoming a better citizen.

Nyambe and Wilmot (2012) conducted research into how teachers were implementing learner-centred education in Life Sciences in Namibia. They found that lack of resources and big class sizes impeded the fostering of science education in a learner-centred way; they also found that teachers were mainly interpreting learner-centred education in terms of changes in methods only. Some teachers appeared to have little understanding of their own practices as

being learner-centred. Teachers were not in agreement whether learner-centred education works. They recommend that continued support should be provided to teachers in the form of in-service training to help teachers understand learner-centred education better and to understand how the methods they use reflect learner-centred education.

A number of other studies have also pointed to distortions and misunderstanding by teachers around learner-centred education. For example, Kanyimba (2002) indicates that learner-centred education and related pedagogical approaches which are currently offered in Namibia are currently being challenged for not meeting the educational goals of social justice and denying learners access to powerful knowledge systems. Haingura (2009) seems to agree with him by recommending that there is a need to strengthen teachers' knowledge of learner-centred education and how to plan and implement it in Namibia. The next section will look at the enablements and constraints for evolutionary education in Namibia.

2.6 Enablements and constraints when teachers mediate learning of evolution

Many education institutions are faced with various challenges that can hinder successful teaching and learning (Hoabes, 2004). As mentioned earlier, in Namibia there are ministerial policy documents that support the teaching of evolution within the curriculum. Yet, evolution education continues to suffer from constraints that hinder its effective incorporation into the curriculum. Ketlhoilwe (2003) states that there are a lot of personal and logistical barriers that can hinder the successful teaching and learning of evolutionary concepts such as a lack of resources, learners' discipline and lack of subject knowledge.

2.6.1 Learning and teaching support materials

There are a variety of materials that can be used to enrich and assist in achieving lesson objectives. Teachers should improvise teaching and learning by using mediational tools as they assist learners to understand the concepts (Vygotsky, 1962). Despite the usefulness of mediational tools in teaching and learning, the main challenge is that resources in schools are inadequate to facilitate learning appropriately. During mediation, teachers are required to support learners in appropriate forms of socialisation, by the use of different mediational tools, such as posters, diagrams, graphs, charts and video tapes, until such time that those learners can reason on their own, which is an essential component of the social cultural

theory used in my study (see Chapter Three). Teachers in many schools do not have most of the teaching and learning resources such as textbooks, laboratories and access to the internet (Uugwanga, 1998). The lack of resources then acts as barriers to effective and appropriate teaching (Rosenberg, 2008). Higher mental processes are mediated by psychological tools such as language, signs and symbols, as reiterated by Vygotsky (1978).

These are taught by adults, in this case the teachers, to learners during their mutual activities and they are internalised by the learners, thereby working as further mediation (Karpov & Haywood, 1998). According to Engeström (2001), tools play such an important role in socio-cultural theories of learning. Segall (2003) emphasises the using of text during mediation and says that text used as curriculum materials do not, however, only provide learners with content *per se*, they also provide them with particular content. Brought into the classroom as subject-area materials, textbooks, newspaper articles, film or video, software programs, and others, present particular versions of the discipline, of reality, truth, and what (and how) it means to know something. According to Eya (2006), enough teaching resources reduce ill-discipline and class disturbances among the learners and make the teachers' job easier, faster and more effective. Eya (2006) maintains that when teachers see that they have relevant material to teach their subject, they become more eager to go teach.

According to Ogbu (2015), for effective teaching of science subjects, instructional materials and facilities are necessary. He further adds that instructional materials and facilities on their own, help to facilitate teaching and learning and are used to influence concrete and permanent change in technical behaviour. He also adds that a lack of instructional aids or mediational tools in schools, makes the teaching and learning of the learners, less effective. According to Graves (2000) and Basturkmen (2010), it is very important for the learners to have textbooks, as textbooks provide security for the learners as they then have a road map of the subject. Learners know what to expect and they know what is expected from them. It further provides a set of visuals, activities and readings, thereby saving the teacher time in finding or developing such materials. Finally, it may include supporting materials (teacher's guide, cd and worksheets) and provides teachers with a basis to ensure effective learning of evolution. For this reason, each learner in the school should have his or her own textbook to ensure effective learning and teaching of evolution (Basturkmen, 2010).

2.6.2 Lack of sufficient teaching time

Inadequate time allocated for Biology as a subject, is one of the main constraints to effective teaching of evolutionary concepts. The time allocated for evolution topics is inadequate to combine theory and practice in teaching evolutionary concepts. I have found through my personal experience that the period allocated for Biology in the timetable in many Namibian schools is a matter of concern. According to the Namibian Education policy, a period should be a maximum of 40 to 45 minutes. Double periods should be allocated to allow enough time for discussions, practical work or experiments instead of the single periods allocated throughout the timetable. It is unlikely that a single period will accommodate both theory and practice. Double periods would be more appropriate to assist in allowing time for both practice and theory, to help learners make essential connections. This is in line with Ham and Sewing (1988) who note that, lack of class time and preparation time are perceived as the greatest barriers for effective and appropriate teaching in schools.

2.6.3 Learners' attitudes and discipline

Many education institutions are faced by the challenges of learners' negative attitudes and disciplinary problems. Teachers as mediators within the classroom, should try to establish a disciplined teaching and learning environment, as much as possible. In some classes, learners with negative attitudes tend to take over and disrupt the classes or lessons. Attitude has one of the largest impacts on learners' success (Miller, 2004). The learner who enters the classroom with a good attitude, eager to learn and participate, brings with them positive energy that makes it easier to learn. If a learner enters the Biology class with a positive attitude, they will positively accept what is being taught in the class and accept it. People do better when they have positive attitudes and are in a positive environment. The learners who are against evolution will enter the classroom with a negative attitude, and then will not participate in the class. These learners then constrain the effective teaching of evolution, as they disturb the class and this leads to disciplinary problems.

Rosenberg (2008) makes the same point when he states that some schools are characterised by a lack of discipline which contributes to ineffective learning. These learners then constrain the effective teaching of evolution, as they disturb the class unnecessarily.

2.6.4 Lack of subject knowledge and exposure

There are fundamental differences between the subject matter knowledge necessary for teaching and subject matter knowledge *per se*, claim Grossman, Wilson and Shulman (1989). According to Shulman (1986), content is the domain of the subject-area specialist, in other words, the knowledge on the subject. Shulman (1986) emphasises that teachers need to understand their subject matter in ways that promote teaching and learning. As is true of any subject, to teach evolution successfully, teachers need to be prepared with a conceptual understanding of the topic and with effective curricular strategies. Teachers that develop a depth of knowledge beyond what is actually expected of learners, will be able to confidently adjust instruction in response to learners' needs and inquiries. This is particularly true in the teaching of evolution, where learners' questions can be numerous and challenging. If a teacher does not have a clear understanding of the concepts that he or she needs to explain to the learners, that teacher will not be able to explain those concepts clearly enough, so that the learners can reach their ZPD. The mediator must have a very good understanding of the concept that he or she must teach to the learners (Vygotsky, 1962).

According to Magnusson, Krajcik and Borko (1999), some researchers report that limited knowledge of topic-specific representations can constrain effective instruction of science subjects. Sanders and Makotsa (2016) intensively studied three secondary science teachers and reported that teachers had difficulty sustaining momentum in a lesson, sometimes confusing themselves and their learners when they struggled to respond to learners' questions requiring more detailed or different representations. This indicates that the teachers did not have a thorough understanding of subject content, which then constrained effective teaching and learning. Subject knowledge is thus a very important aspect of teaching, as a lack of it can constrain effective teaching which then leads to poor performance.

2.7. Teachers' conceptions and dispositions

A conceptual framework in this study is seen as a network of interlinked concepts that provide a comprehensive understanding of phenomena. The following main concepts are discussed below: 1) conceptions and 2) dispositions. Each concept within a conceptual framework plays an ontological or epistemological role.

2.7.1 Teachers' conceptions

Atallah, Bryant and Dada (2010) propose that conceptions have two components, namely, knowledge and beliefs. According to Gao and Watkins (2002), conceptions of teaching are viewed as the different categories of teachers' ideas behind their descriptions of how they experience the teaching process. Pehkonen (2001) corroborates with Atallah et al. (2010), who says that beliefs have cognitive and affective components. Beliefs are seen as personal views, values and assumptions (Atallah et al., 2010). Thompson (1992) sees conceptions as general mental structures that encompass beliefs, and this is in agreement with Gao and Watkins (2002). Osborne, Simon and Collins (2003) describe learners' conceptions as categories of beliefs, theories, meaning and explanations. Oaks (1994) characterises conceptions of a subject as the view that learners or teachers hold of that particular subject. In the case of this study, teachers' conceptions of evolution are the diverse views that the different teachers have towards the teaching of the topic of evolution; how the teachers describe evolution, and what they believe is required in teaching it.

Margolis and Laurence (2007) perceive conceptions as general mental structures that hold someone's beliefs within, and this resonates with Thompson (1992) who sees conceptions as general mental structures that encompass beliefs. Conceptions of a subject are the views that learners or teachers hold of the subject, how they would describe the subject, and what they believe is required in learning and teaching the subject.

Thompson (1992) provides a summary of the history on beliefs and conceptions. She traces interest in the nature of beliefs and their influence on actions, as starting in the early twentieth century in the field of social psychology. For example, teachers who are strongly Christian will be influenced by their religious beliefs and this then could affect their actions, as they could refuse to teach the topic of evolution (Thompson, 1992). The fact that the teachers are Christian is a general mental structure that holds certain beliefs. These beliefs are the ones that affect how a person's conceptions are towards something. Thompson (1992) attributes the interest in teachers' beliefs and conceptions, to paradigm shifts that occur in the field. She classifies the research on conceptions as mostly interpretive in nature and focusing on one of two areas: describing and documenting beliefs and conceptions, or the relation between conceptions and practices.

In Malaysia, a multi-racial and religious nation, the Biohead-Citizen research project aims at analysing Malaysian teachers' religious beliefs and how this affects their conception of evolution. This was conducted by Biology, Health and Environmental Education in promoting a better citizenship, including their affective and social dimensions. Using a questionnaire validated by the Biohead-Citizen research project (2004-2008), 204 teachers teaching in secondary schools or finishing their teachers' training in Kuching and Samarahan in the State of Sarawak, Malaysia, were sampled to identify if their conceptions varied, dependant on their religion. Significant differences were obtained with Muslim teachers being more creationist than their colleagues, and Buddhist teachers being more evolutionist. Some Christian teachers' conceptions fell between these two poles. These results were compared with those obtained in other countries such as Canada, Korea and Malaysia. More than 70% of the Malaysian teachers were shown to be radically creationist, agreeing with the following statement from a questionnaire that was completed by Malaysian teachers: "*It is certain that God created life*".

Accordingly, Malaysian teachers would probably have difficulty in teaching the topic of evolution, because of their mental structures that encompass their Christian beliefs. Nevertheless, with regards to the topics of the origin of life as well as the origin of humankind, 21% of Malaysian teachers indicated that they were both evolutionist and creationist. They could accept and teach evolution, believing that the processes of evolution are controlled by God. These teachers' conceptions were that God created everything, and thus they would teach evolutionary concepts. The question remains whether these teachers are teaching this topic effectively, or whether they are only teaching it because they have to teach it and therefore rush through the topic.

Teachers' attitudes and views about subject matter have an impact on their curricular and instructional decisions (Tatina, 1989; Rutledge & Warden, 1999; Rutledge & Mitchel, 2002). In addition, "Teachers who lack an understanding of evolution and the nature of science may have negative conceptions and thus be incapable of making informed decisions of acceptance or rejection of evolutionary theory'' (Grobschedl & Konnemann, 2014, p. 3).

According to Gao and Watkins (2002), the term teachers' conceptions is referred to as the overall view and beliefs of teachers of the process of teaching. Oaks (1994) similarly defines a conception of a subject as the views that learners or teachers hold of a subject and how they

describe it as a subject. From a phenomenological point of view, teachers' conceptions of teaching, act as a framework through which those teachers view, interpret, and interact with their teaching environment (Jabareen, 2009). In this research study, I use Gao and Watkins (2002), Jabareen (2009) and Oak's (1994) definitions of conceptions.

Teacher conception is the general view and beliefs that teachers hold about a particular phenomenon, in particular, evolution, in the context of my study. Teachers' conceptions about a phenomenon may influence their teaching, which can then influence the learner learning. Essentially, this study explores teachers' conceptions and dispositions towards teaching the topic of evolution in schools, as there is research evidence that suggests that teachers' views and beliefs about certain subject topics, influence their instructional practices and that this can ultimately influence learners' learning and performance (Gao & Watkins, 2002).

2.7.2 Teachers' dispositions

Knowledge, skills, beliefs, attitudes, behaviours and dispositions impact teachers' conceptions of the subjects that they teach (Damon, 2005). Damon (2005) describes a disposition as "a deep-seated component of personality, with roots going back to the origins of our temperaments and tentacles that bear major import for who we are and who we become" (p. 3). Ritchhart (2001) describes dispositions as patterns of behaviour, thinking, and interaction. He maintains that dispositions turn abilities into action, and says that intelligent performance is not just an exercise of ability. Instead, it is more dispositional in nature, in that we must activate our abilities and set them into motion. Halverson (2011) says that disposition is a very different type of learning from skills and knowledge. Dispositions can be thought of as habits of mind and tendencies to respond to situations in certain ways (Kirby & Lawson, 2012). Habits of mind and dispositions are closely related concepts, both pointing to the readiness to act overtly in a given context, therefore, these terms can be used interchangeably. Halverson (2011) who describes disposition as a trait or character that defines 'who we are' or 'become', provides a similar explanation.

"Research on attribution theories demonstrate that the attributions that teachers make to their learners who are doing poorly, may reflect their beliefs, but hinder their effective interventions with learners" (Atallah et al., 2010, p. 46). Concurring, Domovic, Vidovic and Ivanec (2013) point out that Lilian Katz set a framework for the notion of dispositions of

beliefs teachers hold towards learning. She calls them per-disposition and uses the term 'dispositions' as a summary of actions observed in teachers and learners. The research went on to define areas and dispositions that a successful teacher needs to manifest. Dispositions are closely related to skills and practices. For this reason, Bourdieu (1993) stipulates that disposition is an enduring feature of a personality trait. He explains that disposition could be referred to as an attitude or attitudinal tendency. Facione (2000) supports Halverson (2011) and Bourdieu (1993) by suggesting that disposition is a character attribute of an individual.

Atallah et al. (2010) suggest that while disposition is related to emotional intelligence, it goes beyond to include motivational and cognitive roles that emotions play, when thinking is triggered by curiosity or passion. For Nelsen (2015), disposition is a cluster of habits to draw upon modes of responses, within a specific context. Similarly, some authors propose that disposition is a dimension of personality such as habits of the mind (Mall, 2012), personality characteristics and recurrent/patterns of behaviour (Raths, 2001) attitudes and beliefs (Siegel, 1999; Ritchhart, 2001) and habits of thinking and doing (Ros-Voseles & Fowler-Haughey, 2007).

Based on these scholars' definitions and views of disposition, one can suggest that dispositions are habitual ways of behaving and that only a pattern of repetitive behaviour should be identified and accepted as evidence of an internalised disposition. Attitude, being an affective parameter, deals with people's mental dispositions, feelings, postures and the like, toward a subject, an object or even an idea (Taiwo, n.d.). Thus, in this study, dispositions are defined as the attitude an individual has towards something. On that account, disposition is used synonymously with attitude. Some authors actually refer to disposition as attitude (Ajzen, 2001). This study therefore examines the teachers' attitudes (mental dispositions, feelings, postures) towards teaching the topic of evolution.

2.8 Concluding remarks

In this chapter, I discussed what the curriculum states about the natural science field, as well as the aims of the Biology syllabus. I also touched on what the literature clarifies about the acceptance of evolution by different teachers and the factors that play a role in the acceptance and/or rejection of evolution. The chapter further explained the two main concepts, namely, conceptions and dispositions, and also looked at the inclusion of evolution in the school

curriculum. It also deliberates over what the literature discusses on the different pedagogical approaches and also identifies effective pedagogical approaches that can be applied when teaching the topic of evolution. All these were explained in the context of the socio-cultural theory and contiguity argumentation theory, which underpin and guide the study, which I now discuss in detail in the next chapter.

CHAPTER THREE
THEORETICAL AND ANALYTICAL FRAMEWORK

3.1 Introduction

The main goal of this study is to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogical strategies that they use when mediating learning of evolution. In this chapter, I thus present the theoretical perspectives that inform this study. According to Imenda (2014), a theoretical framework assists the researcher in investigating the problem under study. It also informs the meaning the researcher attaches to the data accruing from the investigation, for example, in the teaching of evolution in science classrooms in the context of this study.

Essentially, this study is informed by Vygotsky's (1978) socio-cultural theory in conjunction with Ogunniyi's (2006) Contiguity Argumentation Theory (CAT) as an analytical framework. I now discuss each of these below.

3.2 Socio-cultural theory

The classroom is a social unit (activity system) composed of learners and teachers with different cultures. They have different behaviors, beliefs, values and symbols that they accept generally without thinking about them. It is in the classroom where many social and cultural practices are learned or developed. For instance, learners interact with one another and also with the teachers in the classroom. Vygotsky's (1978) socio-cultural theory describes learning as a social process of the origination of human intelligence in society or culture (Lantolf & Thorne, 2007). Wertsch (1993) describes learning as a change in participation through which one becomes a different person, based on the practices of the settings in which we find ourselves. As a result, one can say that learning results in development of oneself.

Central to Vygotsky's (1978) socio-cultural theory is the notion that learning and hence development entail moving from a social context to an individual understanding. He refers to this as a social plane (Mortimer & Scott, 2003). Socio-cultural theory stresses the interactions between developing people and the culture in which they live. The theory further stresses the role that participation in social interactions and culturally organised activities play in

influencing psychological development. In support of learning as a social process, the social cultural theory states that we must remember that the learning conditions of the individual, the interactions of the individual with the teacher and others learners, and the individual's cultural background, all affect the learners' success in developing and learning.

Classrooms are composed of many learners from different cultural backgrounds. Thus, teachers should take into consideration these factors when planning their daily lessons, to ensure that meaningful learning and development takes place. Doehler (2002) insists that "cognitive development hinges not simply on the involvement in social interaction as such, but on particular ways of expert guidance and learner participation" (p. 22). Hence, teachers as mediators of learning should make use of appropriate and effective pedagogical methods. This could ensure that learners are actively involved and participate during lessons, so that learning among them can take place.

The development of a learners' cognition is very important for the learner and social interactions play a fundamental role in their development. Vygotsky (1978) believes that everything is learned at two levels. First, through interactions with others, and then integrated into the individual's mind. This study focusses mainly on two key concepts of Vygotsky's theory, namely, the zone of proximal development (ZPD) and mediation of learning.

3.2.1 Zone of proximal development

Vygotsky's (1978) theory stresses the idea that the potential for cognitive development is limited to a 'zone of proximal development' (ZPD). The ZPD has become an important concept for clarifying the relationship between development and instruction. It encompasses 'internalisation', 'semiotic mediation' and the 'concept development'.

Vygotsky (1962) introduced the ZPD to criticise psychometric-based testing in Russian schools. A much-quoted definition of the ZPD from one of the earliest translations of Vygotsky's (1978) work is as follows:

> The distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (p. 86)

This suggests that the ZPD is the difference between the level of development already obtained and the cognitive functions comprising the proximal next stage of development that may be visible through participation in collaborative activity (Lantolf & Thorne, 2007). According to Wood (2001), the ZPD is the gap between what a child is able to do on their own and what they are capable of with assistance, from a more competent adult. United Nations Educational, Scientific and Cultural Organisation (UNESCO) emphasizes that the zone is the area of exploration for which the learners are cognitively prepared, but require help and social interaction to fully develop. When a child enters the classroom environment, their skills and competencies within their individual ZPDs have not yet fully emerged, which means that the child needs assistance to help them to grasp or understand the concepts. For that reason, teachers who are more experienced should provide the learners with assistance to support their evolving understanding of knowledge domains or development of complex skills. Teachers need to teach evolutionary concepts effectively, as most learners are not familiar with this concept. They should teach by using appropriate mediational tools, so that learners can learn the new concepts that they cannot learn on their own. If the topic of evolution is not taught accordingly, learners might not reach their ZPD, and this can then affect the performance in evolution, which is a problem. Teachers for this reason play a very important role within the ZPD (Dixon-Krauss, 1996).

According to Newman, Griffin and Cole (1989), the main goal of education from a Vygotskian point or perspective, is to assist the learner within their individual ZPDs – to motivate learners to learn through collaborative endeavours which facilitate problem solving, that is slightly more difficult than what the learner may achieve on their own. This would result in the completion of a given activity, which the learner will be able to achieve individually in the future and consequently this will have raised their level of ZPD.

According to Vygotsky (1962), language plays two important roles in cognitive development. Firstly, language is a means by which adults or teachers transmit information to learners. Secondly, language itself is a very powerful tool of intellectual adaptation, as it is a primary mediational tool. It can be used in classrooms to present the learners with questions, immediate feedback and a deeper understanding of terminology specific to the subject at hand. Internalisation, according to Mortimer and Scott (2003) can be evidenced by how learners talk and communicate about the world they inhabit. It is recognised however, that this requires effective mediation of learning on the part of teachers. The concept of the ZPD

as a result, suggests that learning can lead to developmental change and the use of mediation may influence the learner's capacity to develop more (Karpov, 2005; Stott, 2016).

3.2.2 Mediation of learning

Vygotsky (1962) believes that meaning is constructed through a combination of language and its cultural context and that when learners indulge in play, they are adding to their already existing skills (Bruner, 1977). For Vygotsky, humans are very different from their animal relations because they bring to the learning environment an evolutionary capacity to adapt and manipulate their environment, and have consequently built up cultural and historical tools (Van der Veer & Valsiner, 1991). This collective social history is brought to the classroom and transferred from learner to learner and from educator to learner, through the process of mediation. Vygotsky describes the mediational process as being goal directed and a conscious activity in which the educator creates an environment that is conducive to learning (Van der Veer & Valsiner, 1991). Vygotsky sees mediation happening with the assistance of signs and that it is this that gives it its generative quality. This encompasses the social and cultural qualities of the relationship between the teacher or mediator and the child (Moll, 2004).

During mediation, teachers are required to support learners in appropriate forms of socialisation by the use of different mediational tools, until such time that those learners can reason on their own, which is an essential component of the socio-cultural theory. Language is intimately tied to actions and this enables the child to internalise their new learning and to develop levels of self-regulation (Karpov, 2005; Harrison & Muthivhi, 2013). Thomson (2013) further states that mediation of activities take various forms, such as direct instruction from the teacher, modelling of behavior and helping learners in structured manners, to mention a few.

According to Nelson (2008, p. 213), teachers ''should use interactive engagement'' when teaching evolution in schools. It can help the learners to engage with one another and with the teachers during the lessons. When learners are engaged with others in conversation or with the teacher, they can learn and develop well. Mortimer and Scott (2003) explain that the dialogic-authoritative dimension either entails teachers taking into consideration the learners' point of view (dialogic communicative approach) or emphasis is placed on the school science point of view (authoritative communicative approach). That is, in the former there is an

exploration of different points of view, whereas in the latter there is no exploration of different ideas. In the case of the interactive/non-interactive communicative approach, talk is interactive as participation is allowed amongst learners. Contrary to this, if participation is excluded then it is non-interactive.

Vygotsky (1978) argues that a learner does not develop in a straight line but rather develops through discontinuity, a replacement of one function by another, a displacement and conflict of two systems. Psychological tools such as language, signs and symbols mediate higher mental processes. Adults teach these during their mutual activities and they are internalised by the learners, thereby working as a further mediation (Karpov & Haywood, 1998). From the Neo-Vygotskian point of view, mediation does not only create ZPD of new mental processes, but also creates ZPD of new activities of children, through the conversion of their goals into motives and actions into activities (Karpov, 2005).

As a result, this encompasses the social and cultural qualities of the relationship between the teacher and the learners (Moll, 2004). The socio-cultural theory in this study, helped me to look at pedagogical strategies used by the Biology teachers when teaching evolution. Furthermore, it shed light on the appropriate teaching strategies for teaching the topic.

3.3 Contiguity Argumentation Theory (CAT)

Constructivism has for some time now informed teaching and learning in most science classrooms. The focus in recent years has however, shifted from personal to socio-cultural constructivism, whereby learning is construed within a larger social and situated context embracing beliefs and values (Lemke, 2001; Wickman & Ostman, 2002), and this perspective to learning, highlights the importance of social interactions in the learning process. Social interactions involving arguments and dialogues among peers, are crucial to the performance of tasks and the development of skills that would not have been attained easily by an individual alone (Cobb, Yackel, Wood, Nicholls, Wheatley, Trigatti, & Perlwitz, 1991; Cross, Taasoobshirazi, Hendricks & Hickey, 2008). In addition to Vygotsky's (1978) socio-cultural theory, this study is informed by Ogunniyi's (2007) Contiguity Argumentation Theory (CAT), to explore teachers' conceptions and dispositions towards teaching the topic of evolution in secondary schools.

CAT deals with the nature of interactions between distinctly different thought systems, in the context of this study, science and creation. It deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses. CAT explains a dialogical framework and the dynamics involved in resolving the incongruities that normally arise when two or more competing thought systems (in this case teaching of evolution in schools) are considered together (Ogunniyi, 2007). During the teaching of evolution or reading scientific material on evolution, the two contiguous thought systems (science and creation) clash and as a result, an intra-dialogue (a dialogue within an individual) ensues as the individual attempts to resolve the conflict.

Biology teachers are challenged when they have to teach the topic of evolution, as many learners come from a creationist background, and they must be taught about evolution, which is the opposite of what the learners know on how the earth evolved. Teaching of evolution in schools is a very controversial issue due to conflicting thoughts, for teachers and learners. Thus, when teachers' conceptions and dispositions towards teaching the topic of evolution in schools are juxtaposed, it may result in some sort of dialogue, to find some meaningful form of co-existence.

According to Ogunniyi (2006), within the framework of contiguity principle, there are at least five discernible cognitive states: the dominant, suppressed, assimilated, emergent and equipollent. These are briefly described in the table on the next page:

Table 3.1: Cognitive states within the Contiguity Argumentative Theory

Cognitive states	Description of the states	Relevance to my study on evolution
Dominant	A dominant state arises when the salient assumptions of one thought system are portrayed more convincingly than those of the competing system.	The analysis of data will focus on finding the dominant teachers' conceptions towards teaching evolution in school.
Suppressed	The system of thought is not warranted; it is less adaptable to an arousal context.	The analysis of data will focus on finding the suppressed teachers' conceptions towards teaching evolution.
Assimilated	The system of thought is seen as inferior to a dominant one and hence the former capitulates to the latter.	The analysis of data will focus on finding the assimilated teachers' conceptions towards teaching evolution.
Emergent	Knowledge is lacking or is not well formed and because of the appeal the new knowledge has, a new schema based on the new perception evolves.	The analysis of data will focus on finding the emergent teachers' conceptions towards teaching evolution.
Equipollent	Two competing ideas are exacting equal intellectual force in a given context.	The analysis of data will focus on finding the equipollent teachers' conceptions towards teaching evolution.

(Adapted from Ogunniyi, 2005 – Contiguity Argumentative Theory (CAT))

Ogunniyi (2007) contends that the five cognitive states above exist in a dynamic flux and can change from one to another depending on the arousal context. In this study, the five states of cognition were used as analytical tools. Teachers' views on teaching evolution can be categorised as follows:

- A teacher with **dominant views** on evolution, will be regarded as a total believer of evolution, and therefore suppress views on creation;
- A teacher with **suppressed views** on evolution, will be regarded as a total believer of creation, and therefore suppress views on evolution;
- A teacher with an **assimilated view** will tend to adhere to the dominant worldview;

- A teacher with **emergent views** on evolution, has no prior knowledge of a given phenomenon, which means the teacher is border crossing between these views resulting in new ways of thinking; and
- A teacher with **equipollent views** holds both views together, as both views have equal cognitive power and co-exist without logical connection. That teacher believes in both creation and evolution.

CAT attempts to establish some intellectual bridge between distinct knowledge systems, for example, in this case science and creation, by construing such systems as dynamic and context bound. CAT interprets the different schemas as dynamic, since a given schema has the potential to change from one schema to another, depending on the context in vogue. Thus, CAT is deemed as an appropriate theory, as it is useful in identifying teachers' cognitive stages, and therefore provides a useful lens for this study's aim at exploring teachers' conceptions on teaching the topic of evolution in schools.

3.4 Concluding remarks

In this chapter I discussed Vygotsky's socio-cultural theory as well as Ogunniyi's CAT, which I use as lenses to analyse my data in this study. The chapter thus deliberated on the role of teachers as mediators in the facilitating of learning among learners, so that they can reach their ZPD from a socio-cultural perspective. It also discussed the contiguity argumentation theory (CAT) which explains a dialogical framework and the dynamics involved in resolving the incongruities that normally arise, when two or more competing thought systems (in this case teaching of evolution in schools) are considered together.

In the next chapter, I discuss the research design and methodology used in this study.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 Introduction

The goal of this study is to explore Grade 12 Biology teachers' conceptions, dispositions and the pedagogic strategies that they use, when mediating learning of evolution. The study also aims at examining possible enablements and/or constraints, when Grade 12 Biology teachers mediate learning of evolution. Thus, this chapter gives some details on how I carried out the research and explored the research topic and the research questions. I further discuss the research orientation or the research design and the methods used to collect, analyse, discuss and interpret the data. I also explain the different techniques used to generate data. Validity and trustworthiness issues are also discussed.

4.2 Research orientation

This study is underpinned by an interpretive paradigm as I sought to understand the opinions of human experience (Cohen et al., 2011). In other words, the research describes and tries to understand how people make sense of their world and how people make meaning of their particular actions. According to Bertram and Christiansen (2015), in an interpretive paradigm "researchers make interpretations with the purpose of understanding human agency, behaviours, attitudes, beliefs and perceptions" (p. 26). My research objectives and questions point to an interpretive approach, to get a clear understanding of socio-cultural practices within the context of the Biology classroom, with a focus on evolution in particular. Henning, Van Rensburg and Smit (2004) state that phenomena and events are understood through mental processes of interpretation, which are influenced by, and interact with, social context. This is in agreement with the ideals of the socio-cultural theory, which is my theoretical framework in this study (see Section 3.2).

Thus, using an interpretive paradigm allowed me to understand how teachers make sense of phenomena, such as the teaching of evolution in their classrooms. This paradigm further helped me to understand teachers' actions towards teaching evolution. It also allowed me to gain insight into why teachers use particular strategies in mediating learning of the topic of evolution and its concepts. Within the interpretive paradigm, a case study uses a mixed-

method design (quantitative and qualitative data generated). The case study approach used and the mixed-method design, will be discussed below.

4.3 Case study

Patton (1990) observes that case studies become particularly useful where one needs to understand a particular group of people, a particular problem, or a unique situation in great depth, and brings out the issue of context and history of the issue under investigation. Stake (1995) explains that a case study enables the collection of information that is specific to the particular case and that the idea of a case study, is to understand a particular case under study. Denzin (1989) argues that case studies will often be the preferred method for interpretive research because they are epistemologically in harmony with the reader's experience and thus to that person's natural basis for generalisation.

Ary, Jacobs, Razaviech and Sorensen (2006) state that a case study seeks to understand the whole individual or phenomenon in the totality of that individual or phenomenon's environment. Not only the present actions of an individual, but his or her past environment, emotions and thoughts can be provided. A case study therefore enables the researcher to describe a particular case in depth, in detail, in context, and holistically (*ibid.*). Cohen et al. (2007) define a case study as a study of a case in context. Cohen et al. (2007) concur with Ary et al. (2006), who explain a case study as an investigation of complex, dynamic and unfolding interactions of events and human relations in a unique instance.

Clough and Nutbrown (2007) argue differently as far as generalisation of a case study is concerned. To them case study results are particular to a context and can therefore not be generalised because they cannot be replicated in different settings. Le Roux (2001) seems to support this view, when she indicates that data acquired in a case study provides a description of current conditions and that a series of case studies (one or more) may reveal information that might help in forming a new idea for further research. This means that the results cannot be generalised, but are context based and are useful for further investigation of the issue revealed.

My research study is a case study of six secondary schools in the Hardap and 12 secondary schools in the Khomas region (see Section 3.4). It is a case study, as I was trying to

understand what teachers really do in their real life situations, and this makes my study qualitative in terms of methodology. Additionally, the case in this study is a group of Grade 12 Biology teachers, their views and attitudes towards teaching evolution and the pedagogical approaches they implement during mediation. The unit of analysis comprised the teachers' conceptions and dispositions towards the teaching of evolution, which was framed by the contiguity argumentation theory (see Section 3.3).

This case study also focused on pedagogical strategies used by Biology teachers when mediating evolution and the socio-cultural theory provided an appropriate framework (see Section 3.2). Furthermore, it would help me in identifying the enablements and constraints that teachers face, when mediating evolutionary concepts to Grade 12 Biology learners.

As stated earlier, the study is underpinned by an interpretative paradigm, and within the interpretative paradigm, a case study using a mixed-method design (quantitative and qualitative data generated) was adopted. In a mixed-method research, both quantitative and qualitative data are generated. The quantitative data was analysed to answer my first research sub-question, while the qualitative data was analysed to respond to all four of my research sub-questions.

4.4 Research goal and questions

The main goal of this study was to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies that they use when mediating the learning of evolution. The study also aimed at examining possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution. To achieve this goal, the following questions guided the study:

4.4.1 Main question:

What are Grade 12 Biology teachers' conceptions, dispositions and pedagogical strategies that they use when mediating learning of evolution?

4.4.2 Sub-questions:

1. What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?

2. What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
3. What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?
4. What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?

4.5 Sample of the population

Teachers from the two regions completed 15 questionnaires. Six teachers (40%) from the Hardap region completed the questionnaire, while nine (60%) were completed by teachers from the Khomas region. A summary of the biographical information of the teachers involved in this study is presented in Table 4.1.

4.5.1 Biographical information of the teachers

Teachers from the two regions completed 15 questionnaires. Six teachers (40%) from the Hardap region completed the questionnaire, while nine (60%) were completed by teachers from the Khomas region. Table 5.1 below provides a summary of the biographical information of the teachers involved in this study. The 15 questionnaires were numbered from one to 15 and were given codes. For example, questionnaire one was given the following code T_1Q_1M, whereby T_1 in the code stands for teacher one, while Q_1 stands for the questionnaire number. The last letter in the code represents the teachers' gender. That is, if the last later in the code is an F, then it means that the teacher who completed that questionnaire is female; whereas if the code ends with an M, then it means that the teacher who completed that specific questionnaire is a male teacher.

Table 4.1: Biographical information of the teachers

Biographical information	Category	Teacher' codes	Frequency
Age	20 – 25	T_9Q_9F; $T_{11}Q_{11}F$	2
	26 – 30	T_1Q_1M; $T_{10}Q_{10}F$; $T_{13}Q_{13}M$	3
	31 – 35	TQ_7F_7; T_8Q_8F; $T_{15}Q_{15}F$	3
	36 – 40	T_2Q_2F; T_6Q_6F	2

	41 – 45	None	0
	46 – 50	T_3Q_3F; T_4Q_4F; T_5Q_5M; $T_{12}Q_{12}F$; $T_{14}Q_{14}F$	5
Gender	Female	T_2Q_2F; T_3Q_3F; T_4Q_4F; T_6Q_6F; T_7Q_7F; T_8Q_8F T_9Q_9F; $T_{10}Q_{10}F$, $T_{11}Q_{11}F$; $T_{12}Q_{12}F$; $T_{14}Q_{14}F$	11
	Male	T_1Q_1M; T_5Q_5M; $T_{13}Q_{13}M$;$T_{15}Q_{15}M$	4
Home Language	Oshiwambo	T_1Q_1M;$T_{11}Q_{11}F$; T_9Q_9F; T_8Q_8F;T_7Q_7F; $T_{15}Q_{15}M$	6
	Afrikaans	T_6Q_6F; T_5Q_5M; T_2Q_2F; $T_{12}Q_{12}F$; $T_{14}Q_{14}F$	5
	German	$T_{10}Q_{10}F$; $T_{13}Q_{13}M$	2
	Nama	T_3Q_3F ;T_4Q_4F	2
Religion	Christianity	T_1Q_1M; T_2Q_2F; T_7Q_7F; T_8Q_8F; T_9Q_9F; $T_{10}Q_{10}F$; $T_{11}Q_{11}F$; $T_{12}Q_{12}F$; $T_{13}Q_{13}M$; $T_{14}Q_{14}F$; $T_{15}Q_{15}M$	11
	Lutheran	T_3Q_3F T_4Q_4F; T_5Q_5M; T_6Q_6F;	4
Qualifications	B.Ed	$T_{12}Q_{12}F$; T_2Q_2F; T_5Q_5M; T_4Q_4F	4
	B.Ed (Honours)	T_1Q_1M; T_7Q_7F; T_8Q_8F; T_9Q_9F; $T_{10}Q_{10}F$; $T_{11}Q_{11}F$; $T_{12}Q_{12}F$; $T_{13}Q_{13}M$; $T_{14}Q_{14}F$; $T_{15}Q_{15}M$	11
	B.Sc	T_3Q_3F	1

From Table 4.1 above, six Oshiwambo speaking teachers completed the questionnaire and five were completed by Afrikaans speaking teachers. Of the remaining questionnaires, two were completed by German speaking teachers and the other two were completed by Nama speaking teachers. Additionally, among the teachers who completed the questionnaires, 11 were Christians (73%) while the remaining four were Lutherans (27%).

Pertaining to qualifications, more than a third (67%) of the teachers hold a Bachelor of Education (Honours) as their professional qualification. While four of the remaining five teachers hold a Bachelor of Education, the remaining teacher holds a Bachelor of Science (micro-biology) qualification.

The graph below shows a summary of the above explanation on teachers' teaching experiences in general and their teaching experiences in Biology.

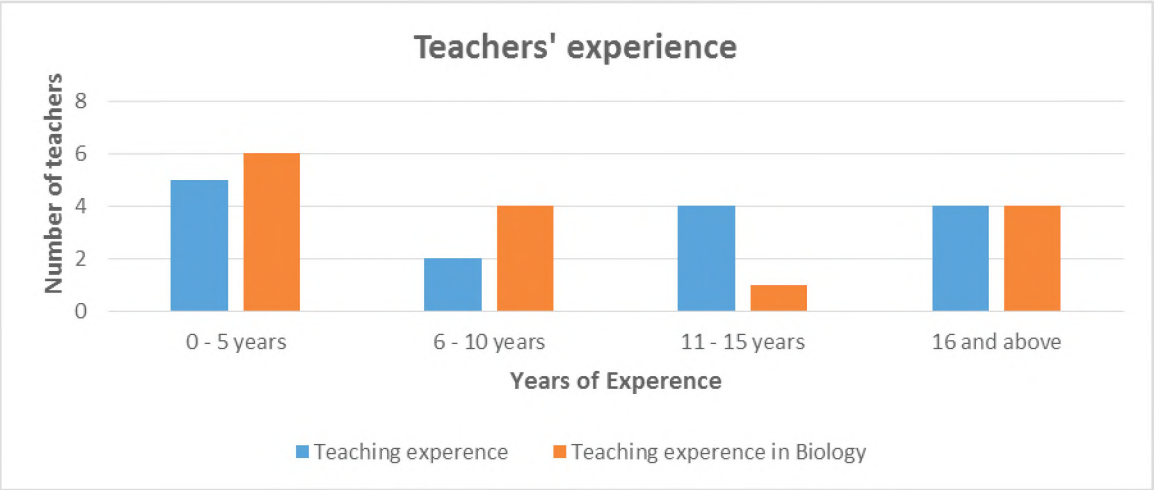

Figure 4.1: Teachers' teaching experience

Five teachers were in the age group of above 50 and had teaching experience of 18 years and more. Of these five teachers, four of them had taught Biology for 23 years and more, while one teacher had been teaching Biology for 13 years. Two teachers were in the age group between 36 to 40 years and both had six years of teaching experience and had been teaching Biology for the past six years. Three teachers were in the age group of 31 to 35 years, one of whom had 13 years of teaching experience and had taught Biology for two years. The other two teachers had 11 years of teaching experience and had taught Biology for six years. Three teachers are in the age group between 26 to 30 years. These teachers had five years of teaching experience, and had been teaching Biology for five years. Lastly, the other two remaining teachers who were in the age group between 20 to 25 years had two years of teaching experience and had only taught Biology for one year.

The semi-structured interviews were conducted with two female Biology teachers. The one teacher who is from the Khomas region, holds a Bachelor of Science degree, while the other teacher who is from the Hardap region holds a Bachelor of Education degree. Five teachers were observed, two Biology teachers from the Hardap region and three Biology teachers from the Khomas region. All the teachers who were observed have Bachelor of Education degrees and have taught Biology for three years and more.

4.6 Data collection techniques

For my main study, I used three methods to gather data, namely: survey questionnaires, interviews (semi-structured and stimulated recall interviews) and observation (only one lesson was videotaped). The use of a variety of data collection techniques afforded me an opportunity to triangulate my data (Cohen et al., 2011). Triangulation involves using more than one method to gather data with the aim of improving the validity (*ibid.*). Additionally, I also used document analysis to strengthen the context of the study. I now discuss each of my main data gathering techniques below.

4.6.1 Questionnaires

According to Cohen et al. (2011), a questionnaire is a useful data gathering tool because it provides structured data. Additionally, it can be completed without the researcher being present and it is generally easy to analyse. Lending support, Bertram and Christiansen (2015) define a questionnaire as a sequence of listed questions for the respondents or participant to answer. Cohen et al. (2011) suggest that open-ended questions enable respondents to answer in their own words, and are more suitable for sensitive topics. My questionnaire was thus composed of open-ended and closed-ended questions (see Appendix 6) and was divided into five parts.

Part A was mainly composed of the teachers' demographic profile. Part B mainly focused on the teachers' conceptions and dispositions towards the topic on evolution, while the third Part C focused on the teachers' content knowledge and the complexity of the topic. Part D focused on teachers' teaching strategies or approaches they use when teaching evolutionary concepts. Finally, Part E was the general comments section.

However, the success of a good questionnaire lies in piloting it many times, to avoid ambiguous questions and to refine and revise questions. Thus, a pilot study questionnaire was done with two teachers from the Hardap region. This was useful in informing me about what kind of questions to add and remove, as well as what questions to include in my interview schedule.

After the pilot study, I made two changes to the questionnaire. The first change I made was to separate Part C from Part D, since this section was too long. I also changed questions based

on teachers' knowledge and the complexity of the topic, from open-ended to closed-ended questions, in order to get specific answers to the questions. For this reason, I can say that the pilot study carried out with the two teachers in the Hardap region, was very useful for my study.

I distributed 25 questionnaires to both regions - the Hardap region and Khomas region. Of all the 25 questionnaires that I distributed, only 15 questionnaires were returned, which is 60%.

An advantage of using questionnaires lies in the fact that they can be completed anonymously, which gives teachers the freedom to be open about their feelings and perceptions, without fear. It is also very time-effective, as a large number of people can be reached at minimum expense – in this context, the different Grade 12 Biology teachers in the Hardap and Khomas regions, each got the questionnaire on the same day.

Notwithstanding, one of the disadvantages of questionnaires is that participants can complete them in a rush or haphazardly, and for that reason fail to provide well detailed and essential rich information expected. Questionnaires also lack validity, which is also a disadvantage, as there is no way one can tell how 'truthful' the participant is being or how much thought has gone into the participants' responses (Cohen et al., 2011). The language used in the questionnaire can also be a barrier, as the words used might not be clear enough to the respondents.

When I came to collect the questionnaire three days after I had distributed them, some teachers in the Hardap region had not completed them, complaining that the questionnaire was too lengthy and thus they had no time, as they were overloaded with too much school work. One teacher refused to complete the questionnaire because she did not want to be associated with anything to do with evolution.

The teachers answered the questions well in the questionnaire, as more than a third of the teachers answered the entire questionnaire, without leaving out some questions. The questionnaires enabled me to get information about the different teachers' conceptions and their dispositions towards the teaching of evolution. It further helped me identify why certain teachers have different attitudes towards the teaching of evolution. The questionnaire also allowed me to generate some responses on the different teaching strategies teachers were

using and why they were using those approaches when teaching evolution. Through the questionnaires, I was also able to gather information about the factors that enable and/or constrain teachers when mediating learning of evolution. Most importantly, data from the questionnaires helped inform me as to what questions to ask during the semi-structured interviews, with a smaller sample of about four teachers.

4.6.2 Interviews

According to Bertram and Christiansen (2015), "an interview is a conversation between the researcher and the respondent" (p. 80), though it is different from an everyday conversation in that the researcher is the person who sets the agenda and asks the questions. McMillan and Schumacher (2006) regard an interview as a purposeful interaction usually between two people, focusing on one person trying to get information from the other person. Interviews enabled the participants in my study to express themselves from their own point of view. With reference to the benefits of interviews, Cohen et al. (2011) state that an interview is a flexible tool of collecting data and that they help to provide an opportunity for the interviewer and the interviewee "to discuss their interpretations of the world in which they live, and express how they regard situations from their own point of view" (p. 409). The advantage of the interviews with the teachers was that it was easier for me to make the questions clearer, as I was present. It was a good method to use, as it helped me to gain in-depth data from the teachers. I used semi-structured and stimulated recall interviews and I discuss each of these below.

4.6.2.1 Semi-structured interviews

A semi-structured interview is flexible, allowing new questions to be brought up during the interview based on the interviewee's responses. It is eminently suited to exploring views, experiences and attitudes of participants. It is about searching for meaning and understanding (van der Mescht, 2011). Leedy and Ormrod (2005) state that interviews allow the researcher to investigate and prompt things that one cannot observe. They further note that, through semi-structured interviews one can probe an interviewee's thoughts, values, prejudices, perceptions, views, feelings and perspectives. It is in this context that I conducted semi-structured interviews with the Biology teachers. I developed an interview schedule to guide the interview (see Appendix 5). In my study, this allowed me to explore teachers' conceptions and dispositions towards teaching of the topic of evolution. Cohen et al. (2011) describe a semi-structured interview as a verbal exchange of views, ideas and information,

where an interviewer attempts to elicit information from another person by asking prepared questions. The main purpose of the semi-structured interviews was to get more insight from the teachers regarding the teaching of the controversial topic of evolution.

The interviews were also conducted to probe participants' (teachers) understanding of evolution, how their religious beliefs and other factors influence their views and attitudes about evolution and any sensitivities about teaching evolution, in secondary schools. The aim of the interview was to enable teachers to express themselves in their own words, express their feelings, preferences and priorities, rather than those of the researcher. During the interviews, each teacher was asked questions that allowed them to reflect on their conceptions and dispositions towards the teaching of evolution. Probing was done when participants did not answer the question, or when a key point was raised that needed further clarification. All interviews were planned for the afternoons so that there would be no conflict with teaching activities, or core functions of the school.

However, I am aware that an interview has certain limitations as Bell (1993) identifies it as a highly subjective technique and therefore there is the danger of bias. Despite this shortcoming, I found using interviews valuable, particularly because of the semi-structured interview format that I deployed. By using the semi-structured interviews, I was able to get detailed and rich responses from the respondents. These interviews enabled the respondents to have the freedom to engage in rich conversations through which they could easily explore their thoughts, without the fear of being limited by closed questions.

The semi-structured interviews were conducted with two teachers. Each interview lasted for about 15 minutes before I did the observations. This was done because I wanted to get the teachers insight, and then go observe them to check if they were practising what they had said during the interview. I had planned to interview at least two teachers from each of the two regions, but I only managed to interview two teachers, one from the Khomas region and one from the Hardap region, respectively. Two female teachers (T1 and T2), were interviewed. T1 who is from the Khomas region, holds a Bachelor of Science degree, while T2 who is from the Hardap region, holds a Bachelor of Education. The second teacher from the Hardap region that I had asked to interview, said she was busy preparing to write her learners licence, so she could not make time for the interview session. The teacher from the Khomas region who had agreed to the interview, changed her mind when it was time for the interview to take

place. I promised her anonymity and that every precaution would be taken to protect her identity using the standards set by Rhodes University in this regard. Her reason was that she was not comfortable, and did not want to be recorded.

Drawing on Clough and Nutbrown (2007), permission was requested from participants to use an audio recorder to obtain interview data and to avoid losing some comments. The audio recorder was used to capture the respondents' unique expressions as well as to enable me to transcribe the interviews. The audio recorder is convenient, as the researcher can then concentrate on eliciting responses without losing what is being said, while taking notes. Using an audio recorder is less time consuming as well, as one can sustain the interview sessions without pausing for note-taking.

Teachers' names were not attached to the interview quotations but were given transcription indices (T1 and T2) to protect their identities, in case they wished to provide sensitive data. The duration of the interviews varied from 14 to 18 minutes, depending on how the participants responded. All the interviews were conducted at schools, for the comfort of the teachers. During the interviews I used probing to gain more information from the teachers. The one teacher (T1), did not like it when I was asking more questions (probing) and she said "*Ag Henry you are asking too many questions*". Before I responded to her comment, I paused the recorder and then explained to her the importance of probing. I told her that I wanted to gain more clear answers from her. She then understood why I was probing and we then continued with the interview.

4.6.3 Observation

Observation is one of the techniques I used to generate data from the participant teachers at the different schools during my study. During observation the researcher goes to the site of the study, which in this case is the classroom and observes what is actually taking place there. According to Cohen et al. (2007), observation is the technique researchers use to generate or gather live data in a social situation and this technique resonates with Vygotsky's socio-cultural theory, which is my theoretical framework in this study (see Section 3.2). In other words, this allows the researcher an opportunity to look directly at what is taking place in the classroom, rather than relying on second-hand information. Stake (1995) indicates that the importance of using observation is to increase understanding of the case being studied. Bell (1993, p. 109) notes that "direct observation may be more reliable than what people say in

many instances. It can be particularly useful to discover whether people do what they say they do, or behave in the way they claim to behave. In addition, observation allowed me to pick up information that I did not think of when I was planning my research. Cohen et al. (2007) state that there is a huge difference between what people say and what they do and I agree with them. Hence, observation really offered a reality check, as I was able to observe and see what and how things were done in the classroom context.

I am aware of the weaknesses of the observation method, as noted by Simpson and Tuson (2003), that observation has a high demand on time, effort and resources. I went about solving this weakness by piloting my observation and procedures so that I could make a fair estimate at the outset, of how long the data collection process might take. That also helped me plan the study within the limits of my resources. Simpson and Tuson (2003) further note that observation is susceptible to various factors, one being bias, which might occur either because the observer records what he or she thought occurred, rather than what actually took place, or because of the observer's lack of attention to significant events. To solve this weakness, classroom observation was done in conjunction with informal follow-up discussions.

In light of the above idea, five Grade 12 Biology lessons were observed: three lessons from two teachers from the Hardap region and three lessons by three different teachers at three different schools in the Khomas region. I initially planned to observe at least three lessons from each teacher, but it did not go accordingly. I could not observe more lessons from these teachers, as at the time of data collection, many teachers were done with teaching and were preparing the learners for the examinations. The duration of the lessons in the Hardap region schools changed day by day, as some days the lessons were 35 minutes and others they were 45 minutes. The reason for this was that the schools were using a seven-day cycle timetable. For some days the school day had seven periods, while on other days the school had eight periods. On a school day with seven periods, the lessons were 45 minutes, while on a school day with eight periods, the lessons were shorter and thus only 35 minutes. This was the main reason for the differences in the lesson durations in the Hardap region. While in the Khomas region, all the lessons I observed were 35 minutes.

As a non-participant observer, I tried to minimise description associated with my presence, by taking a seat at the back of the classroom and not saying anything during the lessons.

There was a conscious effort to observe other unexpected or unanticipated actions and utterances which might give clues, as participants were responding to changes in the teaching methods (Cohen et al., 2007). The primary focus during lesson observation was to understand the teachers' interactions with the learners and teaching methods being used. Observations also had to focus on events as they occurred in the Biology classroom; for example, verbal interactions between teachers and learners, the number of learners in the classroom, the teaching and learning materials used to present evolution lessons and the seating arrangements in the classrooms. I further looked at how teachers communicated with the learners with reference to the four aspects of the communicative approach, namely: dialogic/authoritative and interactive/non-interactive, as advised by Mortimer and Scott (2003). I took notes of any written work on the chalkboard and transparencies, as well as any teaching aids used. It was also necessary to observe the teachers' non-verbal gestures to see how confident they were in presenting the lesson and as an indicator of interaction. I also observed specific factors that influenced the lessons (for example class size, resources used, time spent on tasks) to provide further perspective on the enabling and constraining factors of evolution implementation.

4.7 Data Analysis

Data analysis is described as a process of bringing order and reducing large amounts of data to make sense of them (Bertram & Christiansen, 2015). The research generated a lot of data through questionnaires, interviews and observation. Data analysis included identification of sub-themes, which were inductively derived from the data. The identical sub-themes were then linked and formed themes. Thereafter, the different themes were grouped to form analytical statements. Each theme was then discussed in more detail. As this was a mixed-method research, both quantitative and qualitative data were generated. The quantitative data was analysed to answer part of research question one, while the qualitative data was analysed to respond to research sub-question one, two, three and four.

4.7.1 Approach to quantitative data analysis

Exploratory data analysis using frequency, percentages and cross tabulation (Cohen et al., 2011; Bertram & Christiansen, 2015) were used to describe the data. Exploratory data analysis is usually descriptive and mostly concerned with reporting the data itself without making inferences (Cohen et al., 2011). It makes use of graphical presentation of data such as

bar charts (Cohen et al., 2011; Christensen et al., 2015). Bar charts are pictorial, vertical, presentations of categorical variables/data (Cohen et al., 2011). In this study, the percentages for each frequency of teachers' responses were represented using bar graphs and pie charts. It represents teachers' views towards the teaching of evolution to Grade 12 learners.

4.7.2 Approach to qualitative data analysis

The method of qualitative data analysis chosen for this study was content analysis. According to Mayring (2000), content analysis is a method for summarising or reducing any form of data by counting various aspects of the content. Qualitative data can be analysed by placing it into themes and categories (Merriam, 2009).

Content analysis was used to analyse data from the questionnaires, semi-structured interviews and classroom observations. As the study used questionnaires, semi-structured interviews and classroom observation, content analysis was used to transform answers from the questionnaires, transcribed interviews and classroom observations (stimulated recall interviews). One of the strengths of content analysis is that it provides a way of extracting information from a wealth of real-world situations (Mayring, 2000). Data generated from the questionnaires, semi-structured interviews and classroom observations were transcribed. After transcription, the data from the questionnaires, semi-structured interviews and classroom observation, were studied thoroughly and analysed inductively.

Inductive analysis is primarily a form of pattern recognition within data, where themes or concepts are derived through the reading and interpretation of raw data (Cohen et al., 2011). As the data was studied it was colour coded to identify sub-themes. The overlapping sub-themes were than linked to form themes. Themes communicated the reality obtained from the questionnaires, interviews and classroom observation in an effort to explain teachers' conceptions, dispositions and pedagogic strategies, when mediating learning of evolution. The themes further communicated the factors that enable and constrain the effective teaching of evolution in these schools.

The socio-cultural theory guided me to focus on mediation as I categorised data into forms of semiotic mediation, associated with teaching. These included language, concepts, signs, prior knowledge, pictures, diagrams, posters and models. These mediational tools guided me during my observations, to see what mediational tools the teachers used during the teaching

of evolution. It also guided me during the interviews to discuss the efficiency of using different mediational tools to enhance learning. Additionally, for my observations, I also used Mortimer and Scott's (2003) four communicative approaches discussed earlier (see Section 3.3.2).

4.8 Validity and trustworthiness

According to Bassey (1999), validity is the extent to which a research fact or finding is what it is claimed to be. To ensure validity and trustworthiness in this study, I made use of triangulation in my data gathering process. According to Cohen et al. (2007), "triangulation techniques in the social science attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint" (p. 141). In this study, I made use of different methods (questionnaires, interviews and observation) to gather data in order to enhance validity in my study. Triangulation is the using of more than one method to gather data and is a powerful way of demonstrating concurrent validity. Triangulation reduces the risk of chance associations and systemic bias, as it relies on information collected from a diverse range of individuals, teams and settings, using a variety of methods (Maxwell, 1992). Triangulation thus helps one to detect errors made in the analysis of the data gathered. Cohen et al. (2007) further suggest that exclusive reliance on one method is likely to bias or distort the researcher's picture of the particular slice of reality being investigated.

For instance, if I only believe in teachers' words or statements they tell me during the semi-structured interviews on the pedagogical strategies they use when teaching evolution, I might miss out on the reality of what is actually happening in the classroom, if I do not conduct classroom observation. Thus, triangulation is very important in research, as it assists in validating the data collected. There are different kinds of triangulation methods, but for my study I only used survey questionnaires, interviews (semi-structured interviews and stimulated recall interviews) and observations (including a videotaped lesson). Watching the videotape with the teacher about the lesson plan was also a form of validation of what really happened in the class. Piloting the questionnaire with two teachers assisted in testing the efficacy of the questionnaires, to test and see if the questions were clear for the participants. This piloting of the questionnaires also served as a validation technique. The stimulated recall interview also became a validation technique. Some scholars also use member checking,

whereby the researcher gives the transcripts to the participants, for them to see that the researcher has accurately captured what they said.

4.9 Ethical considerations

I have followed the normal procedure in this type of research with regards to ethical consideration, as honouring the ethics in research is important to ensure that the validity of the research is not threatened. Cohen et al. (2011) alert researchers to the importance of seeking the cooperation and consent of all individuals that take part in social research. I therefore sought permission from the Directors of Education in both the Hardap and Khomas regions.

Once permission was obtained from the Regional Directors (see Appendix 1), I sought formal permission from the school principals (see Appendix 2), and the Grade 12 Biology teachers (see Appendix 3) of the different schools, by visiting them to make appointments and to present the letters of permission from the regional office. During these visits, I outlined my plans and explained the nature and purpose of the research. The letters clearly stated that the study was for the purpose of obtaining my Master in Science Education degree, as well as to improve things in the regions, where possible. The letter stipulated clearly that all information gathered would be treated as confidential and that participation in the research investigation was voluntary. All consenting participants were guaranteed anonymity at all times and were fully informed of their rights and the benefits of their participation in the research investigation. I further informed them that they had the full right to withdraw from further participation at any time, if they felt like it.

4.10 Limitations

This study involved only two regions out of the 14 and hence its findings cannot be generalised to all 14 regions. However, it points out issues that need to be addressed and possibly improved, and these could be applied to any school, irrespective of its location or region. One of the serious limitations of the study was that only two teachers were interviewed as all the other teachers that were approached did not want to be recorded. If more teachers could have been interviewed, that would have further authenticate the findings.

Findings emerging from this research may be available to any interested party forming part of the community involved in the research.

4.11 Concluding remarks

This chapter described the research design which entailed a qualitative interpretive paradigm used to investigate Grade 12 Biology teachers' conceptions, dispositions and their pedagogic strategies when mediating learning of evolution. The chapter further described the different data-gathering techniques employed, namely: survey questionnaires, interviews (semi-structured and stimulated recall interviews) and observation. Lastly, the chapter took into consideration the validity and trustworthiness, ethical considerations, and limitations of the study, and explained the methods used in the data analysis and interpretation stages, to draw conclusions from the findings.

In the next chapter, I will present, analyse and discuss the quantitative and qualitative data from the survey questionnaires.

CHAPTER FIVE
DATA PRESENTATION, ANALYSIS AND DISCUSSION

5.1 Introduction

The main goal of this study is to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies when mediating learning of evolution in the Hardap and Khomas regions. In this chapter, I present, analyse and discuss the quantitative and qualitative data from the questionnaires. This chapter commences by outlining the teachers' profiles or information. This is followed by the presentation, analysis and discussion of the quantitative data from the questionnaires. Lastly, I present, analyse and discuss qualitative data from the questionnaires (open-ended questions). Both the quantitative and qualitative data provided answers to my research sub-questions 1 and 2:

- What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
- What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?

5.2 Quantitative data from the survey questionnaire

Quantitative data were generated from the questionnaires composed of five different sections or parts. Each section had its own respective quantitative data and it is thus presented in that order (see Appendix 6). Furthermore, the quantitative data are presented in tables and graphs.

5.2.1 Quantitative data

Quantitative data from Part B of the questionnaire were analysed and presented in graphs. Thereafter, a discussion on what the graphs illustrate is provided.

5.2.1.1 Teachers' views towards evolutionary statements

Table 5.1 shows a summary of how the 15 teachers responded towards the different evolutionary statements, based on the origin of life. Data for each statement is presented in a graph and then discussed.

Table 5.1: Summary of teachers' conceptions and dispositions towards evolution

Statements	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
a) It is certain that the origin of life resulted from natural phenomena.	5	2	2	2	4
b) The origin of life may be explained by natural phenomena without considering the hypothesis that God created life.	0	2	3	3	7
c) The origin of life may be explained by natural phenomena that are governed by God.	7	4		2	2
d) It is certain that God created life.	12	1	1	1	0
e) Science and religion should be separate.	6		1	2	6
f) Science and religion should be integrated.	6	1	2	1	5
g) A person can hold a scientific view of nature and be religious at the same time.	8	4		2	1

Figure 5.1 below shows a summary of teachers' responses towards the first two evolutionary statements A and B (see Appendix 6).

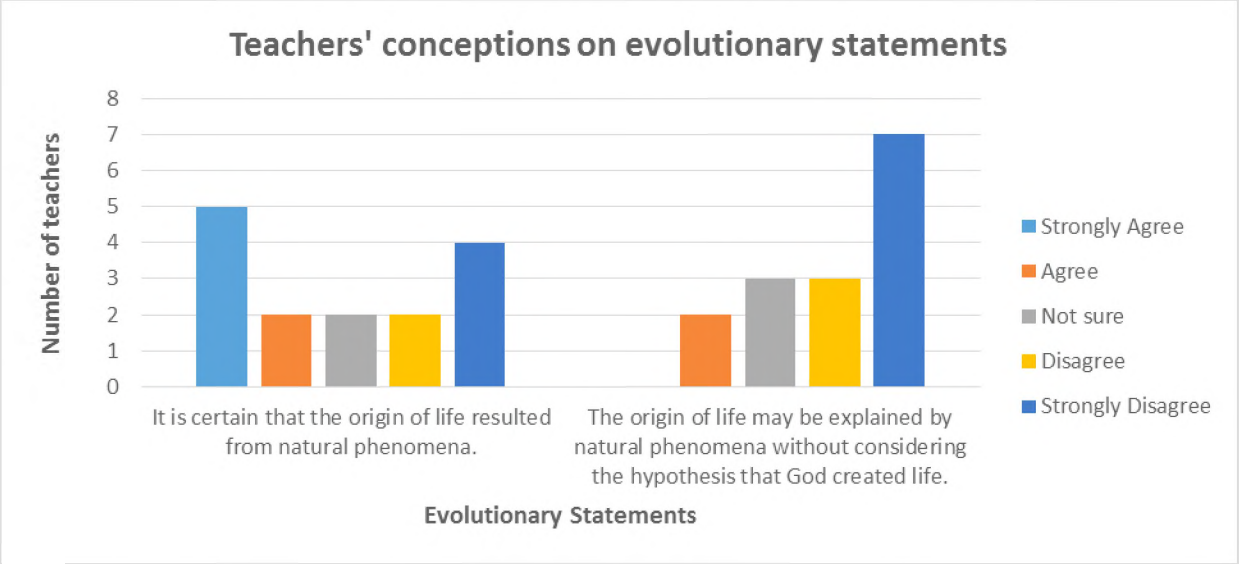

Figure 5.1: Teachers' conceptions on the first two statements A and B

Figure 5.1 shows that seven teachers (47%) agreed with the first statement which states that it is certain that the origin of life resulted from natural phenomena, while two teachers (13%) were not sure. The remaining six teachers (40%) disagreed with the statement. It further shows that two teachers (13%) agreed that the origin of life may be explained by natural phenomena without considering the hypothesis that God created life, while three teachers (20%) were not sure. The remaining 10 teachers (67%) disagreed with the statement. It could be deduced that these teachers believed that God was involved in the origin of life, and that is why they disagreed with the given statement. It can also be further argued that many teachers were against this statement because they are Christians and Christians strongly believe that God created everything on earth.

Figure 5.2 below shows a summary of the teachers' responses towards the third and fourth statement C and D (see Appendix 6).

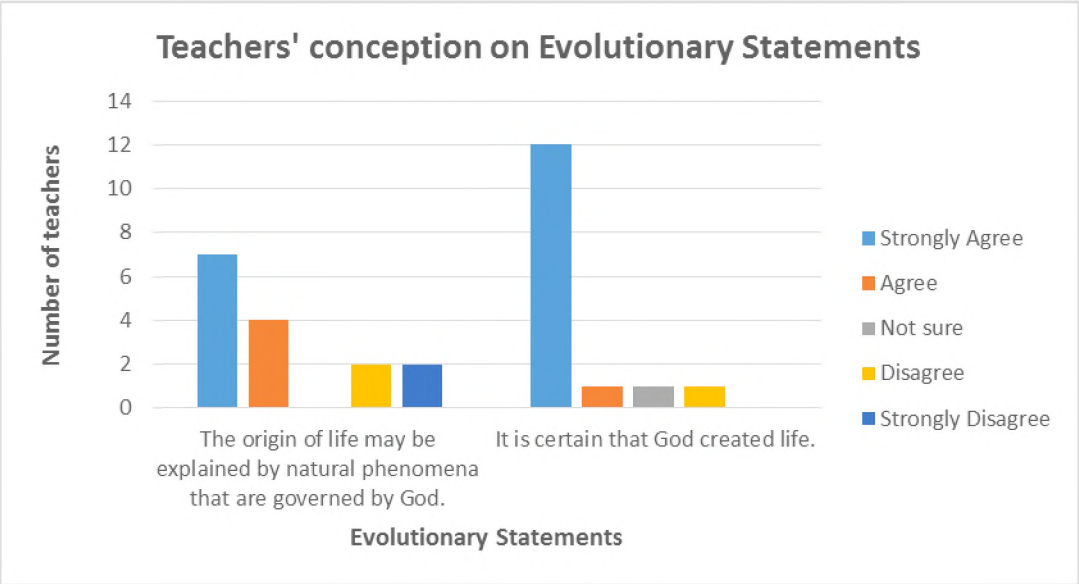

Figure 5.2: Teachers' conceptions on the third and fourth statements C and D

Figure 5.2 shows that 11 teachers (73%) agreed that the origin of life may be explained by natural phenomena that are governed by God, while four teachers (27%) disagreed with this statement. Once again, the majority of the teachers indicated that they were Christians and agreed with this statement because God is involved. The figure further indicates that 13 teachers (87%) agreed with the statement that it is certain that God created life, while one teacher was not sure and another teacher disagreed with the statement. Figure 5.3 shows a summary of the teacher's responses towards the last three statements E, F and G (see Appendix 6).

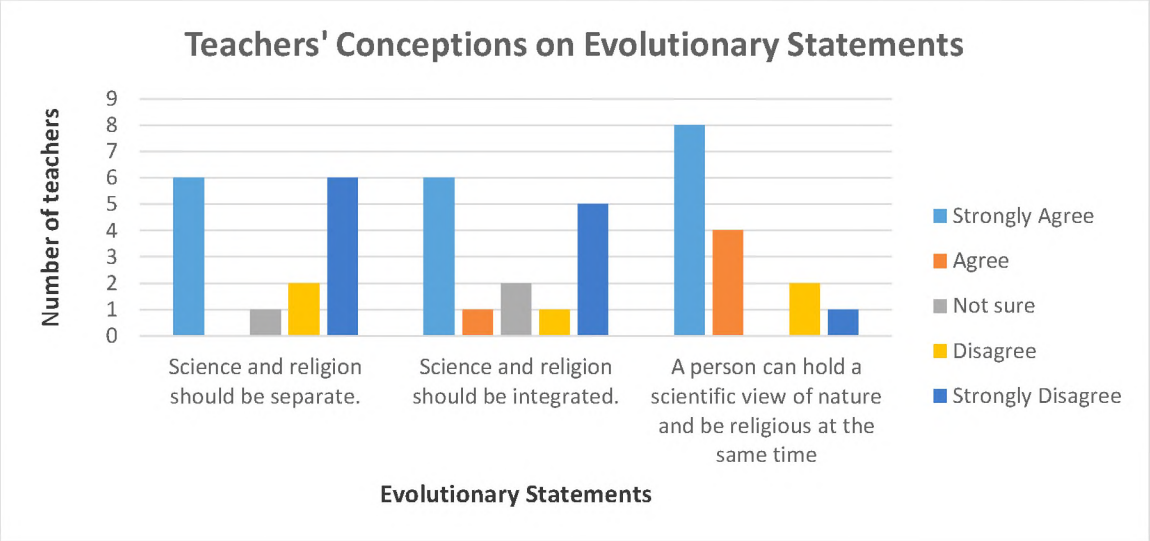

Figure 5.3: Teachers' conceptions on the last three statements E, F and G

Figure 5.3 shows that six teachers agreed that science and religion should be separate, while one teacher was not sure about the separation. Eight teachers (53%) disagreed with the separation of science and religion. The figure further shows that seven teachers (47%) agreed that science and religion should be integrated, while two teachers were not sure about that. Six teachers (40%) disagreed with this statement. Finally, this shows that 12 teachers (80%) agreed that a person can hold a scientific view of nature and be religious at the same time, while three teachers (20%) disagreed with this statement.

5.2.2.2 Teachers' views on the inclusion of evolution in the Grade 12 syllabus/curriculum

The graph below shows the teachers' views towards the inclusion of evolutionary concepts in the syllabus or curriculum.

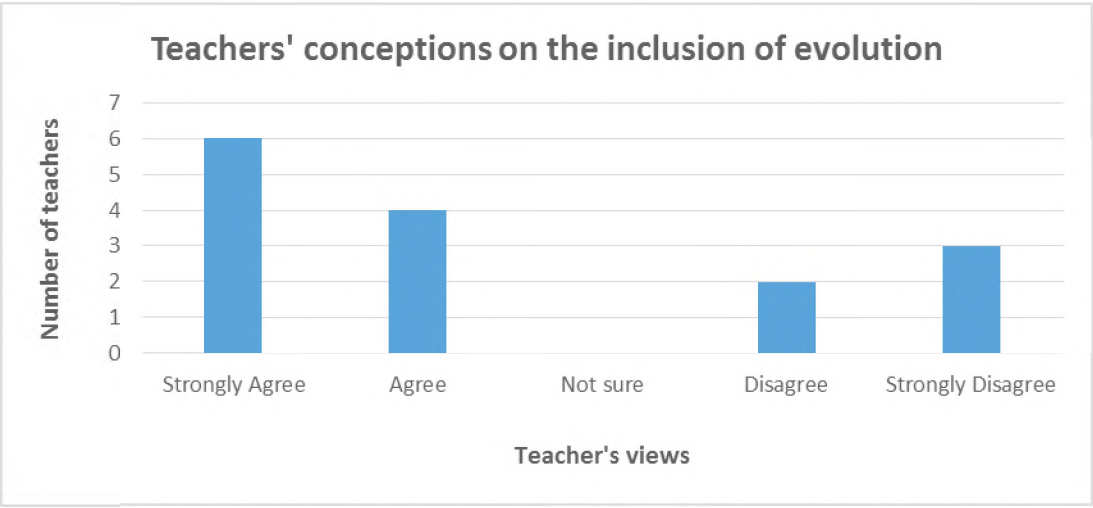

Figure 5.4: Teachers' conceptions on the inclusion of evolution in the syllabus

From Figure 5.4, 10 teachers (67%) agreed that evolution should be included, while four teachers (27%) disagreed with the inclusion of evolution. The reason for the teachers' views are explained in more detail later (see Section 5.3).

5.2.2.3 Teachers' comfortability and/or uncomfortability in teaching evolutionary concepts

Figure 5.5 below shows the teachers' comfortability and/or uncomfortability towards the teaching of evolutionary concepts.

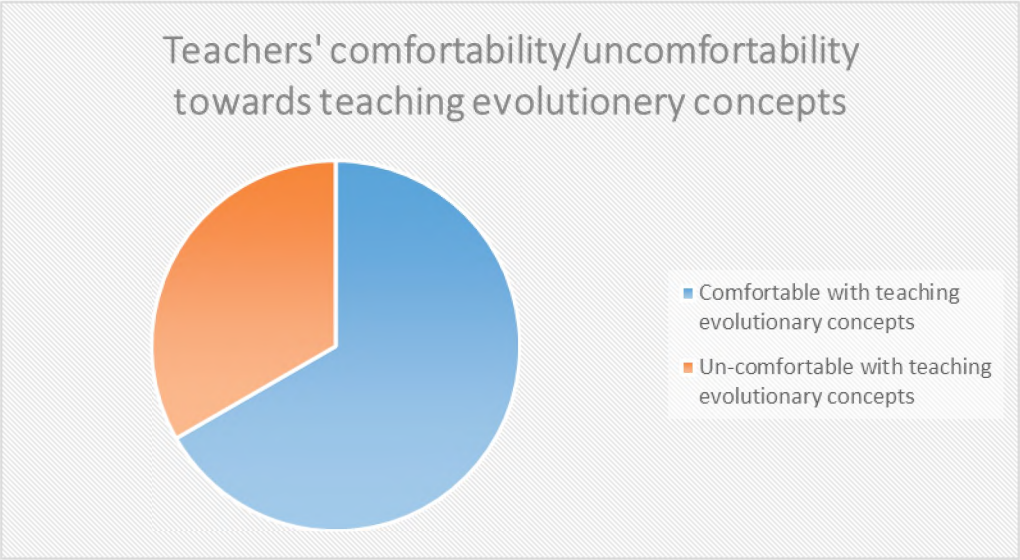

Figure 5.5: Teacher's comfortability and/or uncomfortability in teaching evolutionary concepts

Figure 5.5 shows that 10 teachers (67%) were comfortable with the teaching of evolutionary concepts, while five teachers (33%) were uncomfortable with the teaching of evolutionary concepts. This suggests that the majority of teachers who were involved in this study were comfortable with teaching evolutionary concepts. The reasons behind their answers are discussed under the qualitative data in Section 5.3.

5.2.2 Quantitative data on teachers' content knowledge

In this section I present the quantitative data from Part C of the questionnaire (see Appendix 6). This section had questions based on teachers' content knowledge and how complex the topic of evolution is perceived to be.

5.2.3.1 Teachers' content knowledge and understanding of evolution

This section shows how the teachers rated themselves in terms of their content knowledge and understanding of evolution and its processes.

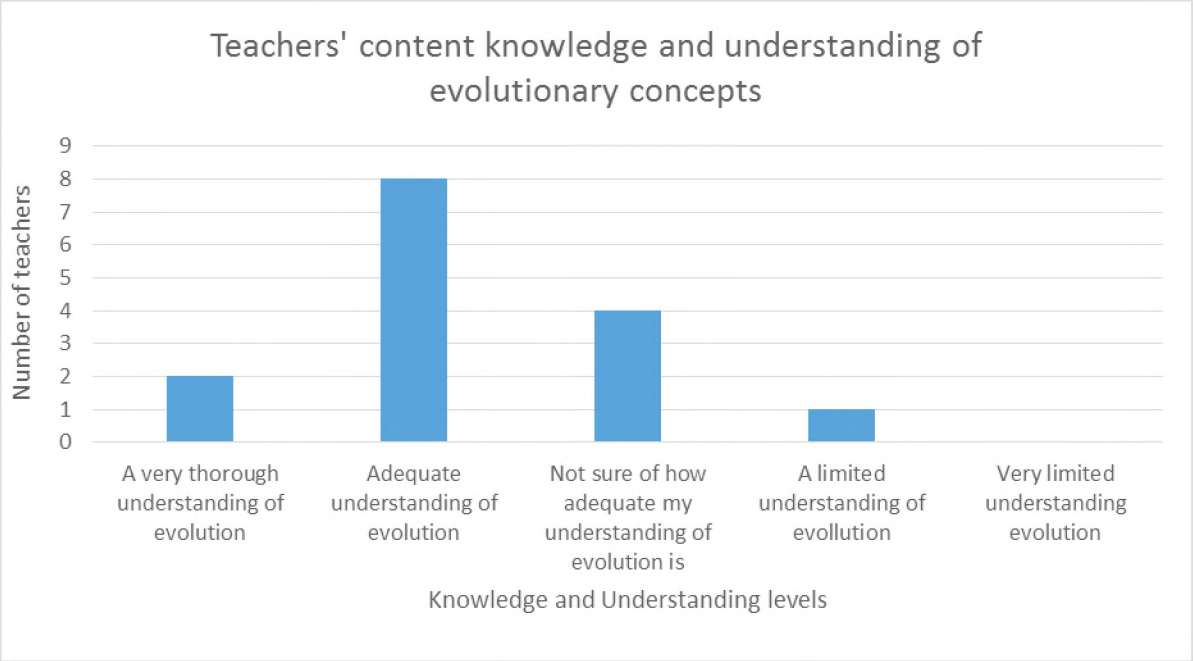

Figure 5.6: Teacher's content knowledge and understanding of evolutionary concepts

Figure 5.6 shows that 10 teachers (67%) had an adequate to very thorough understanding of evolution, while four teachers were not sure about their understanding of evolution. Only one teacher indicated that she has a limited understanding of evolution.

5.2.3.2 Teachers' rating of their Grade 12 learners' content knowledge and understanding of concepts

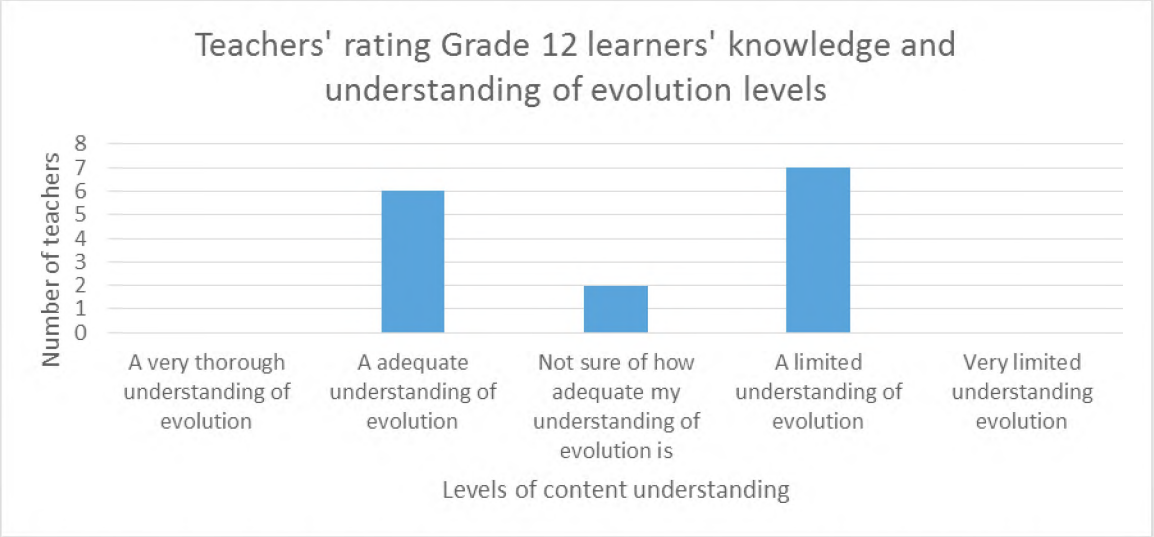

Figure 5.7: Teachers' rating the levels of Grade 12 learners' content knowledge and understanding of concepts

Figure 5.7 shows that six teachers (40%) rated their learners as having an adequate understanding of evolution after they had taught the topic in class, while two teachers (13%) were not sure how adequate their learners' understanding was after they had taught the topic. Seven teachers (47%) indicated that their learners showed a limited understanding of evolution, after they were taught the topic.

5.2.3.3 Teachers' thoughts about the prescribed textbooks

In this section, the teachers had to give their thoughts on the quality of the textbooks. That is, whether they explain the content knowledge on evolution in-depth enough. The figure on the next page shows teachers' thoughts about the prescribed textbooks.

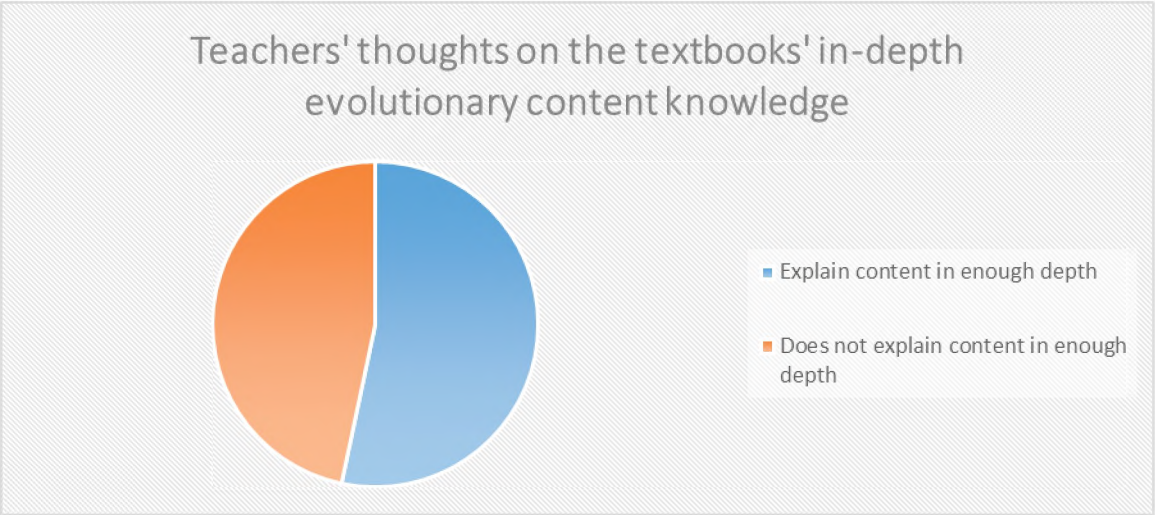

Figure 5.8: Teachers' thoughts on the textbooks' in-depth evolutionary content knowledge

Figure 5.8 shows that eight teachers (53%) believed that the prescribed Biology textbook explained the evolutionary content well, while seven teachers (47%) indicated that the prescribed Biology textbook does not explain evolutionary content in-depth enough.

5.2.4 Quantitative data on teachers' teaching strategies/approaches

In this section I present the quantitative data from Part D of the questionnaire (see Appendix 6).

5.2.4.1 Effectiveness of teaching strategies/approaches used by the teachers

The teachers were asked if the approaches they applied when teaching evolutionary concepts were effective or not.

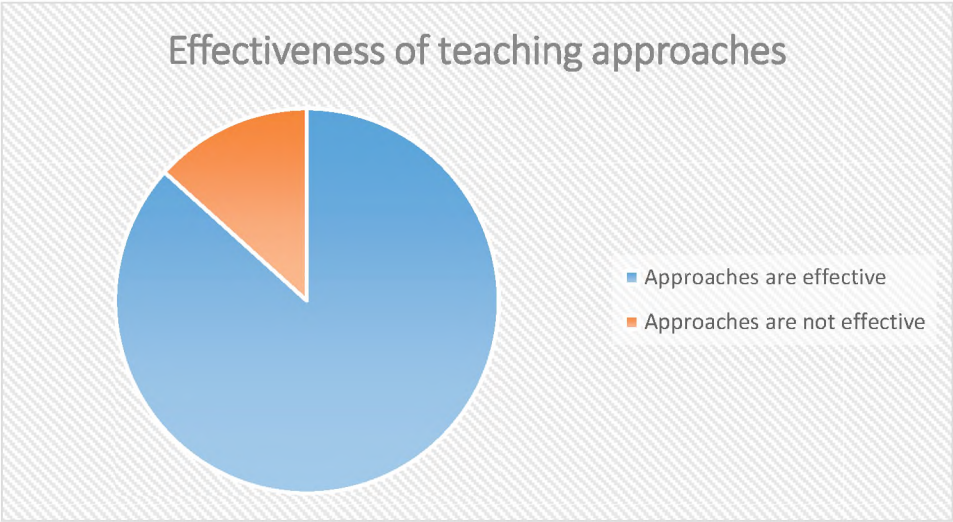

Figure 5.9: Shows effectiveness of teaching approaches

Figure 5.9 shows that 13 teachers (87%) said their approaches they used when teaching evolutionary concepts were effective, while two teachers (13%) said the methods they used were not effective. The reasons for this will be discussed under the qualitative data section (see Section 5.3).

5.2.5 Discussion of quantitative results

The results are discussed in relation to my research sub-question 1: What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?

It could be deduced from the quantitative data that the majority of the teachers (73%) believed that God was involved in the origin of life (see Figure 5.3). One can argue that teachers believed so because they were influenced by the Bible, as many of the teachers indicated that they were Christians (see Table 5.1). Christianity is regarded as the dominating factor that influences teachers' conception towards the teaching of evolution. The reason is that many teachers believe in creation and thus reject evolution (Rutledge & Warden, 2000). In this study, 11 teachers indicated that they were Christians but did not reject evolution education, as they believed that a person could hold a scientific view of nature and be religious at the same time (see Figure 5.3). This is an indication that these teachers may not have a problem with the teaching of evolution. Furthermore, 10 teachers (67%) indicated that they are for the inclusion of evolution in the syllabus, and this shows that these teachers have a positive view about evolution and will be able to teach the concepts to the learners.

According to Trani (2004), teachers with a positive view about a subject matter or topic will be able to teach that topic to the learners.

In light of the above mentioned, one can conclude that the majority of the teachers (73%) in this study, have a positive view towards evolution as a topic, which then results in them having a positive attitude towards teaching evolutionary concepts. This conclusion is based on the fact that more than a third of the teachers are Christians and still accept evolution, though Christianity is regarded as the dominating factor that influences teachers to reject evolution. From this qualitative data one can conclude that religion did not really affect many of their views towards the acceptance of evolution. It can further be argued that the teachers of whom more than a third are Christian, support the inclusion of evolution in the syllabus, which would be the opposite if religious beliefs influenced their views.

Finally, 11 teachers (73%) agreed that a person could hold a scientific view of nature and be religious at the same time. These teachers according to Ogunniyi (2006), hold an equipollent view (see Section 3.3) which means that they hold both views together, as both views have equal cognitive power and co-exist without logical connection. The fact that these teachers hold both views together is another sign that they have a positive view about the topic, as they do not reject the topic because of their religious views, but rather support it along with their religious views.

5.3 Qualitative data from questionnaires

In this section I present, analyse and discuss qualitative data from the questionnaires, that is, open-ended questions.

5.3.1 Teachers' conceptions and dispositions towards teaching evolution

Regarding the data analysis process, I started by colour coding the qualitative data to identify preliminary sub-themes (see Tables 5.3a and 5.3b). Thereafter, I grouped the overlapping sub-themes to form themes, in relation to my research sub-question 2. The common themes were then grouped into three analytical statements. Analytical statement one is on teachers' conceptions and experiences of evolution (see Table 5.3c), while analytical statement two is on the factors influencing teachers' views on the inclusion of evolution (see Table 5.3d).

Analytical statement three is on the factors that influence teachers' views on the exclusion of evolution (see Table 5.3e).

Table 5.3a: Preliminary themes from coded text

Research sub-question 1: What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?		
Teacher Questionnaire	**Description of coded text**	**Sub-themes**
T_1Q_1M; T_2Q_2F T_3Q_3F; T_4Q_4F T_6Q_6F; T_7Q_7F T_8Q_8F; T_9Q_9F $T_{10}Q_{10}F$; $T_{11}Q_{11}F$ $T_{15}Q_{15}M$	Important to teach evolution; generations get to better understand biology; to be confronted with it, be included in the syllabus; do not see it as a problem; it is a good idea; should be included.	Teaching and learning of evolution.
T_4Q_4F; T_7Q_7F T_9Q_9F; $T_{11}Q_{11}F$ $TQ_{15}M$	A good experience; was an interesting topic; it was interesting that time; teacher taught us very well.	Learned evolution, through teaching.
T_1Q_1M; T_2Q_2F T_4Q_4F $T_{10}Q_{10}F$ $T_{11}Q_{11}F$; $T_{13}Q_{13}M$ $T_{15}Q_{15}M$	Understand the whole concept and its importance; was taught well in details; discussed in greater details; gained a better understanding; content was a bit deep to be taught in one module.	Gained knowledge on evolutionary concepts.
T_5Q_5M ; T_8Q_8F $T_{10}Q_{10}F$	My Christian principals; my belief in the existence of God; point in saying humans evolved from an ape like creature; different religion nowadays.	Teachers' beliefs affect teacher's views.
T_2Q_2F; T_5Q_5M T_8Q_8F; $T_{11}Q_{11}F$ $T_{14}Q_{14}F$	Don't feel good; don't like teaching this topic; just run through the topic, without explaining concepts; views influence me negatively; don't teach this topic seriously; I don't like the topic; effect it negatively; I do not like teaching the topic.	Views influenced them not to teach the topic appropriately or at all.
$T_{14}Q_{14}F$	Concepts are difficult; the topic is not clear at all.	Lack of subject knowledge.
T_5Q_5M	Christian principals.	Religious views affect teaching.
T_1Q_1M ; T_3Q_3F T_4Q_4F; T_6Q_6F T_9Q_9F; $T_{10}Q_{10}F$ $T_{12}Q_{12}F$; $T_{15}Q_{15}M$	Is a good understanding of the topic; that micro-evolution is evident; know the topic very well; my knowledge of the topic makes it easier to teach; I have sufficient knowledge; qualified facilitator; I explain it to the learners; living organisms change over many years; survival of the fittest in environment; my ample knowledge on evolution; can make the concepts very clear; am good in this topic.	Sufficient subject knowledge makes it comfortable to teach.

T_2Q_2F; T_4Q_4F T_8Q_8F	More about humans; the facts need to be taught; I do teach it to help the learners understand the concepts.	For the sake of developing the learners.
T_4Q_4F; T_6Q_6F T_7Q_7F; $T_{11}Q_{11}F$	Lack of content knowledge; knowing what evolution is all about; poor understanding of the topic; have enough teaching experience on that topic.	Lack of subject knowledge can make teachers uncomfortable when teaching.

Table 5.3b: Preliminary themes from coded text

Research sub-question 1: What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?		
Teacher Questionnaire	**Description of coded text**	**Sub-themes**
T_5Q_5M; T_8Q_8F $T_{11}Q_{11}F$; $T_{12}Q_{12}F$	Don't believe in evolution; does not affect my belief; grounded on what their religion taught them; religious point of view; it is not good; believe that God created everything.	Against the inclusion of evolution.
T_5Q_5M; $T_{12}Q_{12}F$ $T_{13}Q_{13}M$	Topic might create a lot of confusion; confuses the learners.	Topic confuses the learners.
$T_{13}Q_{13}M$; $T_{14}Q_{14}F$	Should not be included in the syllabus; topic should not be included.	Evolution should be excluded.
T_1Q_1M; T_5Q_5M T_8Q_8F; $T_{11}Q_{11}F$ $T_{12}Q_{12}F$	Was not really comfortable; did not teach the topic as well; never thought about evolution; didn't get a better understanding of evolution; we were not taught that topic in school; did not explain the concepts to us.	Lack of learning on evolution concepts.
T_5Q_5M; $T_{12}Q_{12}F$, $T_{13}Q_{13}M$	Never believed in anything about evolution; God created heaven and earth and everything; God created humans; teacher was a Christian.	Believers of creationism, poor knowledge of evolution.
$T_{11}Q_{11}F$; $T_{14}Q_{14}F$	When I started knowing that it attacks what I believe in, do not believe in evolution when it was taught.	Beliefs affected their knowledge of evolution.
T_1Q_1M; $T_{11}Q_{11}F$ $T_{13}Q_{13}M$; $T_{15}Q_{15}M$	Understand the impact of environmental changes on organisms; learners wanting to pursue careers in that field; be granted the opportunity to be taught in school; want to pursue a career in evolution; can get help to develop the learner for the future.	For the interest of the learners.

T_1Q_1F; T_4Q_4F T_6Q_6F; T_7Q_7F T_9Q_9F; $T_{10}Q_{10}F$ $T_{11}Q_{11}F$; $T_{12}Q_{12}F$ $T_{13}Q_{13}M$; $T_{15}Q_{15}M$	Without any fear or feeling; fine with teaching the topic; teach the topic normally; don't have bad views concerning topic; makes it easy for me to teach the topic; influenced my teaching in a better way; views do influence me positively; to deliver it with passion; teach them about changes; views do not influence me in any way; teach evolution well; am for evolution; not have a problem with teaching; approach it very scientifically.	Views influenced them to teach the topic of evolution.
T_5Q_5M; $T_{11}Q_{11}F$	Go beyond my religious principles; I don't believe in it; it goes against my biblical theory; attacking my creator God.	Religion affects teaching.
T_7Q_7F; $T_{13}Q_{13}M$ $T_{14}Q_{14}F$	Scared that learners will ask me questions I won't be able to answer; don't know the topic very well.	Poor subject knowledge affects teaching.
$T_{14}Q_{14}F$	Lack of resources to be used.	Affect appropriate teaching practices.
T_1Q_1M	A balance in their science and religious perspectives; is an imbalance between the understanding of science and religion.	Misunderstanding of evolution and science.
T_9Q_9F; $T_{10}Q_{10}F$ $T_{11}Q_{11}F$; $T_{13}Q_{13}M$ $T_{14}Q_{14}F$; T_2Q_2F TQ_3F; T_5Q_5M T_8Q_8F; T_9Q_9F $T_{12}Q_{12}F$; $T_{14}Q_{14}F$	Depends on what you believe in; do not mix subjective beliefs with what is expected; believers of God and his creation; don't believe in creation; the topic does not affect their religious beliefs; their religions allow them; religious beliefs can affect; religious concerns; Christian principals; religious beliefs can influence strong believer of Christianity; fully Christians; going against God; evolution goes against Christians beliefs; goes against what they believe; religious beliefs can make them uncomfortable; Christian principals.	Religious belief is determined as a factor influencing teachers comfort level and ability in teaching evolution.

Table 5.3c: Research sub-question, analytical statements, themes and supporting theory/literature

Research sub-question 1: **What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?**	
Analytical statement 1: Teachers' conceptions and experiences of evolution	**Theory/literature**
Inclusion of evolution	
Learning of evolution	Dobzhansky (1973), Farber (2003), National Academy of Sciences (2008) Sanders and Makotsa (2016),
Teachers gained knowledge on evolutionary concepts from school and tertiary institutions.	
Learned evolution through teaching; gained knowledge on evolutionary concepts.	Vygotsky (1978), Contiguity Argumentative Theory (CAT), Ogunniyi (2006), Heggart (2016).
Evolution be excluded.	
Against the inclusion of evolution; topic confuses the learners; evolution should be excluded.	Deckard and Smithwick (2002).
Teachers who gained nothing to little evolutionary knowledge in schools and tertiary institutions.	
Lack of learning of evolution concepts; believers of creationism, poor knowledge on evolution; lack of evolutionary knowledge; beliefs affected their knowledge on evolution.	Tatina (1989), Magnusson et al. (1999), Contiguity Argumentative Theory (CAT); Trani (2004); Ogunniyi (2006).

5.3.1.1 Analytical statement 1: Teachers' conceptions and experiences of evolution

It emerged from the qualitative data that teachers had different views towards the inclusion of evolution in the syllabus, as some teachers were for it, while others were against it. These differentiations produced five discernible cognitive states, which are the dominant, suppressed, assimilated, emergent and equipollent (see Section 3.3) (Ogunniyi, 2006). This shows that when thoughts about a certain issue differ from one another, an individual will fall into one of the five cognitive states, depending on the individual views towards the issue. The majority of the teachers indicated that they were Christian (see Table 5.1). At the heart of the matter is the widely held but erroneous perception that evolution contradicts many fundamental religious beliefs, especially in Christianity.

Despite the fact that more than a third of the teachers indicated that they were Christians, more than two thirds (73%) of the teachers had no problem with the inclusion of evolution – this is despite the fact that Christianity is seen as the dominant religion that rejects the evolutionary theory. Less than a third (27%) were opposed to the inclusion of evolution in the syllabus. Some teachers who expressed their perceptions supporting the inclusion of evolution in the syllabus made the following statements. *"It is important to teach evolution, so the generations get to understand the way life on earth have evolved since day 1. Thus, it is of great importance that evolution be included in school syllabuses as a topic"* (T_1Q_1M). *"Personally, I have no objection on including the topic in the syllabus. Future scientists need some sort of background of evolution from grass root level, school. I believe evolution is just an ideology"* ($T_{10}Q_{10}F$).

Lending support, T_1Q1M emphasised that evolution should be included in the curriculum for the following compelling reasons:

> *"As children need to understand the metamorphic changes of organisms due to natural environmental changes. When organisms change to acquaint themselves with the changes of their environment such as climate, we call that evolution. And it is important for children to understand those evolutionary concepts, thus it is important to include evolution in the school curriculum".*

According to Ogunniyi (2007), it could be argued that the teachers who were for the inclusion of evolution in the syllabus, held a dominant cognitive state on the inclusion of evolution in the Grade 12 syllabus. This arose because the salient assumption of one thought system is portrayed more convincingly than those of the competing system. For these teachers the inclusion of evolution in the syllabus was more convincing and that is why they agreed that it should be included in the syllabus.

In support of the inclusion of evolution in the syllabus, Dobzhansky (1973) states that nothing in biology makes sense, except in the light of evolution. Farber (2003) also asserts that the theory explains the facts of biology, as evolution tells us why the living world appears as it does, and thus should be included so that learners can learn about evolution. The National Academy of Sciences (2008) describes evolution as the cornerstone of modern sciences and numerous scientists such as Futuyma (2009) among others, consider the theory of evolution to be one of the most powerful ideas in the sciences. For this reason, these scholars argue that it should be taught to learners in schools.

Concurring with the inclusion of evolution in the syllabus, Sanders and Makotsa (2016) state that from an educational point of view, the omission of evolution from any syllabus dealing with biology, is incomprehensible. Firstly, evolution provides an explanatory framework for understanding many of the fundamental phenomena, principles and processes that explain the living world, many of which could not previously be explained. They further maintain that evolution is a unifying theme that links many disparate fields, both within biology (for example, genetics, anatomy, embryology and molecular biology) and in other sciences (such as geology, palaeontology and archaeology).

Regarding knowledge on evolutionary concepts, it emerged from the data that 11 teachers (73%) were taught about evolution at their tertiary institutions. Some teachers gave the following statements about their past experiences on evolution. T_1Q_1M explained below:

> *"I got to understand the whole concept and its importance. I however also had a little bit of a problem in relating evolution to my religion (Christianity) but later got the glimpse that the two actually speak of the same language but from different perspectives".*

$T_{11}Q_{11}F$ had a different experience. "*At tertiary level, the content was a bit deep and that is when I started knowing that it attacks what I believe in*". $T_{15}Q_{15}M$ felt that in his experience, "*it was taught well, as we did it as part of zoology. We also did it in introduction to biology and in genetics as well*".

The fact that these teachers were taught quite extensively about evolution at school and university is good and might have resulted in them gaining sufficient subject knowledge on the topic. This is very important, as it may help these teachers understand the importance of learners' learning evolution. Additionally, these teachers may have a positive attitude towards the teaching of this topic. According to Trani (2004), the lack of understanding of concepts, and consequently the ability to teach the concepts competently, are some of the factors that affect teachers' views and attitude towards the teaching of a topic. Teachers who understand evolutionary concepts well, may have positive views and attitudes towards the topic (Trani, 2004). The gaining of evolutionary concepts by teachers from schools and tertiary education is of significance and is supported by Vygotsky's (1978) socio-cultural theory. Vygotsky believes that learners can reach their zone of proximal development (ZPD), with the

assistance of peers or teachers, who are more knowledgeable. For this reason, teachers as mediators must have sufficient subject knowledge on the concepts they have to teach.

According to Morris (2011), the whole teaching standards fall into three main areas: subject knowledge, ability to relate to young people and effective use of methodologies. An effective teacher should demonstrate an ability in each of these categories. She insists that subject knowledge is important, as without it, teachers cannot hope to deliver the requirements of the curriculum effectively.

Subject knowledge is important for teaching, and theme one collaborates well with the literature, which emphasises that gaining of subject knowledge can influence teachers' views and attitudes towards that topic (Morrison, 2014). Most of these teachers who gained evolutionary knowledge from school and tertiary institutions supported the inclusion of evolution in the syllabus (see Table 5.3a). It can be deduced from the data that those teachers who supported the inclusion of evolution are also the same teachers who gained knowledge from their schools and tertiary institutions. For this reason, I can conclude that these teachers have a positive view towards the topic of evolution and hence they may thus have a positive attitude towards its teaching, as they have enough knowledge about it and they support its inclusion in the syllabus.

Contrary to the above mentioned, less than a third (27%) of teachers claimed that evolution should not be included in the syllabus. These teachers opposed the inclusion of evolution in the syllabus, because they felt the topic was confusing both the learners and teachers. The topic also attacked Christian beliefs. In support of their claims, the following teachers made these statements. *"I believe God created humankind and I believe by including this topic might create a lot of confusion amongst learners from different religious backgrounds. And to top it all the topic is difficult and confuses the learners"* (T_5Q_5F). Another teacher stated that her Christian principals did not allow her to support anything that attacks God in anyway*: "For this reason, I cannot support the inclusion of evolution in the curriculum as it will make me feel like I am supporting something that is anti-God"* (T_8Q_8F).

$T_{13}Q_{13}M$ elucidated: *"I think that it should not be included in the syllabus as it does not make sense and confuses the learners as well as me the teacher. It is not true and should not be taught to the learners".*

$T_{13}Q_{13}M$ explained his reason for his viewpoint:

> *"Evolution is claiming that life started from somewhere from a single cell that evolved. That to me does not make sense, as I learned from my childhood that God created everything on this planet, and thus I reject the inclusion of evolution in the curriculum. That is why I don't teach this topic to my learners at all".*

From these excerpts, it could be deduced that these teachers held a suppressed cognitive state towards the inclusion of evolution in the syllabus. Clearly, showing how these teachers view evolution is their belief that the topic confuses the learners and also attacks their Christian beliefs. The fact that evolution is unreal to the learners and that learners do not support it, is because of their religious background, as supported by Deckard and Smithwick (2002) and because the topic is not well accepted by the learners and some teachers, they believe it should be removed or excluded from the syllabus.

It also emerged that some teachers were not taught evolutionary concepts when they were both school learners and students at tertiary institutions (see Tables 5.3a and b). These teachers believed that their past experiences of evolution were not good and that resulted in them not gaining enough or sufficient knowledge. Less than a third (23%) of the teachers indicated that they were not taught well as evidenced by the following statements. T_6 (Q_6F) elaborated that,

> *"We were not well prepared in this evolutionary theory and the evidence for evolution. The biology modules that we did at university, did not specifically deal with evolution. These modules only explained the basics of evolution only and did not go into depth".*

$T_{14}Q_{14}F$ expanded on her experience below:

> *"I never believed in evolution when it was taught to us in school, and thus I did not like it and I was only studying it because it was in the syllabus. Our teacher was also not explaining concepts well to us. This was the case as well at University level".*

These teachers claimed that they did not receive enough subject knowledge on evolution both from their schools and tertiary institutions. This can affect teachers' views and attitude towards evolution and indeed the mediation of the topic. According to Magnusson et al. (1999), some researchers have reported that limited knowledge of topic-specific

representations can negatively impact teachers' views and attitude towards that topic. Furthermore, studies have found that teachers' attitudes and views about a subject matter can also influence their curricular and instructional decisions (Tatina, 1989). In other words, if teachers do not have sufficient knowledge on a particular topic, it can affect their views and attitude towards teaching the topic.

Teachers with a limited understanding of evolutionary concepts will not understand the significance of teaching evolution. This can then negatively influence their conceptions and dispositions towards the teaching of evolutionary concepts. Teachers with the lack of or limited understanding of evolutionary concepts may tend to have negative views about the topic and spend less time teaching it effectively, as highlighted by Rutledge and Mitchell (2002). The fact that the teachers are not well equipped with knowledge of evolutionary concepts may also affect their capabilities in assisting the learners to reach their ZPD (Vygotsky, 1978; Stott, 2016). This is supported by the socio-cultural theory of Vygotsky that states that in order for a peer or an adult to assist the child, he or she must be more experienced (more knowledgeable) than the child. If a mediator does not have enough subject knowledge on the subject, he or she may not be comfortable in teaching it and thus this lack of knowledge can influence the teacher to have a negative attitude towards teaching the subject or topic.

One can conclude that 23% of the teachers in this study had a negative attitude towards the teaching of evolution because of their lack of subject content knowledge. There are also other factors that influence teachers' conceptions and dispositions towards teaching evolution. These factors will be discussed below.

Table 5.3d: ***Research sub-question, analytical statement, themes and supporting theory/literature***

Research sub-question 2: What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?	
Analytical statement 2: Factors influencing teachers' views on the inclusion of evolution	**Theory/literature**
Teachers' beliefs influences their views on the inclusion of evolution.	
Teachers' beliefs affect teacher's views.	Tatina (1989), Rutledge and Mitchell

	(2002), CAT theory.
Teacher's views influence them positively towards teaching evolutionary concepts.	
Views influenced them not to teach the topic appropriately or at all; religious view affect teaching; lack of subject knowledge.	Rutledge and Warden (2000); Wiles and Branch (2008); Sanders and Ngxola (2016).
Factors that make teachers comfortable teaching evolution.	
Sufficient subject knowledge makes it comfortable to teach; for the sake of developing the learners.	Vygotsky (1978), Katung, Johnstone and Downie (1999).
Subject knowledge can affect teachers' comfort ability.	
Sufficient subject knowledge a factor determining other teachers' comfortability in teaching evolution; lack of subject knowledge can determine teachers to be uncomfortable in teaching evolution.	Social cultural theory (1978), Grossman et al. (1989); Sanders et al. (1993).
Adequate understanding of evolution concepts.	
Adequate training resulted in an adequate understanding of evolution.	Vygotsky (1978); Morrison (2014).

5.3.1.2 Analytical statement 2: Factors influencing teachers' views on the inclusion of evolution

Only a minority of teachers (20%) indicated that religious beliefs influenced their views towards the inclusion of evolution in the syllabus. T_8Q_8F stated the following:

> *"My belief in the existence of God, looking at nature itself. Humans are just humans; apes are just apes, there is no point in saying humans evolved from an ape like creature. Evolution is just change but not dramatic change".*

These teachers indicated that they were Christians and according to Miller et al. (2006), US adults including teachers who prayed regularly and believed in God, were more likely to reject evolution. In maintaining this, several studies (Aguillard, 1999; Rutledge & Mitchell, 2002; Trani 2004) show that religious beliefs and subject knowledge are the two main factors that influence teachers' conceptions and dispositions towards the teaching of evolutionary concepts – meaning that these teachers have a negative attitude towards evolution as a topic. Evolution is believed to contradict some religious beliefs, which affect teachers' attitude toward evolution (Miller et al., 2006). Research done amongst certain groups of teachers in

America indicated that there were some teachers whose lack of belief in evolutionary theory affected their teaching to the point that they taught evolution superficially or did not teach evolution at all (Aguillard, 1999; Rutledge & Warden, 2000; Trani, 2004; Wiles & Branch, 2008). Some 20% of the teachers were influenced negatively by their religion, as they opposed the inclusion of evolution in the syllabus.

One can deduce that religious beliefs can influence teachers' views and attitude towards the teaching of evolution. These teachers would probably have negative views and attitudes towards evolution and difficulty in teaching biological evolution, because of their mental structures that encompass their Christian beliefs. Not all teachers were influenced by their religions, as some teachers who indicated that they were Christian, also supported the inclusion of evolution in the syllabus. These teachers fell in the equipollent cognitive stage of Ogunniyi (2007) as they held both views together, as both views had equal cognitive power and co-existed without logical connection.

As stated earlier, there are factors that influence teachers' views and attitudes towards the teaching of evolution. These factors can influence the teachers' views positively or negatively. The two common factors that influence teachers' views towards teaching evolutionary concepts are their religious beliefs and their knowledge about evolution, as shown by several studies that highlight these two factors (Aguillard, 1999; Rutledge & Mitchell, 2002; Trani, 2004). This is also evident in this study, as religious believers and teachers' knowledge about evolution were also the two main factors that emerged from the data on what influences teacher's views and attitude towards teaching evolution.

Religious beliefs are very important to many people and thus can influence people to behave in certain ways, when faced with situations that contradict or attack their religion. According to Alters and Nelson (2002) and Scharmann (2005), the degree to which religion is important in people's lives, tends to be negatively correlated with the acceptance of evolution. At the heart of the matter is the widely held but erroneous perception that evolution contradicts many fundamental religious beliefs (Ashrif, 1998; Reiss, 2008). For example, evolution is believed to contradict some religious beliefs such as held by Christians, which affect teachers' attitude toward evolution (Miller et al., 2006).

In addition, surveys have found that many high school Biology teachers reject evolution and instead opt to identify with creationism (Moore, 2007). This then influences their views and attitude towards evolution. Teachers, whose views about the inclusion of evolution in the school syllabus are influenced by a lack of evolutionary knowledge, may have a negative view about evolution and thus a negative attitude towards the teaching of evolutionary concepts. Scharmann (2005) argues that the primary goal of evolution education is an understanding of evolution, not a belief in evolution. Teachers may not accept evolution and may have a negative view and attitude towards evolution education, if they lack knowledge about it. Research done amongst certain groups of teachers in America, indicated that there were some teachers whose lack of knowledge in evolutionary theory affected their attitude towards evolutionary concepts (Aguillard, 1999; Rutledge & Warden, 2000).

It emerged from the data that there were factors that made teachers comfortable when it came to teaching evolution. For instance, more than 65% of the teachers (see Table 5.3a) indicated that they were comfortable with the teaching of evolution, despite their religious beliefs which was Christianity. These teachers said their good understanding of evolution was the main factor that made them comfortable when teaching evolutionary concepts. To this end, T_6Q_6F commented that *"Yes, my knowledge of the topic makes it easier to teach the subject"*.

Here are some statements that the teachers made, showing how they perceived that their knowledge on evolution influenced them to be comfortable when teaching evolutionary concepts. *"Yes, what makes me comfortable is the good understanding of the topic that I have as well as the good understanding of my religion. It makes it possible for me to relate them two"* (T_1Q_1M). *"Yes, the fact that is involves the gradual change of lives make the topic interesting and also my ample knowledge on evolution makes me to feel comfortable when teaching the topic. I can make the concepts very clear to the learners as am good in this topic"* ($T_{15}Q_{15}M$).

It could be surmised from these teachers' statements that they had a good understanding of evolutionary concepts. More than a third of these 10 teachers (65%) previously indicated that they were taught about evolution at school and tertiary institutions. This serves as evidence that these teachers may have a good understanding of evolution. Most of these teachers (80%) also supported the inclusion of evolution in the syllabus. Sufficient knowledge of evolution influenced teachers and helped them to be comfortable when it came to the

teaching of evolutionary concepts. According to Aguillard (1999), subject knowledge is one of the factors that influence teachers' conceptions and dispositions towards the teaching of evolutionary concepts. A teacher with sufficient subject knowledge on evolutionary concepts might be able to teach the concepts effectively to the learners. A reasonable assumption therefore, is that teachers need to have enough knowledge on evolutionary concepts in order to be comfortable in the teaching of these concepts, and this can ensure that the teacher develops a positive view and attitude towards the teaching of evolution.

On the other hand, these teachers also gave their opinions on what might make other teachers comfortable when it came to the teaching of evolution. It clearly emerged from this data that more than a third (73%) of the teachers' believed that sufficient subject knowledge is the dominating factor that makes teachers comfortable with the teaching of evolution. Here are some of their statements: *"Enough content knowledge about the topic can make a teacher comfortable in teaching the topic well"* (T_4Q_4F). *"Teachers content knowledge can be a big factor because a teacher who does not have enough information on the topic, won't be comfortable with teaching the subject"* ($T_{13}Q_{13}M$). *"Teachers knowledge on the topic can be a factor if a teacher does not have enough knowledge on the topic*" ($T_{15}Q_{15}M$).

It could be deduced from these statements that teachers believed that other teachers were comfortable with teaching evolution because they knew the evolutionary content very well. A teacher with sufficient subject knowledge on evolutionary concepts might be comfortable with the teaching of the concepts effectively to the learners. Magnusson et al. (1999) maintain that subject knowledge is key to comfortable teaching. They state that some researchers have reported that limited knowledge of topic-specific representations can negatively impact science instruction. Teachers with a limited understanding of evolution, tend to spend less time teaching the topic to the learners, as they are not comfortable. For this reason, the majority of the teachers in this study (73%) believed that subject knowledge on evolution is the key to teachers' comfortability towards teaching evolution. These teachers also believed that religious belief was the key to teachers being uncomfortable when teaching evolution.

Regarding teachers' views towards how they rated themselves in terms of their content knowledge and understanding of evolution and its processes, more than half of the teachers indicated that they had an adequate understanding of evolution and hold either a Bachelor of Education or Bachelor of Education (Honours) except T_3Q_3F who holds a Bachelor of

Science in microbiology. Two teachers (13%) indicated that they had a very thorough understanding of evolution. Of these two teachers who indicated that they had a very thorough understanding of evolution, one has a Bachelor of Education, while the other one has a Bachelor of Education (Honours). Here are some statements of these teachers on why they ranked themselves the way they did: *"I think I have sufficient knowledge about the topic compared to what is required of me to teach the topic in the syllabus. My knowledge is adequate"* (T_4Q_4F). *"Because I am a scientist and I have covered evolution as a topic and many of my biology modules during the time when I was a student which give me more understanding and knowledge to explain evolution to the learners"* (T_9Q_9F). *"I know the content very well, so I deliver it in my own best way, but however when learners ask questions of things that are not in the syllabus I struggle a lot"* ($T_{11}Q_{11}F$). *"I have adequate knowledge on evolution as I learned it at school and University and do understand it well"* ($T_{15}Q_{15}M$).

It is clear from these statements that these teachers have learned about evolution and that is why they believe that they have an adequate understanding of evolutionary concepts. These teachers earlier indicated that they were taught about evolution in school and at tertiary institutions. The fact that these teachers have an adequate understanding about evolutionary concepts according to themselves, is of great significance, as subject knowledge can influence teacher's comfort level and ability and attitude towards the teaching of the subject or topic. Morrison (2014) states that strong subject knowledge is the most important component of being a good teacher, as it boosts the teacher's confidence when teaching a particular topic. Though subject knowledge is seen as a factor that influences teachers' conception towards the inclusion of evolution, there are also factors that influence teachers' conceptions on the exclusion of evolution.

Table 5.3e: Research sub-question, analytical statement, themes and supporting theory/literature

Research sub-question 2: What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?	
Analytical statement 3: Factors influencing teachers' views on the exclusion of evolution	**Theory/Literature**

Teachers' evolutionary knowledge influences their views towards evolution inclusion.	
Understanding of the significance of evolutionary knowledge; for the interest of the learners.	Katung et al. (1999); Social-cultural theory; Morrison (2014), Sanders and Ngxola (2016).
Subject knowledge and beliefs influence teachers' views positively.	
Views influenced them to teach the topic of evolution.	Sinatra et al. (2003); Trani (2004); Heggart (2016).
Factors that makes teachers uncomfortable teaching evolution.	
Religion affect teaching; poor subject knowledge affect teaching; effect appropriate teaching.	Tatina (1989); Cooper (1996), Katung et al. (1999).
Religious beliefs can affect teacher's comfortability.	
Misunderstanding of evolution and science; religious belief is determined as a factor influencing teacher's comfort level and ability in teaching evolution.	Weld & McNew (1999); Good (2003); Miller et al. (2006); Moore (2007).
Inadequate understanding of evolution concepts.	
Lack of training resulted in lack of subject knowledge; improving their understanding of evolutionary concepts.	Social Cultural Theory, Vygotsky (1978); Sanders and Ngxola (2016).

5.3.1.3 Analytical statement 3: Factors influencing teachers' views on the exclusion of evolution

This analytical statement emerged from overlapping themes pointing to subject knowledge or knowledge on evolutionary concepts being the factor that influenced teachers' views towards the inclusion of evolution. Subject knowledge refers to the knowledge that the teachers have about the subject or the topic. In other words, how much they now about the subject or topic, in this case is how much content the teachers have about evolution. More than a third of the teachers (80%) indicated that their knowledge on evolutionary concepts influenced their views towards the inclusion of evolution. Some teachers indicated that their views towards the inclusion is influenced by their knowledge they have on the significance of teaching evolution to the learners. *"My understanding of the concept actually influenced my views on the inclusion of evolution in the school curriculum"* (T_1Q_1M). *"Just knowing the origin of life and how it continues changing up to how and how it is going to change after millions of*

years to come. Example life started due to certain kinds of chemical reactions that took place in water" (T_7Q_7F).

Magnusson et al. (1999) say that some researchers have reported that limited knowledge of topic-specific representations can impact negatively on the teachers' views towards that specific subject or topic. A reasonable assumption is that if teachers have a limited understanding of the subject knowledge, they would not support its inclusion in the syllabus, as they would not want to teach a topic that they were not comfortable with. On the other hand, teachers with sufficient subject knowledge may support its inclusion, as they may not mind teaching it and may be comfortable with teaching the subject or topic to the learners.

There is a relationship between the teachers' subject knowledge and their views towards the inclusion of evolution. The teachers' knowledge on evolution plays a role in influencing teachers' views towards teaching evolution. As teachers with sufficient knowledge on evolution were for the inclusion of evolution which means they have a positive view about evolution and thus will also have a positive attitude towards teaching evolution and therefore teach it appropriately. There is also a relationship between the teachers' religious backgrounds and their views towards inclusion of evolution. Religious beliefs have an effect on teachers' views toward the inclusion of evolution in the syllabus and curriculum. Some teachers were against the inclusion of evolution as they believed that the topic was contradicting their beliefs and thus opposed its inclusion in the syllabus. Seventy-three percent of the teachers indicated that they were Christians and Christianity includes religious beliefs that reject the evolutionary theory, as the theory is believed to contradict Christianity (Trani, 2004). For this reason, one can say that religious beliefs can affect some teachers' attitude towards evolution.

Some teachers can be Christians and still have a positive attitude towards evolution. A study by Clement, Quessada, Laurent, and Carvalho, (2008), states that a great majority of teachers in South Korea are Christians and do not have any problem with teaching the topic of evolution. These teachers according to the contiguity argumentative theory (Ogunniyi, 2006) hold the equipollent cognitive state. Teachers falling in this stage are said to have a positive attitude towards evolution, despite the fact that evolution contradicts their religion. These teachers usually have a good understanding of evolution which then influences them to have a positive attitude towards evolution.

A teacher with sufficient subject knowledge about evolution may be able to accept evolutionary concepts and may be influenced positively towards evolution, which is the opposite when a teacher lacks subject knowledge on evolution. Sanders and Ngxola (2010) maintains that teachers with a limited understanding of evolution, tend to dislike evolution and spent less time teaching the topic to learners. They believe that subject knowledge on evolution is key in influencing teachers' views and attitude towards evolution. For this reason, it is obvious that if you are going to teach evolutionary concepts, you need to have adequate knowledge as this will ensure that you are comfortable with the topic and thus have a positive view and attitude towards it, as proposed by Heggart (2016). According to Sinatra et al. (2003), teachers' own beliefs and dispositions towards evolution are influenced by their understanding and acceptance of evolutionary concepts.

The lack of subject knowledge and religious beliefs were identified as factors that influenced teachers' comfortability when it comes to the teaching of evolutionary concepts. Less than a third (27%) (see Table 5.3e) of the teachers identified that their lack of knowledge on evolutionary concepts affected their comfortability towards the teaching of the topic. Here are some of the teacher's statements on what influences them to be uncomfortable in teaching evolution. T_7Q_7F elaborated that:

> *"No, it's really not an easy topic to teach because there are some points about it that are not so clear of (what really happened at first and why and how it happened). Different people have different views about evolution and this makes it difficult and uncomfortable to teach and explain to the learners".*

$T_{14}Q_{14}F$ also acknowledged, *"No, I don't know the topic very well and it's uncomfortable to teach things that I don't know and there is a lack of resources to be used".*

It is clear from these statements that teachers do not have sufficient knowledge of evolution. Research has proven that subject knowledge is a very important aspect in education, as it can determine teachers' attitudes towards the teaching of a subject or topic (Hawley, Short, McCune, Osman, & Little, 2010). The acceptance of evolution by teachers, their knowledge of evolution and overall attitude toward evolution, are very much related to each other.

Sanders and Ngxola (2010) maintain that teachers with a limited understanding of evolution, tend to spend less time teaching the topic to the learners. They believe that subject knowledge on evolution is the key to effective and appropriate teaching of evolutionary concepts.

Vygotsky (1978) stresses that a mediator needs to have more experience in order for him/her to assist and guide the learners so that they can reach their ZPD. This suggests that the teacher should have more knowledge on evolutionary concepts in order to be able to guide the learners appropriately. The teachers who lack subject knowledge might not be comfortable with the teaching of evolution and thus will develop negative views and attitudes towards the teaching of evolution.

Some teachers identified religious beliefs as the factor that influenced their comfortability towards the teaching of evolution. T_5 Q_5M made the following statement: *"No, the fact that I have to go beyond my religious principles and teach learners things that I don't believe in and things that I really don't know that well"*. $T_{11}Q_{11}$F also expressed the same view when she stated: *"No, it goes against my biblical theory, as I feel that it is attacking my creator God"*.

One can deduce from these statements that these teachers were uncomfortable with the teaching of evolution because they felt that evolution contradicted their religious beliefs. According to Ashrif (1998), many teachers reject evolution because at the heart of the matter is the widely held, but erroneous perception, that evolution contradicts many fundamental religious beliefs. Teachers who feel that evolution contradicts their religion tend to omit the topic, as they do not feel comfortable in teaching the topic. These teachers may feel that teaching evolution would be like going against their own religious beliefs and might be construed as if they were supporting evolution. For this reason, some teachers omit evolution because as Christians they cannot teach concepts that contradict their religion.

The majority of the teachers (67%) indicated that they thought religious beliefs and lack of subject knowledge were the main causes of uncomfortability towards teaching evolution among other teachers. Below, I discuss how religion affected teachers' comfortability towards teaching evolution. Thereafter, I discuss how subject knowledge affected teachers' comfortability towards teaching evolution. Here are some statements from the teachers based on how religious affected teacher's comfortability towards teaching evolution. *"It depends on what you believe in – Science or Christianity, as religion can affect the teaching of this topic"* (T_9Q_9F). *"Their religious beliefs can influence their teaching, for example, if a teacher is a strong believer of Christianity, he or she won't be comfortable teaching this topic"* (T_8Q_8F).

It can be drawn from these statements that these teachers think religious beliefs are the main factor that can influence other teachers' comfortability with the teaching of evolution. These teachers think that religious beliefs influence other teachers to be uncomfortable with teaching evolution as evolution is believed to contradict religious beliefs such as those in Christianity. According to Good (2003), a religious belief is the dominating factor that influences teachers' attitudes towards the teaching of evolution. Good (2003) further states that religious beliefs affect teachers' comfortability towards the teaching of evolution. In addition, surveys have found that many high school Biology teachers reject evolution and instead identify with creationism, as they are uncomfortable with teaching evolutionary concepts (Moore, 2007). Miller et al. (2006) maintain that teachers who pray regularly and believe in God, were more likely to be uncomfortable with teaching evolution and would rather reject evolution. This corroborates well with Weld and McNew (1999) who state that religious belief is one of the dominating factors that influence teachers to reject the teaching of evolutionary concepts.

Subject knowledge can also be seen as a factor that can influence teachers' attitude towards teaching a subject. Some teachers in this study indicated that a lack of subject knowledge was the dominant factor that influenced other teachers to teach evolution or reject it. These are the reasons that teachers gave in response to what they thought influenced other teacher's comfortability towards teaching evolution. Below is a statement from a teacher based on how a lack of subject knowledge affects teacher's comfortability towards teaching evolution. *"If a teacher has a poor understanding of the topic, he or she won't be comfortable teaching it"* (T_7Q_7F).

It can be deduced from these statements that some teachers believed that subject knowledge was the main factor that influenced teacher's comfortability towards the teaching of evolution. According to Mitchell Chester, an education commissioner for Massachusetts in the US, improving the quality of teaching was the crux of the challenge in schools. He further said subject knowledge was at the core of being a good teacher and that this would result in teachers being comfortable with the teaching of the subject. For this reason, teachers felt that sufficient knowledge of evolution was core to comfortable teaching of evolutionary concepts.

A minority of the teachers (34%) indicated that they were not sure about their understanding of evolutionary concepts. These are some of their statements they gave, based on why they

thought they were not sure of how adequate their understanding of evolution was. T_2Q_2F explained that, *"I have a limited understanding because at college we were not taught a lot about this topic. So I need to do more research and projects, as my knowledge is limited on the topic"*. T7Q7F described her uncertainty: *"I think evolution involves two things. Evolution and God. I think new research needs to be made about evolution to make it clearer, as it is really confusing"*. Another teacher $T_{14}Q_{14}F$ said, *"I read some books about evolution to understand the theories and explanations about the origin of humankind through evolution but it is not clear to me as I do not understand it well"*. T_8Q_8F gave this explanation:

> *"When evolution is defined, it refers to changes which occur over millions and millions of years. So I get stuck and ask so things, example living organisms can / could live for over millions of years? By now some microorganisms have lived for millions of years but then we are not learning about new dramatic evolutions compared to human beings"*.

All these teachers except for T_2Q_2F indicated that they were not sure of how adequate their understanding of evolution was. While T_2 indicated that she had a limited understanding of evolution, it can be deduced from the statements that these teachers also had a limited understanding of evolutionary concepts. They would get to a certain point and then become confused by the evolutionary concepts. The fact that these teachers get confused by the concepts is a sign that these teachers do not have an adequate understanding of concepts. If a teacher has a limited understanding of the subject knowledge, he or she will not be comfortable with the teaching of those concepts and tend to omit them. This was evident in South Africa after the introduction of the new curriculum which was implemented in 2008 (Sanders & Ngxola, 2010).

The introduction of evolution at senior level has raised concerns among many South African teachers, as many teachers do not have sufficient knowledge of evolution. As a result, the teachers omit the topic and this has resulted in poor performances in Life Sciences. Mitchell Chester the education commissioner for Massachusetts Department of Elementary and Secondary Education emphasized in one of his speeches that teachers with good subject knowledge always have positive attitudes towards teaching that subject. The importance of subject knowledge in teaching, echoes well with the socio-cultural theory of Vygotsky (1978), which emphasises that for learning to take place, learners need to be assisted by more experienced adults – more experienced in the sense that the adults need to know more then what the learners know, and that is why subject knowledge is so essential for mediation.

When a learner enters the classroom environment, their skills and competencies within their individual ZPDs have not yet fully emerged, which means that the child needs assistance to help them to grasp or understand the concepts. For that reason, teachers who are more experienced should provide the learners with assistance, to support their evolving understanding of knowledge domains or development of complex skills. As stated earlier, teachers' knowledge on a topic or concept can determine their views and attitude towards teaching that particular topic. For this reason, it is important for a teacher to have an adequate understanding of the concepts in order to mediate learning appropriately.

5.3.2 Teaching strategies that teachers use during mediation

Data from the questions in Part D of the questionnaire, which was based on pedagogical strategies teachers used when teaching evolutionary concepts, was analysed thoroughly. As I was reading through the data, I colour coded it to identify preliminary sub-themes emerging from the data (see Table 5.4a). Thereafter, I grouped the overlapping sub-themes, and formed themes (Table 5.4b). The themes that emerged from this data pointed towards answering research sub-question 3: What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?

Table 5.4a: Preliminary sub-themes from coded text

Research sub-question 3: What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?		
Teacher Questionnaire	**Description of coded text**	**Sub-themes**
T_1Q_1M ; T_3Q_3F T_5Q_5M; T_6Q_6F T_9Q_9F; $T_{12}Q_{12}F$ $T_{13}Q_{13}M$; $T_{14}Q_{14}F$; $T_{15}Q_{15}M$	More lecturing; explain the concepts; giving examples explain how changes took place.	Explanatory teaching approach where teacher talks more in the class and explains concepts.
T_2Q_2F,$T_{14}Q_{14}F$	Do not really teach these concepts; I just read the concepts to learners.	Do not teach the concepts at all.
T_2Q_2F	Questions – I refer them to go and check the answers on the internet.	Teacher lacks knowledge on the topic.
T_3Q_3F, T_5Q_5M T_6Q_6F, $T_{10}Q_{10}F$ $T_{11}Q_{11}F$, $T_{13}Q_{13}M$	Show them video-clips; posters on the projector; evidence such as video-clips and posters; use YouTube videos; show short video clips; learners' pictures and diagrams.	Use of mediational tools during mediation.

T_4Q_4F, T_6Q_6F T_7Q_7F, T_8Q_8F T_9Q_9F, $T_{10}Q_{10}F$ $T_{15}Q_{15}M$	Do class discussions; allow the learners to share what they understand; divide learners in groups; allow them to have discussions; groups and discuss; discuss the topic in the class; group discussion; ask learners questions.	Discussion and collaborative learning.
T_1Q_1M , T_3Q_3F T_5Q_5M, T_6Q_6F $T_{11}Q_{11}F$; $T_{13}Q_{13}M$	Learners get more information; learners learn; provides additional information; learners to understand learn more; really learning.	Learning is taking place.
T_2Q_2F, $T_{14}Q_{14}F$	Not effective; not really performing that well.	Minimum to no learning taking place.
T_4Q_4F	Helps learners to think on their own.	Learners use their minds.
T_7Q_7F, T_9Q_9F $T_{10}Q_{10}F$, $T_{15}Q_{15}M$	Allows learners to share their experience; share their different understandings; learners to talk and participate; learn from one another.	Collaborate in learning as they share knowledge.
T_8Q_8F	Learners are doing well in this topic	Good performances in the topic.
$T_{12}Q_{12}F$, $T_{13}Q_{13}M$ $T_{15}Q_{15}M$	Learners understand changes; show that they understood; understand the work.	Understanding of concepts.

All the common themes were then grouped into analytical statement 4: pedagogical strategies used during mediation of learning of evolution.

Table 5.4b: Research sub-question, analytical statement, themes and supporting theory/literature

Research sub-question 3: What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?	
Analytical statement 4: Pedagogical strategies used during mediation of learning of evolution	**Theory/literature**
Teachers' use more of a teacher-centred approach to the mediation of evolution.	
Explanatory teaching approach where teacher talks more in the class and explains concepts; use of mediational tools during mediation.	Segall (2004); Kevin (2014).
Teachers make use of learner-centred approach when teaching evolutionary concepts.	
Discussion and collaborative learning.	Alexander and Murphy (1998); Lambert and McCombs (1998); Vygotsky's socio-

	cultural perspective (1978); Lantolf et al. (2007); Nelson (2008).
Effective approaches resulting in learning of evolutionary concepts is to take place.	
Learning is taking place; learners use their minds; collaborate in learning as they share knowledge; good performances on the topic.	Ketlhoilwe (2003); Kostova and Atasoy (2008); Loubser (2008); Donnelly (2014). .
Ineffective approaches resulting in poor learning.	
Minimum to no learning taking place.	Vygotsky (1976); Newman, Griffin and Cole (1989).

5.3.2.1 Analytical statement 4: Pedagogical strategies used during mediation of learning of evolution

According to Shulman (1986), pedagogical approaches are the different methods or strategies that can be used during mediation. Shulman emphasises the importance of pedagogical content knowledge in teaching, referring to the particular content-appropriate approaches that are best suited to teaching specific topics so that learners understand the concepts involved. In the case of evolution, such approaches include strategies for dealing with potential controversy, including the need to develop an attitude of open-mindedness and tolerance of other viewpoints.

In this regard, more than three quarters (73%) of the teachers indicated that they taught the topic by using a more teacher-centred approach, where the teachers are more active than the learners. These are some of the teachers' statements in response to their teaching approaches. *"Lessons are more of lecturing, diverted a little bit too learner-centred. This makes enough time for the teacher to give more content to the learners about the topic of evolution"* (T_1Q_1M). $T_{13}Q_{13}M$ explained that, *"I teach by explaining concepts and also by showing learners pictures and diagrams to help them get a clear understanding of the concepts"*. T_{15} $Q_{15}M$ had the following approach: *"I teach evolution by explaining the different concepts to the learners. I ask learners' questions on evolutionary concepts to see it they understand the work. I also allow the learners to ask questions"*.

Teacher-centred approaches are often aligned with transmission models of teaching. Within this framework, instruction is the activity in which the information is moved or transmitted to and into the learner. Typical characteristics of teacher-centred instruction include more

teacher talk and questions, than learner talk and questions, more whole group instruction, reliance on textbooks with other sources, such as media used as support, recall of factual information, and a classroom in which desks are in rows facing a board with the teacher's desk nearby.

These teachers used the teacher-centred approach during the mediation of evolution. Most of these teachers were explaining the concepts to the learners, without the learners being actively engaged and interacting with the teacher or other learners. T_5Q_5M said that he teaches the topic by explaining the concepts to the learners and then gives them extra notes from the projector. The explanatory approach on evolutionary concepts by teachers, were applied by the majority of these teachers, as they thought they were sharing knowledge that had been defined and organised from their expert perspective. During the explanatory approach, the instruction included more teacher talk and questions, than learner talk and questions.

The explanatory approach used by these teachers, is more of a traditional or teacher-centred approach, which is regarded as ineffective according to Nelson (2008) and the Namibian Education policy. Donnelly (2014) opposes the idea that traditional or teacher-centered teaching strategies are ineffective. Donnelly believes that teachers need to be explicit about what they teach and make better use of whole-class teaching. Donnelly further says that initial instruction when dealing with new information and concepts, should be explicit and direct, and thus support teachers that teach, by directly explaining concepts to the learners.

Vygotsky (1962) disagrees and states that learning best takes place during social engagement. He further states that language plays an important role in cognitive development. Firstly, language is a means by which adults or teachers transmit information to learners. Secondly, language itself is a very powerful tool of intellectual adaptation, as it is a primary mediational tool. Segall (2004) affirms this and further stresses that the use of language and symbols, icons and images, signals and sounds, text producing representations of the world, images, descriptions and explanations are frames for understanding how the world is and why it works as it is said and shown to work. It can be used in classrooms to present the learners with questions, immediate feedback and a deeper understanding of terminology specific to the subject at hand.

During explanation of aspects, learners can experience problems with understanding the language teachers are using during their lesson presentations. This can then affect the learners learning and development. On the other hand, in the interactive and engagement approach, learners speak the same language and argue with one another to resolve tension, which is crucial during group engagements and discussions.

In light of this, teachers should use the learner-centered approach more, as this approach allows for learners to participate in their own learning. This resonates well with one of the nine requirements of the new South African curriculum, first implemented in 1998, which requires that a learner-centered approach be used. During a learner-centered approach, more discussions take place in class and the slower learners can learn from their peers. This resonates with the socio-cultural theory, which emphasises that learners can achieve their ZPD by engaging and interacting with the teacher and other learners, which can then assist them in making the content more understandable. The ZPD is the difference between the level of development already obtained and the cognitive functions comprising the proximal next stage of development that may be visible through participation in collaborative activity (Lantolf et al., 2007).

According to Chisholm and Leyendecker (2008), policy makers prescribe learner-centered and competency-based education without being knowledgeable about the meaning of it. They further state that for learner-centered education to take root in the local African context, teachers need to understand the underlying idea, be motivated to change practice, adapt and apply appropriate pedagogies, and have the capacity to do so. Supporting Chisholm and Leyendecker (2008) is Donnelly (2014) who opposes the idea that traditional or teacher-centered teaching strategies are ineffective. One can deduce from this that teachers in this study were exposed to learner-centered education but then could not practice it during mediation of learning of evolution in particular.

Less than a third (27%) of the teachers indicated that they taught evolutionary concepts by using the learner-centred approach, which is the required approach to teaching according to the Namibian curriculum (Nyambe, 2008) and the South African curriculum (Sanders & Ngxola, 2016). These teachers had the following to say: *"I teach the theory. I then give learners a chance to do their own research and then do class. Discussions, by allowing learners to talk and communicate with one another"* (T_4Q_4F). *"I divide learners in groups*

and then allow them to have discussions based on evolution" (T_7Q_7F). *"I give learners hand outs and allow them to work in groups and discuss among each other"* (T_8Q_8F). *"I teach evolution by explaining the different concepts to the learners. I ask learners questions on evolutionary concepts to see if they understand the work. I also allow the learners to ask questions"* ($T_{15}Q_{15}M$).

It can be drawn from these statements that these teachers really involved learners, who were actively involved and engaged. Learner-centred teaching (LCT) moves the focus from the teacher and instruction, to the learner and learning. LCT is based on a proposed set of principles derived from over a century of previous research on teaching and learning (Alexander & Murphy, 1998). Foundations of LCP include that learning is a natural, constructive process where learning is most productive when it is relevant and meaningful to the learner, in a positive learning environment. It is a holistic view of the learner in a complex living system that extends well beyond the classroom walls, in both time and space. Instruction based on learner-centred principles, provides opportunities for learners to draw on their own experiences and interpretations of the learning process (McCombs & Whistler, 1997).

These teachers made sure that their learners were involved in their own learning, by allowing discussion and research on concepts on their own. Teacher T_7Q_7F stressed that she divides the learners into groups and then allows them to discuss amongst themselves. This is a very good approach to teaching, as learners are then engaged in the learning process. This resonates with Vygotsky's socio-cultural perspective and also that of Nelson (2008).

Vygotsky's (1978) socio-cultural theory describes learning as a social process of the origination of human intelligence in society or culture (Lantolf & Thorne, 2007). Socio-cultural theory stresses the interactions between developing people and the culture in which they live in. The theory further stresses that participating in social interactions and culturally organised activities, plays a role in influencing psychological development. The theory goes on to stress the roles that participating in social interactions and culturally organised activities play, in influencing psychological development.

Several research studies have proved that social interactions involving argument and dialogue among peers, are crucial to the performance of tasks and the development of skills that would

not have been attained easily, by an individual alone (Cobb et al., 1991; Cross et al., 2008). Cobb et al., 1991 further emphasises that we must remember that the learning conditions of the individual, the interactions of the individual with the teacher and other learners and the individual's cultural background, all affect the learner's success in developing and learning. T_7Q7F explained that she divided the leaners into groups and then allowed them to discuss amongst themselves. This approach is endorsed by Nelson (2008) who identifies pedagogical strategies that can make a difference in learners' understanding.

Nelson (2008) identifies pedagogical strategies that can make a significant difference in learners' understanding and acceptance of evolution. These strategies are the extensive use of interactive engagement, and a focus on critical thinking in science. Using these two strategies during mediation, will help the learners to actively compare their initial conceptions (and publicly popular misconceptions) with more fully scientific conceptions. This is a very constructive approach as it benefits those learners who do not understand the concepts well. The learners who do not understand the concepts will benefit by learning from their peers who do understand them. In this way, these learners may be able to reach their ZPD with the assistance of other learners during the group discussions as highlighted by Stott (2016).

More than a third of the teachers indicated the approaches they used or implemented when teaching evolutionary concepts to the learners. Though the majority of the teachers used a teacher-centred approach to teaching evolution, they remained firm and stated that this method was effective, despite many education systems (such as the Namibian and South African) believing that this method (teacher-centred) otherwise. These are some of the statements that the teachers gave in response to the effectiveness of their teaching approaches towards evolution. "*Yes, the approaches I use are effective in such a way that learners get more information within the limited time"* (T_1Q_1M). *"Yes, it is very effective as the learners learn by seeing pictures and watching video clips. I also explain the concepts to them to make it clear to them"* (T_3Q_3F). *"Yes, it provides additional information to the learners by viewing on the projector, which will help to enhance learning"* (T_5Q_5M).

These teachers indicated earlier that they used a teacher-centred approach towards teaching when mediating the learning of evolution. They strongly believed that the approach was effective as it helped the learners get more information within a limited time. They further maintained that during explanations they made the concepts clear to the learners, which

ensured that the learners internalised the concepts well. These teachers' approaches to teaching evolution gives credence to Donnelly's (2014) assertions, that teachers need to be explicit about what they teach and make better use of whole-class teaching, especially in areas like English, Mathematics and Natural Science. He further states that initial instruction when dealing with new information and concepts should be explicit and direct. Thus, when a teacher is teaching evolution to the learners for the first time, it is important for them to explain the concepts directly to the learners. This may help the learners to understand the concepts and make sense of them.

Less than a third (see Table 5.5a) of the teachers (27%) indicated that they used a learner-centered approach when teaching evolutionary concepts. This method (learner-centered approach) is believed to be the most effective teaching method and is implemented in many education systems. These are the statements that the teachers who used learner-centered approaches gave: "*Yes, learners need to be taught to state their own points of view, as it helps learners to think on their own and come up with their own ideas"* (T_4Q_4F). *"Yes, it allows learners to share their experience based on evolution. Also when learners discuss among each other they can learn from one another"* (T_7Q_7F). *"Yes, because the learners are doing well in this topic, this is an indication that the teaching method I am using is effective"* (T_8Q_8F).

These teachers strongly believed that the methods that they used were effective as it helped the learners to think on their own and come up with their own ideas. The teachers further said that the learner-centred approach was effective as it allowed the learners to share their points of view and knowledge. Ketlhoilwe (2003) supports the use of learner-centredness and participatory and active learning methodologies, when facilitating science subjects. Concurring, Kostova and Atasoy (2008) argue that a combination of teaching and learning methods, oriented towards agency, capabilities, social and structural changes, are likely to achieve science education objectives. Corroborating with Kostova and Atasoy (2008), Loubser (2008) emphasises that effective learning has to move away from teaching and learning approaches based solely on the transmission of knowledge. It has to move towards approaches which encourage development of qualities, such as initiative, reflection and responsibility in relation to the science.

In Namibia, teaching methods have shifted from early positivist approaches, where science education was about transferring information and raising awareness, towards participatory methods based on social constructivism, influenced by the learner-centred education policy in Namibia (Ministry of Education, 2009). Vygotsky's socio-cultural theory also supports the learner-centred approach, as it states that learning takes place during social interaction. Though the learner-centred approach is popular, it also has its shortcomings. Rosenberg (2008) indicates that learner-centred approaches to education are being interpreted in problematic ways, resulting in empty, superficial or incoherent learner activities, with little content. For this reason, it can be argued that both teaching approaches are effective. Those teachers who used the teacher-centred approach stated that the method was very effective because their learners were learning and gaining knowledge, while those who used the learner-centred approach said it was very effective as learning was taking place among the learners.

Only two teachers (T_2Q_2F; $T_{14}Q_{14}F$) admitted that the teaching methods they implemented when teaching evolution were ineffective. According to T_2Q2F, her approach was not effective, as she did not teach the learners and also did not test them to see if they had learned. This teacher only gave learners questions which were based on evolution and then instructed them to go and answer the questions on their own, without explaining any concepts. This approach would surely be ineffective, as learners need assistance according to Vygotsky's socio-cultural theory (1978) (see Section 3.2). During mediation, teachers are required to support learners in appropriate forms of socialisation, by the use of different mediational tools, until such time that those learners can reason on their own, which is an essential component of the social cultural theory.

The social-cultural theory aims at trying to develop the learners through mediation. According to Newman, Griffin and Cole (1989), the main goal of education from a Vygotskian point or perspective, is to assist the learner within their individual ZPDs and to motivate them to learn through collaborative endeavours, which facilitate problem solving that is slightly more difficult than what the learner may achieve on their own. This would then result in the completion of a given activity which the learner will be able to achieve individually in the future, and consequently will have raised their level of ZPD. For this reason, one can argue that the method used by this (T_2Q_2F) teacher will be ineffective as learners need assistance to learn what they cannot learn on their own.

Learners cannot learn certain concepts on their own and the fact that this teacher only gave the work without explaining the concepts to the learners, makes the approach inactive, as learners need assistance to reach their ZPD. $T_{14}Q_{14}F$ also said that the approach she used when teaching evolution was not effective. She explains that she "*only reads the concepts to the learners from the textbook, and tells them to underline the key points per the syllabus*" (see Table 5.4a). This approach is ineffective as the teacher was only reading the concepts to the learners, without explaining and engaging learners to learn from one another. Teachers as mediators should guide the learners and assist them to internalise the content and develop (Vygotsky, 1978). If the teacher only reads the concepts to the learners, this will not help the learners in any way, because the teacher must explain and use artefacts, to make learning easier.

5.3.3 Enablements and constraints for effective teaching of evolution

Data from Part D of the questionnaire that were based on factors that enable and constrain effective teaching of evolution within the classroom, the school and community, were studied and analysed. This data provided answers for my research sub-question 4. I thus colour coded the data to form sub-themes (see Table 5.5a). The overlapping sub-themes were then linked together and formed themes (see Table 5.5b). These themes were then grouped into analytical statement 4.

Table 5.5a: Preliminary themes from coded text

Research sub-question 4: What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?		
Teacher Questionnaire	**Description of coded text**	**Sub-themes**
T_1Q_1M; T_2Q_2F T_5Q_5M; $T_{11}Q_{11}F$	Not enough teaching aids; lack of appropriate teaching resources; lack of appropriate teaching aids; lack of textbooks; lack of teaching material; does not have enough appropriate teaching material.	Availability of teaching resources is a problem.
T_2Q_2F; T_6Q_6F $T_{10}Q_{10}F$; $T_{14}Q_{14}F$ $T_{15}Q_{15}M$	Learners' attitude towards the topic; learners do not take the topic seriously; do not want to participate; this topic is not true; do not want to participate.	Learners' attitude towards learning evolution.
T_2Q_2F; T_3Q_3F T_5Q_5M; T_6Q_6F T_8Q_8F; T_9Q_9F $T_{13}Q_{13}M$	Topic is attacking their God; against their religious background; religion plays an important role; issue of the religious background; conflicts with their religion; attack their beliefs; religious issue is a problem; the religion is very challenging; going against their God.	Religion affects leaners' attitude towards learning of evolution.

T_6Q_6F; $T_{10}Q_{10}F$	Learners do not have foundation knowledge; new information to the learners.	Learners' lack prior knowledge.
T_2Q_2F; $T_{12}Q_{12}F$	Concepts are difficult; human evolution is difficult; does not make sense at all.	The topic is difficult for the learners.
T_4Q_4F; $T_{14}Q_{14}F$	Large class groups can be too difficult to control; leads to class disturbances.	Disciplinary problems.
T_7Q_7F; T_8Q_8F	Time is a problem; time is limited; results in lengthy debate; a lot of time to be wasted.	Teaching time is limited.
T_1Q_1M; T_5Q_5M T_7Q_7F; T_9Q_9F $T_{10}Q_{10}F$; $T_{14}Q_{14}F$ $T_{15}Q_{15}M$	Parents do not believe in evolution; limited understanding; discourage learners to study evolution; parent attacks teachers; parents said they should not do the topic; lack of parents' involvement; parents discourage learners.	Parents' attitudes towards evolution influences learners' views and attitudes on the topic.
T_3Q_3F; T_4Q_4F T_6Q_6F	No problems experienced; none.	No challenges from the school and community.
T_8Q_8F	Received with negativity.	Negative views towards evolution.

Table 5.5b: Themes and supporting theory/literature

Research sub-question 4: What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?	
Analytical statement 5: Enablements and/or constraints in mediation of learning of evolution	**Theory/Literature**
Factors that constrain the effective teaching of evolutionary concepts.	
Availability of teaching resources is a problem; teaching time is limited; learners attitude towards learning evolution; religion affects leaners attitude towards learning of evolution; learners lack prior knowledge; topic is difficult to the learner's negative views towards evolution; disciplinary problems; parents attitudes towards evolution influences learner's views and attitudes on the topic, lack of resources.	Ashrif (1998); Graves (2000); Rutledge and Warden (2000); Ogwa (2002); Eya (2006); Miller et al. (2006); Reiss (2008), Basturkmen (2010); The National Science Teachers Association (2013); Carter, Infanti and Wiles (2015); Ogbu (2015).
Factors that enable the effective teaching of evolutionary concepts.	
No challenges from the school and community.	Morrison (2014).

5.3.3.1 Analytical statement 5: Enablements and/or constraints in mediation of learning of evolution

Teachers did not really specify the factors that enabled the effective teaching of evolutionary concepts at the school, although some teachers mentioned earlier that their subject knowledge encouraged and enabled them to teach evolutionary concepts. These teachers felt that they were able to teach evolutionary concepts appropriately because they had sufficient knowledge about evolution. Morrison (2014) states that a strong subject knowledge is the most important component of being a good teacher, as it boosts the teachers' confidence and enables them to teach concepts appropriately.

Furthermore, the teachers identified different factors that enabled and/or constrained the appropriate teaching of evolutionary concepts. These are factors from within the classroom, the school and also from the community, as they are all involved in the education of the learners. The teachers identified several factors that they felt constrained the effective teaching of evolutionary concepts at schools. These are factors such as a lack of resources, limited teaching time, learner's negative attitude towards evolution and lack of prior knowledge, just to mention a few (see Table 5.5b). They identified these factors as the factors that constrained effective learning and for this reason all these factors fell under theme one, and will be discussed separately in more detail.

5.3.3.1.1 Resources and textbooks

Teachers complained about the teaching resources, as they stated that the available resources were not adequate and enough, in order for them to effectively teach the concepts clearly. Teaching materials are the resources a teacher uses to deliver instruction. A quarter of the teachers indicated that generally resources to teach evolutionary concepts are not sufficient (see Table 5.5a). $T_{11}Q_{11}F$ said that there was limited resources available to help with lesson delivery which hinders effective teaching of evolutionary concepts. These are the statements that the teachers gave in response to resources as constraining effective mediation of learning: *"There are not enough teaching aids that can be employed to sustain the theoretical information given to learners. Textbooks are not enough and learners have to share them"* (T_1Q_1M). *"The issue of the religious background of the learners causes the learners not to take these concepts seriously. There are also not enough textbooks for all the learners at my school"* (T_5Q_5M).

One can deduce from these responses that a lack of resources is a key constraint to effective teaching of evolutionary education. The learners have to share text books, and this can be a real problem. From my experience when I was a school learner, I shared a biology textbook and it was very difficult as we had conflict when it came to when and who could use the book. Also from my experience as a teacher, the sharing of textbooks encourages learners to become lazy and not complete their homework, as they use the excuse of not having a textbook or that the textbook was with the other person with whom they are sharing. Each teacher requires a range of tools to draw upon in order to assist and support learners to reach their ZPD. The ZPD is the area of exploration for which the learners are cognitively prepared, but require help and social interaction to fully develop (see Section 3.2.1). For this reason, each learner needs to have his or her own textbook.

Textbooks are very common teaching aids and are used in many schools, though some teachers criticised the current Namibian prescribed Biology textbook and gave some suggestions about the prescribed textbook. One teacher gave the following response on the quality of the textbook: *"The current biology Namibian textbook has enough information on the topic, and thus it should be integrated in the government textbook catalogue so it becomes a prescribed Grade 11 and 12 textbook"* (T_1Q_1M).

Two teachers made the following suggestions about the prescribed textbook. T_2Q_2F thought that *"they should put or add more pictures on evolution, so that the learners can see pictures which can help them to understand evolution better"*. T_9Q_9F thought that *"the information is old and thus the textbooks must be updated with new information to enhance learning. Put more pictures in that serve as evidence of the changes that took place. The textbooks need to be revised"*.

One can further infer that the textbooks are not of good quality, as they do not explain the evolutionary concepts in-depth and also do not have clear pictures showing evolutionary concepts. Textbooks are the most common teaching element that are used in many Namibian schools, and are essential. According to Graves (2000) and Basturkmen (2010), textbooks inform the syllabus because the authors of the syllabus have made decisions about what will be learned and in what order. They provide security for the learners because they have a road map of the subject, as they now know what to expect and what is expected from them. It further provides a set of visuals, activities and readings, saving the teacher time in finding or

developing such materials. Finally, it may include supporting materials (teacher's guide, CD and worksheets) and provides teachers with a basis for assessing learners' learning and is also supported by the socio-cultural theory.

Vygotsky's socio-cultural theory (1978) sees mediation as happening with the assistance of signs and that this gives it its generative quality. According to Ogbu (2015), for effective teaching of science subjects, instructional materials and facilities are necessary. He further adds that instructional materials and facilities on their own, help to facilitate teaching and learning and are used to influence concrete and permanent change in technical behaviour. Instructional materials include audio visual aids, tools, equipment, machines, educational materials such as charts and ICT instructional resources (Ogbu, 2015). He further states that the utilisation of instructional aids or mediational tools by teachers, makes teaching and learning more effective and meaningful to the learners. Wale (2006) supports Ogbu and stresses that he is of the opinion that the use of instructional materials will make discovered facts become firmly fixed in the memory of learners.

The lack of teaching resources in schools, can generally influence the teaching and learning, as it affects learners' knowledge acquisition (Ogbu, 2015). The lack of teaching resources at schools can affect teachers' motivation negatively when teaching. Ogbu further emphasises that a lack of teaching resources hinders the effective teaching of a subject and reduces the learners' interest and participation in the subject or topic. This affirms what T1 stated in the interview, that it was difficult to get the learners attention as they do not take the topic of evolution seriously. If there were appropriate teaching resources, one could use them to encourage the learners to take the topic of evolution seriously and participate, as there would be evidence that the learners could see.

For these reasons, Ogwa (2002) emphasises that for effective teaching to take place, mediators require mediational tools to successfully help the learners acquire the necessary knowledge and reach their ZPD. He further maintains that if a mediator is provided with the necessary mediating tools, he or she will feel energised and motivated and their sense of ownership and empowerment would increase. According to Eya (2006), teaching resources make the teachers' job easier, faster and more effective. Eya maintains that when teachers see that they have relevant material to teach their subject, they become more eager to teach.

Having said the above, it is very important for the government and the schools to make sure that teachers are provided with the necessary teaching materials, so that effective teaching can take place in schools. The lack of teaching resources constrains the effective teaching of Grade 12 Biology teachers when mediating the learning of evolution. Teachers as mediators need the additional mediational tools, to help in assisting the learners to learn and develop in order to reach their ZPD, which is indeed the main goal of teaching and learning.

5.3.3.1.2 Learners' attitude towards evolution

Every person believes differently, but it is safe to say that attitudes affect learning. Some teachers identified learners' attitude towards evolution as a problem. This is because every culture has different beliefs and the different beliefs can affect a learner's success; not only because of the belief, but also because educators and peers fail to understand, accept and make provision for the different beliefs. Central to Vygotsky and Cobb et al., 1991 states that we must remember that the learning conditions of the individual, the interactions of the individual with the teacher and other learners, and the individual's cultural background, all affect the learner's success in developing and learning.

Some learners do not have a problem with learning the controversial topic of evolution despite their religious beliefs, while others reject it and do not want to participate in this topic at all because of their cultural background. T_2Q_2F stated that learners have a certain attitude towards the topic of evolution, because according to them, in the first place, it is attacking their religion and secondly, the topic is difficult and confuses them. She explained:

> *"The learners' attitude towards the topic, as some learners do not participate claiming that this topic is attacking their God, or it's against their religious background. Some learners are saying the concepts are difficult to understand and the lack of teaching aids is a problem".*

Attitude has one of the largest impacts on a learner's success (Miller, 2004). The learner who enters the classroom with a good attitude, eager to learn and participate, brings with him or her positive energy that makes it easier to learn. If a learner enters the Biology class with a positive attitude, he/she will positively accept what is being taught in the class and accept it. People do better when they are positive in a positive environment. The learners who are against evolution will enter the classroom with a negative attitude, and then will not

participate in the class. These learners then constrain the teaching of evolution, as these learners disturb the lessons unnecessarily.

According to T_4Q_4F,

> *"Learners do not want to participate because they feel that this topic is not true. Some learners make fun of the topic and tease one another that their parents are apes, that is why they [other learners who are interested in learning evolution] look like apes. This than leads to class disturbances".*

Learners who are anti-evolution miss very important content that they should learn for the examination, which then results in poor academic marks. Classrooms are composed of many learners from different cultural backgrounds and teachers should take into consideration these factors when planning their daily lessons, to ensure that meaningful learning, and development takes place among all the learners. The best way to solve this problem however is for the teacher to offer learners, whose beliefs go completely against the theory of evolution, an alternative assignment from the beginning (Miller, 2004). The teacher should also explain to the learners that learning evolutionary aspects does not mean that they [learners] are anti-God, or that they are going against their religion. Teachers should emphasise to the learners that they need to learn these aspects because it is required of them to do so according to the syllabus, and that they will be assisted on evolutionary content.

5.3.3.1.3 Parental involvement in the learners' education

Some parents are not involved in their children's education, and show this by not paying attention to what they need to be taught. Some parents reject the theory of evolution, and thus discourage its learning in schools. Some parents feel that evolution is against God, and thus it should not be taught in schools. According to T_1Q_1M, many parents do not believe in evolution or they have limited understanding about it, thus they discourage learners to study these evolutionary concepts. T_5Q_5M who has not experienced any problems yet, emphasised that the parents can be a challenge when teaching evolution to their learners. According to him,

> *"I have not really experienced problems, despite one parent who came to attack me because according to him I was teaching the learners evil things. There are also not enough textbooks for all the learners at my school" (T_5Q_5M).*

This clearly informs that the parents lack knowledge on evolutionary concepts, and that is why they reject it. According to Alerts and Nelson (2002), not only does the general public lack an understanding of evolution, but so do a considerable proportion of teachers. In many countries there are still problems around the acceptance of evolution being taught in schools by some members of the community (Mohlala, 2007). Science magazines have published the results of international polls assessing public acceptance of evolution around the world. A comparison of peoples' views across 34 countries reveals that the United States ranks near the bottom when it comes to the public acceptance of evolution. Only Turkey ranked lower, with about 25% of the population accepting evolution and 75% rejecting it (Miller et al., 2006). This clearly demonstrates that the public, which includes the parents, misunderstand the theory of evolution. In the United States for instance, a group of Christian parents instituted legal action in 2005 to challenge the implementation of teaching evolution in schools, because they felt it undermined their notion of God (Mohlala, 2007).

Additionally, Wiles and Branch (2008) emphasise that for those who read Genesis literally and believe that God created the world along with all creatures big and small in just six days, there is no reconciling faith with Darwin's theory. Polls indicate that approximately 45% of Americans believe this. It is no wonder that almost one third of the 1,050 teachers who responded to a National Science Teachers Association online survey in March on teaching evolution in schools, said they had felt pressured by parents and students to include lessons on intelligent design, creationism or other nonscientific alternatives to evolution in their science classes; 30% noted that they also felt pressured to omit evolution or evolution-related topics from their curriculum.

Christianity in Namibia comprises more than 90% of the population, and for this reason the majority of parents in Namibia are Christian. The fact that the majority of parents are Christians and have read from the book of Genesis in the Bible and believe that God created the world, means that there is no reconciling their faith with Darwin's theory. For this reason, many parents see evolution as being anti-God, and thus would discourage it being taught to their children at school.

Many parents do not believe in evolution or they have limited understanding about it, thus they discourage learners from studying evolutionary concepts. If parents discourage learners from learning evolutionary concepts because they see it as a notion that attacks God, then

learners will not take the topic seriously or will not want to participate and learn the topic. This can then negatively affect the learners' results. Parental involvement in their children's education is important and thus parents should encourage learners to learn all the aspects in the syllabus/curriculum. The teachers gave the following statements with regards to the attitude of the parents. $T_{10}Q_{10}F$ felt that there was *"poor parental involvement in the learners' education. Thus the learners do not take education seriously, as their parents are not encouraging and supporting them"*. According to T_7Q_7F, she did *"not really have a problem, just that some learners who are saying their parents said they should not do or study evolution"*.

Parents want good results for their children and that is why they should be involved in their children's education. This is very important because parents are the mediators at home, and teach the children different things, such as moral values and human ethics. According to Carter (2002), parental involvement is associated with increased learner achievement and decreased behavioural problems among the learners. Carter (2002) further states that parents' sense of efficacy for helping their children succeed in school, focuses on the extent to which parents believe that through their involvement they can exert a positive influence on their children's educational outcomes. To have good results or outcomes, parents should encourage their children to study and learn all the aspects that form part of the curriculum, despite their religious beliefs. Parents should be aware that the learners are only learning the content, and learning the content does not mean that teachers are trying to change learners' religious beliefs. Teachers are only teaching the concepts as is required by the syllabus, so that the learners can learn and understand them for the examination. Thus, learners should learn the concepts as is required of them, according to the syllabus. Parents who discourage their children from taking part and learning about evolution as per the syllabus, are doing grievous harm to their children.

The parents should remember that evolution is the most fundamental concept of life sciences and serves as a powerful scaffold around which a comprehensive and integrative understanding of biology and related fields can be built (Carter et al., 2015). It would seem to follow then, that learners who understand evolution ought to have higher levels of achievement in biology and related science subjects than those who do not. The National Science Teachers Association (2013) agrees with this assessment, explaining that if evolution is not taught, learners will not achieve the level of scientific literacy needed to be well-

informed citizens and be prepared for university and careers in the biological field. For this reason, parents should rather encourage their learners to participate in learning evolutionary aspects in school, despite their religious beliefs. It is also important for educators to discuss the lesson plan for evolution with parents before its implementation. This gives the parents a chance to prepare their child for something that goes against their beliefs, or take their child out of the lessons. This will help to avoid any conflict which constrains the effective teaching of evolution to Biology learners.

5.4 Concluding remarks

In this chapter, I discussed the quantitative and qualitative data from the survey questionnaires. It emerged from the quantitative data that religious beliefs did not affect teachers' attitudes towards teaching evolution. For instance, the majority of the teachers (73%) indicated that although they are Christian, this did not affect their attitude towards the teaching of evolution. Similarly, from the qualitative data it emerged that the majority of the teachers in this study had a positive view towards evolution, despite their religious views. Surprisingly, it emerged that religious views did not really influence teachers' views and attitude towards the teaching of evolution, though religious beliefs in the literature are believed to be the dominating factor that influence teachers' views and attitudes towards evolution. It also emerged that evolutionary knowledge is the main factor that influenced the teachers' views and attitudes towards teaching evolution.

In the next chapter, I present, analyse and discus data from the semi-structured interviews and observations.

CHAPTER SIX
DATA PRESENTATION, ANALYSIS AND DISCUSSION

6.1 Introduction

The main goal of this study was to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies when mediating learning of evolution in the Hardap and Khomas regions. In this chapter, I present, analyse and discuss the qualitative data from the semi-structured interviews and classroom observations. The semi-structured interviews helped me to gather data that answered all four research sub-questions, while the observations helped me to answer my research sub-questions three and four.

- What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
- What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
- What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?
- What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?

This chapter commences by presenting the qualitative data from the semi-structured interviews, followed with the analysis and discussion of this data. Thereafter, qualitative data from the classroom observation are presented, analysed and then discussed.

6.2 Qualitative data from the semi-structured interviews

As stated earlier, the semi-structured interviews helped me to generate data to answer the four research sub-questions mentioned above. Regarding the data analysis process, I started by colour coding the qualitative data from the semi-structured interviews to identify preliminary sub-themes (see Table 6.1a). Thereafter, I grouped the overlapping sub-themes to form themes in relation to my research sub-questions. Five themes were identified (see Table 6.2b), and then discussed in more detail. T1 and T2 represent the two teachers that were interviewed.

Table 6.1a: Preliminary themes from coded text

Teacher	Description of coded text	Sub-themes	Research Question
T1	So evolution is a process that happens after a period of time, mostly after a long period of time.	Sufficient knowledge about evolution.	1 & 2
T2	Evolution is the gradual change over time on living organisms.	Sufficient knowledge about evolution.	1 & 2
T1	My views are 100 % in supporting the teaching of evolution; it should be taught to the learners in the school; I believe we do share the same ancestors with apes; I don't think God created or started life as it is just a belief; I don't believe in the bible, but rather believe in evolution.	Positive towards teaching evolution.	1 & 2
T2	As a biologist I don't oppose the teaching of evolution at all; I should equip my learners with the evolutionary concepts, as they need to have the background knowledge on evolution; I teach the topic because I have to.	Teach concepts because they have to teach them.	1 & 2
T1	Give learners homework; discuss their findings together in class as a group.	Engage learners with their learning.	3
T2	Explain the different concepts to the learners; explain the concepts to the learners.	Teacher is doing most of the work in class.	3
T1 & T2	The main challenge is the religious belief issue; some learners also do not want to participate in the topic, because of their religious issues; the lack of proper teaching resources is another; the textbooks that they we are currently using are not learner friendly.	Challenges in teaching evolutionary concepts to the learners.	4

Table 6.1b: Themes and supporting theory/literature

Theme	Research Question	Theory/Literature
Theme 1:Understanding of evolution		
Sufficient knowledge of evolution.	1	Vygotsky (1978); Heggart (2016).
Theme 2: Dominant views towards teaching evolution		
Positive towards teaching evolution	1	Aguillard (1999); Miller et al. (2006); Ogunniyi (2007).
Theme 3: Equipollent view towards teaching evolution		
Teach concepts because they have to teach them.	1	McKeachie et al., (2002); Blackwell et al. (2003); Ogunniyi (2007).
Theme 4: Learner-centred approach		
Learners are discussing in groups.	2	Vygotsky (1976); Hake (1998); Mortimer and Scott (2003); Rosenberg (2008); Namibia. MoE (2009); Sanders and Ngxola (2016).
Theme 5: Teacher-centred approach		
Teacher is doing most of the work in class.	2	Vygotsky (1962); Moll (2004); Namibia. MoE (2009), Donnelly (2014).
Theme 6: Enablements and constraints when teaching of evolution		
Challenges in teaching evolutionary concepts to the learners.	4	Vygotsky (1962); Aguillard (1999); Rutledge and Warden (2000); Trani (2004); Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005); Miller et al. (2006); Nehm and Schonfeld (2007); Wiles and Branch (2008). Thomson (2013).

6.2.1 Theme 1: Understanding of evolution

Theme 1 emerged from the data of the first question of the semi-structured interview that was on the teachers understanding of evolution. Here are some of the statements that the teachers gave on how they understood evolution. *"So evolution is a process that happens after a period of time, mostly after a long period of time"* (T1). *"Evolution is the gradual change over time on living organisms"* (T2).

It can be deduced from these statements that both teachers indicated and showed that they have a good understanding of evolution. According to the Namibian Senior Secondary Certificate Syllabus, evolution is simply seen as a process of change over a period of time. This corroborates well with de Klerk's (2010) assertion that evolution states that all the life forms on earth share a common ancestor as a result of variation and selection over a very long time.

6.2.2 Theme 2: Dominant view towards teaching evolution

Theme 2 emerged from the semi-structured interview data on teacher's views towards teaching evolution. This is the statement by T1 based on her views towards teaching evolution.

> *"Ahhh, my views are 100 % in supporting the teaching of evolution. It should be taught to the learners in the school. It should remain part of the syllabus because evolution helps learners to become aware of how life started and how and why changes are occurring among species".*

It can be deduced from this statement that T1 has a positive view towards the teaching of evolutionary concepts. As she stated that she is in support of teaching evolution, it can be concluded that she has a positive view and attitude towards the teaching of evolution. T1 also stated that:

> *"I believe we do share the same ancestors with apes. Human evolution came a long away from starting with the apes, until these apes started moving upright on two limbs, rather than on four limbs. No I don't think God created or started life, as it is just a belief ... I don't believe in the bible, but rather believe in evolution".*

It can be further deduced from these statements that T1 holds a dominant view towards

evolution. A teacher with dominant views on evolution, is regarded as a total believer of evolution, and therefore suppresses views on creationism (Ogunniyi, 2007). T1 clearly stated that she does not believe in the Bible, but rather believes in evolution. One can conclude that T1 has a positive view about evolution and thus will not have a problem with teaching the concepts to learners. According to Aguillard (1999), religious beliefs and subject knowledge are the two main factors that influence teachers' conceptions and dispositions towards the teaching of evolutionary concepts.

Based on this, one can further argue that T1 has a positive view and attitude towards the teaching of evolution, as she has a good understanding of evolutionary concepts (see Table 6.2a) The fact that she believes in evolution, also means that she will not be affected by her religious beliefs when teaching the subject, as religious beliefs are one of the factors that affect teacher's views towards the teaching of evolution (Miller et al. 2006). Although T1 one has a dominant view towards the teaching of evolution, T2 has an equipollent view towards the teaching of evolution.

6.2.3 Theme 3: Equipollent view towards teaching evolution

Theme 3 emerged from the semi-structured interview data on teacher's views towards teaching evolution. This is the statement by T2 based on her views towards teaching evolution.

> *"We have different ideologies, different ways of seeing things, but as a biologist I don't oppose the teaching of evolution at all. I should equip my learners with the evolutionary concepts, as they need to have the background knowledge on evolution. As a full born again Christian I don't enjoy the teaching of evolution, though it's something that I must do".*

It can be deduced from these statements that T2 is teaching evolution because she is compelled to do so, even though she does not enjoy the teaching of evolution. For this reason, one can say that T2 holds an equipollent view about the teaching of evolution. This means that the teacher holds both views together, as both views have equal cognitive power and co-exist without logical connection (Ogunniyi, 2007) (see Section 3.3). T2 indicated that she only teaches evolution because she has to equip the learners with the knowledge. Evolution is believed to contradict some religious beliefs, which affect teachers' and learners' attitude toward evolution (Miller et al., 2006). This resonates well with T2, whose views about evolution are affected by her religious beliefs, as she does not enjoy teaching evolution as it

contradicts these beliefs. Research done amongst teachers has indicated that some teachers have strong prejudices against evolution, often because of their religious beliefs (McKeachie et al., 2002; Blackwell et al., 2003). T2 teaches evolutionary concepts because she has to equip the learners with the necessary knowledge for examination, but does not enjoy teaching the concepts, as she feels it contradicts her beliefs. The teachers also used different approaches in teaching the topic, which leads to the next two themes below.

6.2.4 Theme 4: Learner-centred approach implied

Theme 4 emerged from the semi-structured interview data and answers research sub-question 3 – what pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution? T1 used more of a learner-centred approach. According to T1,

> *"I then give learners homework where they have to go and read about evolution and talk to their parents about the topic. Ask their parents about evolution and weather they believe in it or not. The next day we discuss their findings together in class as a group".*

It can be deduced from this statement that T1 was trying to involve the learners in their learning by allowing for class discussions. Learner-centred education techniques are based on involving the learners in the learning process. This is done by using different teaching techniques such as group work, group discussions, project work, eliciting prior knowledge, drama and role-play (Namibia. MoE, 2009). During the class discussions, the learners are engaging with one another and can learn from each other, which is key to Vygotsky's (1978) socio-cultural theory, which sees learning taking place through social interaction, thus recommending the use of interactive engagement. Interactive engagement methods are those designed at least in part to promote conceptual understanding through interactive engagement of learners in heads-on (always) and hands-on (usually) activities, which yield immediate feedback through discussion with peers and/or instructors (Hake, 1998).

T1 used this approach during the mediation of evolution, as this approach is recommend by the Namibian curriculum (Namibia, Ministry of Education, 2010) and is articulated in the Biology syllabus that:

> teaching and learning should be characterised by critical thinking, investigating phenomena, interpreting data, and applying knowledge to

> practical skills and abilities which are essential to understanding the value and limitations of natural scientific knowledge and methods, and their application to daily life. (p. 2)

When learners are engaged with others in conversation or with the teacher, they can learn and develop well. Mortimer and Scott (2003) accentuate that the concept of the communicative approach is central to the socio-cultural theory, so that teachers can develop learners' ideas. Though the learner-centred approach is favoured by many education systems, such as the South African education system (Sanders & Ngxola, p. 122), it also has its critics.

T1 further indicated that the method she was using, which is learner-centred, was not 100% effective and according to her:

> *"It is effective to an extent, but not 100% effective, maybe 60 % effective, because after I have taught this, I ask the learners questions to measure whether they have understood the work or not, but their responses to the questions is very weak. Many learners perform poorly in the topic test".*

Rosenberg (2008) indicates that learner-centred approaches to education are being interpreted in problematic ways, resulting in empty, superficial or incoherent learner activities with little content. It could be argued that this method was not effective as stated by T1, because she found it difficult to use available, content-rich resource materials effectively, to plan and support appropriate learner-centred lessons.

6.2.5 Theme 5: Teacher-centred approach implied

Theme 5 emerged from the semi-structured interview data that was on the pedagogical approaches that the teachers used when teaching evolution. T2 used more of a teacher-centred approach in teaching evolutionary concepts to the learners. T2 said the following in her statement on how she teaches evolution:

> *"Ok how do I teach? I just explain the concepts to the learners. Then further I use media a lot, such as YouTube videos. I show these videos on evolution to the learners. This helps the learners to see how the changes took place".*

It can be deduced from this statement that T2, who is a qualified teacher with a Bachelors of Education, was teaching by using an explanatory approach. She was explaining evolutionary concepts to the learners, meaning that she was the one doing most of the talking during the

lessons. Despite T2 using a teacher-centered approach, she also uses media during her explanation of concepts. She stated that she showed the learners videos on evolution, which is very useful for learning and understanding. Vygotsky (1978) sees mediation as happening with the assistance of signs and that this gives it its generative quality. This encompasses the social and cultural qualities of the relationship between the teacher or mediator and the child (Moll, 2004). During mediation, teachers are required to support learners in appropriate forms of socialisation, by the use of different mediational tools, until such time that those learners can reason on their own, which is an essential component of the social cultural theory.

T2 stated that the explanatory approach used during mediation of evolution was very effective, which corroborates well with Donnelly (2014), who believes that teachers need to be explicit about what they teach and make better use of whole-class teaching, together with the use of mediational tools. It could be argued that the fact that T2 used mediational tools during her lessons helped the learners to understand the concepts easier and perform better. This resonates with Vygotsky's (1962) socio-cultural theory which states that learners can reach their ZPD, when mediators make use of mediational tools during lessons to promote easier learning and understanding of concepts.

6.2.6 Theme 6: Enablements and constraints when teaching evolution

Evolution is a topic in the Namibian Senior Secondary Education Syllabus and has to be taught to Grade 12 learners. Despite the importance of evolution education (see Section 2.3.1), it continues to suffer from constraints that hinder its effective teaching and learning. According to Dobzhansky (1973), nothing in biology makes sense, except in the light of evolution. For this reason, he believes that evolution is a very important topic and should be taught to learners.

Data on challenges teachers face when teaching evolutionary concepts, were studied to identify the challenges. These teachers (T1 and T2) identified constraints that hinder the effective teaching of evolutionary concepts. They identified religious beliefs as a major issue that hinders the effective teaching and learning of evolution. They further identified the lack of teaching resources as an issue as well. T1 reiterated that:

> *"The main challenge is the religious belief issue. Many learners are coming from a Christian background and think that evolution is against or is attacking God. For instance, at a time a learner shouted out and said evolution is against their religion, and thus he won't learn".*

T2 confessed that "*as a Christian, it's a challenge for me to teach the concept. Some learners also do not want to participate in the topic, because of their religious issues*". It could be inferred from these statements that evolution hinders the effective teaching and learning of evolution and there are several reasons why evolution and its teachings constitute a controversial issue in many countries (Miller et al., 2006; Nehm & Schonfeld, 2007). For example, evolution is believed to contradict some religious beliefs, which affect teachers' attitude toward evolution (Miller et al., 2006).

Research done amongst certain groups of teachers in America indicate that there are some teachers whose lack of belief in evolutionary theory affects their teaching, to the point that they teach evolution superficially or do not teach it at all (Aguillard, 1999; Rutledge & Warden, 2000; Trani, 2004; Wiles & Branch, 2008). In addition, surveys have found that many high school Biology teachers reject evolution, as they feel it contradicts their religious beliefs (Moore, 2007). This corroborates well with T2 who stated that she was not comfortable with the teaching of evolution, as she feels it contradicts her religious beliefs. This further concurs with several authors (Aguillard, 1999; Rutledge & Mitchell, 2002; Trani 2004) who state that religious beliefs are one of the dominating factors that influence teachers' views and attitude towards the teaching of evolution.

In addition to religious beliefs, these teachers also identified lack of appropriate teaching resources as another constraint to effective teaching of evolution in schools.

> *"The lack of proper teaching resources is another challenge because the learners do not understand the concepts that well, when I only explain to them. It would be good if I could show them videos and posters so that they can see the evidence for themselves" (T1).*

The textbooks that they are currently using are not learner friendly, as it is only words on paper and there are not enough visual colour full representations of the content. As I stated earlier, pictures are important as they serve as prove or evidence for the learners. The content in the textbook is too shallow with no proper examples that can help the learners to grasp the concepts.

It could be established from these statements that both teachers experienced problems with the teaching resources, and this constrained the effective teaching of evolution. Teaching materials are the different resources that teachers use to deliver knowledge during mediation (Kasanda et al., 2005). Each teacher requires a range of tools to draw upon in order to assist, support and ensure appropriate learning. These materials play a large role in making knowledge accessible to a learner and can encourage a learner to engage with knowledge in different ways (Thomson, 2013). This is in agreement with Vygotsky (1962), who sees mediation as happening with the assistance of signs or symbols. If there is a lack of appropriate teaching materials such as textbooks, which are an important feature of any school, then appropriate teaching and learning might be hindered.

6.3 Qualitative data from observation

Observation is one of the data-gathering techniques that I used in this study. This technique allowed me to collect live data occurring in a social situation as espoused by the interpretive paradigm. This technique further enabled me to observe the pedagogical strategies that the teachers used in trying to enhance the learning of evolution to their Grade 12 learners. Finally, it helped me to identify the different factors that enabled and constrained effective mediation of evolution.

I observed two teachers from the Hardap region, and I observed one lesson on the topic of evolution by one teacher and two lessons from the other teacher teaching evolution. While in the Khomas region, I managed to observe three teachers from three different schools. I observed one lesson from each of these three teachers, as they were teaching the topic of evolution to their Grade 12 learners. Some observations lasted for 30 minutes, whereas some lasted for 40 minutes. All the lessons that I observed are presented below. I have labelled the teachers that I observed with letters A to E. Similarly, I have labelled learners as L1, L2 and so on. After the presentation of all the observed lessons, I will discuss the findings for all the lessons.

6.3.1 Teacher A

Lesson 1 (30 minutes):

At the beginning of the lesson, the teacher started by introducing me to her class and thereafter explained the purpose of my visit. The teacher asked the learners to give me a

round of applause. She then asked the learners to take their seats and take out their books. She started the lesson by reading out the learning objectives of the lesson from a projector. She read as follows ''*Define evolution*' and ''*Explain how evolution takes place in terms of speciation*". The purpose of informing the learners about the learning outcomes was intended to alert them to what was expected from them and what they needed to know by the end of that lesson.

She then introduced the learners to the definition of evolution, which she defined as it appears in the syllabus. For example, "*Evolution is a process of change over a period of time*''. She further explained what the definition implied by stating "*that as time is passing by organisms change their shapes and develop into new organisms*". The teacher further said that ''*evolution is just a theory*''. She went on to explain that ''*evolution is the theory about the origin of life*'' and that life evolved (and continues to evolve) randomly, or by chance. She gave an example: ''*Humans evolved from apes, but as time was passing by we became human*''. She used Figure 6.1 to explain to the learners that organisms change their forms slowly as time passes by.

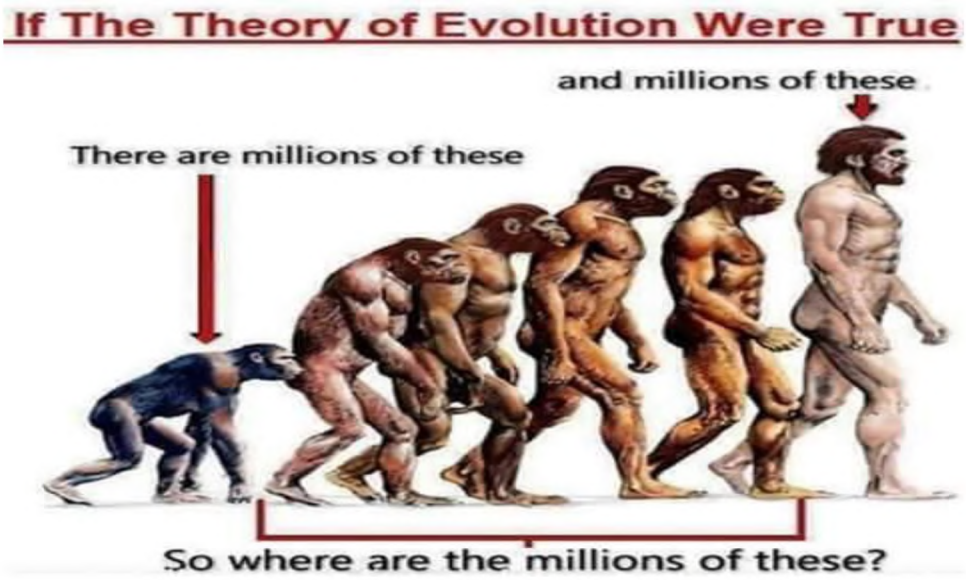

Figure 6.1: Showing how evolution occurred

She then asked the learners what they knew about evolution. During the conversations with the learners, one learner asked the teacher whether she believes in evolution or not. The teacher responded and said ''*No I don't believe in evolution*''. Another learner asked the teacher why they should do evolution? The teacher responded and said "*Evolution is part of*

the syllabus and for that reason you must do the topic''. At the end of the lesson the teacher asked the learners to go and find out what is meant by natural selection for homework.

Lesson 2 (40 minutes):

The teacher started the lesson by asking some recap questions based on the previous day's work, as the teacher wanted to build on the previous lesson. One of the questions the teacher asked, was for the learners to define evolution in their own words. After the questions, she introduced the learning objectives for the day and she read them from the projector: ''*What is natural selection?''* L1 answered: *"Natural selection is when the nature selects the best animals to survive"*. L2 answered: *"Natural selection take place when the strong animals survive and the weak ones die"*.

Thereafter, she explained how natural selection can lead to microevolution. The learners were nodding their heads which is a sign that they understood what the teacher was explaining. She then started explaining what natural selection was by saying, ''*Natural selection is the differential survival and reproduction of individuals due to differences in phenotype''*. She further said that ''*During natural selection only the organisms that are well adapted and those that can withstand the harsh environmental condition will survive*". In her explanation of natural selection, she came up with the following example, in trying to help the learners understand how the process of natural selection occurs:

> *"For example, at the Etosha National Park, we have many springboks and many cheetahs, and the springbok is being hunted by the cheetahs. Now those springboks that run slower compared to the other ones, will be caught by the cheetahs and will be eaten, while those ones that run faster will be able to escape and will survive. So, in that way natural selection has taken place. Because the nature only selects those organisms that are able to withstand the pressure of the environment"*.

The learners appeared to understand how natural selection takes place after the teacher explained to them using the example. The learners showed an understanding as they were asking questions to get a clearer picture of natural selection. The one learner asked the teacher the following: *"So sir, does it mean that the speed of the springbok will be passed on to their offspring, and the offspring will be fast as well and will be able to run and escape away from the predators?"* The teacher responded in the affirmative.

After the example she moved on to how natural selection leads to microevolution. For that part she did not explain how natural selection leads to evolution, as she instructed the learners to write down the following notes from the chalk board. Microevolution is the change in allele frequencies that occur over time within a population:

- This change is due to four different processes: mutation, natural selection, gene flow and genetic drift;
- This change happens over a relatively short (in evolutionary terms) amount of time compared to the changes termed 'macroevolution' which is where greater differences in the population occur;
- Population genetics is the branch of biology that provides the mathematical structure for the study of the process of microevolution;
- Ecological genetics concerns itself with observing microevolution in the wild. Typically, observable instances of evolution are examples of microevolution; for example, bacterial strains that have antibiotic resistance;
- Microevolution over time leads to speciation or the appearance of novel structure, sometimes classified as macroevolution; and
- Macro and microevolution describe fundamentally identical processes on different scales.

After the learners finished with the writing, the teacher told them to go and study the summaries on microevolution.

Discussion of Teacher A's lesson 1 and 2:

It could be deduced from these teacher's lessons that she was using more of a teacher-centered approach, as she was explaining the concepts to the learners most of the time. She did not really involve the learners to participate or engage with one another during the lessons. According to Donnelly (2014), in teacher-centered education, learners place all of their focus on the teacher. The teacher talks, while the learners exclusively listen. During activities, learners work alone, and collaboration is discouraged, which happened in this class as the learners were only working on their own. This approach is regarded as ineffective by Nelson (2008), who says that evidence quite strongly shows that traditional teaching is not very effective in schools, and thus teachers are encouraged to use learner-centred approaches, by involving and engaging with the learners.

When learners are engaged with others in conversation, or with the teacher, they are able to learn and develop well. Mortimer and Scott (2003) accentuate that the concept of the communicative approach is central to the socio-cultural theory, so that teachers can develop learners' ideas. They further explain that the dialogic-authoritative dimension entails either teachers taking into consideration the learners' points of view (dialogic communicative approach) or the emphasis is on the school science point of view (authoritative communicative approach). Therefore, this teacher was using the authoritative communicative approach, as there was no exploration of different ideas in the classroom. The teacher was the one that was doing most of the talking, as she was explaining the concepts to the learners. This contradicts Vygotsky's (1978) theory, which sees learning as taking place among learners when they are socially involved and engaged with one another.

On a positive note, during the lesson presentation, the teacher made use of diagrams and posters to show the learners how the changes took place within the organism. According to Vygotsky (1978), during mediation of learning, teachers are required to support learners in appropriate forms of socialisation by using different mediational tools or artifacts. The fact that the teacher used mediational tools was good, as it helped the learners to understand the concepts easier.

6.3.2 Teacher B

Lesson (40 minutes):

The teacher started the lesson by introducing me to the learners and thereafter explained the purpose of my visit. Similarly, the teacher asked the learners to give me a round of applause. He then instructed the learners to take out their textbooks and exercise books. He started the lesson by introducing the new topic which was 'Selection and evolution'. He read the learning objectives of the lesson from his syllabus. He read as follows ''*Learners should be able to define evolution*'' and ''*Learners should be able to explain how evolution takes place*''.

He then asked the following question: ''*What is evolutionary theory and evolution?*'' He gave the learners two minutes to think about the answer. Two learners responded and one learner answered that ''*Evolution has to do with how life started*''. Another learner said that ''*Evolution is the changes that take place in the life of organisms*''. Some of the learners

were laughing at the others who were trying to answer the questions, and this discouraged other learners from trying to answer. It was also clear that most of the learners were not sure about the answer, as they were scared to raise their hands.

This to me was quite disturbing, as the two learners did not give the correct answer, even though evolution had been covered in their previous grades, although not in great detail. This made me question why the Grade 12 learners found it difficult to give a proper explanation about what evolution is. The answer for me was that these learners could not give an appropriate explanation, because the topic was omitted by the teachers in the previous grades.

The teacher added that evolutionary theory implies that life evolved (and continues to evolve) randomly, or by chance. He then explained evolution to the learners and in his explanation he said that ''*Evolution in the broadest sense explains that what we see today is different from what existed in the past*''. He further went on in his explanation and said that ''*Biological evolution concerns change in living things during the history of life on earth*''. He then referred the learners to the definition of evolution in the textbook, where it is defined as ''*a process of change over a period of time*''. In trying to make learners understand what is meant by change over time, he used a diagram similar to the one used by Teacher A above (see Figure 6.3), in her first lesson. ''*Look at this diagram, we were like this, pointing at the first picture, which are apes, and then we changed over time, and we developed into humans, which means we evolved from apes*''. The learners were laughing at the pictures. The one learner called the name of another learner and said, "*That's how your great-grandmother looks like*". The one learner said to the teacher that she does not believe that human beings were that ugly.

Before he concluded the lesson, he asked the learners whether they believed in evolution or not? Most learners said that they did not believe in evolution. The one learner asked ''*How is it possible that life evolved randomly, it's not true. God created everything*''. The teacher did not respond to the learner's question, and asked the learners to go and do some more research on evolution. If I had to repeat this study, I would definitely observe the follow-up lesson.

Discussion of Teacher B's Lesson:

It can be deduced from this lesson that the teacher tried to involve the learners in the lesson by asking them questions, to ensure that the learners were participating in the class. This approach, whereby learners are involved in the lesson is supported by Crouch and Mazur (2001). According to these scholars, questions asked during lessons encourage learners to be active listeners. This teacher also made use of pictures during his presentation as proposed by Vygotsky (1968), who sees learning taking place with the assistance of mediational tools.

6.3.3 Teacher C

Lesson (30 minutes):

On this day, the school principal took me to the teacher's class and introduced me to the learners and explained the purpose of my visit. The teacher started the lesson by introducing the new topic to the learners, which was selection and evolution. She then asked the learners to sit in groups and discuss for five minutes what they knew about selection and evolution. During the discussions, the teacher was moving around in the class from one group to another. The learners were discussing in their groups, and they were discussing in English and Afrikaans. The approach adopted by this teacher is supported by the socio-cultural theory (see Section 3.2). One learner from one group responded and said that selection has to do with *''selecting things so that you only have what you want, while evolution has to do with how life started''*. Another learner from another group contributed and said that *''Selection occurs when farmers select the best animals to produce good products, while evolution is an explanation on how life started''*. The teacher was responding positively by nodding her head and saying *"good"*.

The teacher defined evolution to the learners as the process of change over a period of time. In her explanation of evolution, she made it clear that *''evolution does not attempt to give a scientific explanation for the origin of life, but only for the development and diversification of life forms after the first life began''*. She further said that evolution tries to explain that what we see today, differs from what existed in the past. She again reminded the learners about the definition of evolution, which is the process of change over a period of time and wrote it on the chalk-board. During the lesson, she also allowed learners to ask questions.

One learner asked the teacher "*How is it possible that we humans evolved from apes? Did the white people also evolve from apes?*" In response, the teacher said that humans did not evolve from modern apes, but that humans and modern apes shared a common ancestor. This species did not exist anymore. She went on to explain that evolution was a branching process in which populations split off from one another and gradually became different. As the two groups became isolated from each other, they stopped sharing genes, and eventually genetic differences increased, until members of the groups could no longer interbreed, which meant at this point they became different species. This is what happened between humans and modern apes many years ago. We shared a common ancestor, but then as changes were taking place over time, we parted ways, as we became two different species. A few learners were nodding their heads, while the others were just sitting quietly listening to the teacher.

The teacher then allowed learners to ask more questions. Another learner insisted that "*It is not true that we share the same ancestor with apes. We were rather created by God*". The teacher responded calmly and commented that,

> *"Some people consider evolution to be equivalent to disbelief to God, thinking it replaces God or otherwise rules out God's involvement in the development of life. But that is not the case as God works through the process of evolution. God is simply controlling the evolution process".*

To make her lesson exciting and understandable, the teacher even made use of pictures to show how the changes took place over a long period of time (see Figure 6.3). The teacher used this picture to show the learners that it was evident that organisms change shape over long periods of time. According to the teacher, "*This is how the old human beings used to look like, then as time was passing by they were changing until they eventually changed to human beings that looks like us*". The learners were laughing at the pictures, and the one learner joked and said, "*Thanks that I am born in this era so that I don't have to be that ugly*".

This was a useful mediational tool, as it served as evidence that evolution did take place. It also helped learners to see what was meant by change over time. The learners could look at the pictures and look at their friends' faces and observe that there was a clear difference between what they see in the picture and what they were seeing with their friends, and this showed that change had taken place. Before the teacher concluded the lesson, she asked the

learners a few questions based on the lesson content, such as: "*What is meant by evolution? What do you understand by the term species*?" This was important as the teacher was able to establish whether the learners understood the concepts well.

She concluded the lesson by introducing the learning objectives of the next lesson. She then gave the learners some questions for homework. I wish I could have observed the next day follow-up lesson, to see how the teacher aligned the previous day's lesson with the new lesson.

Discussion of Teacher C's Lesson:

This teacher divided the learners into groups (seven learners in a group) and allowed them to discuss amongst each other what they understood by evolution. Learner engagement with one another is very effective, as according to Vygotsky (1968), learners learn better when they are socially involved with one another. Vygotsky further emphasises that those learners can help each other to reach their ZPD, when they are engaged in discussions in classrooms.

I also liked the idea that she asked some questions and then allowed the learners to answer. Additionally, she gave learners an opportunity to ask questions too, however, rather than providing answers to the questions that the learners asked, she could have re-directed them to the entire class. Finally, this teacher also used pictures during her lesson presentation, even though the learners were laughing at the pictures. The learners could see how the organism changed over a long period of time. The use of pictures during lesson presentations is a very useful way of mediation, as it assists the learners to understand the concepts easier, according to Vygotsky (1968).

6.3.4 Teacher D

Lesson (30 minutes):

The teacher started by introducing me to the learners and explained to them the purpose of my visit. The teacher then asked the learners to give me a round of applause. The teacher then instructed the learners to take out their textbooks and exercise books. The teacher introduced the new topic – selection and evolution – to the learners. He then asked the learners to open their textbooks where that topic was. He then instructed the learners to read through that chapter on their own. Some of the learners were sharing a textbook, as not all the learners had

textbooks. After reading silently, he instructed the learners to do all the activities in that chapter.

The teacher then went to sit behind his table and started marking some other books, while the learners were busy reading for the rest of the period. Learners were not allowed to talk or discuss with one another and were just reading silently through the work. The learners were intently reading as they were all quiet and looked very busy.

After the bell rang, we had time to reflect on the lesson. In his reflections, he confessed that he had been teaching Biology for the past six years and had never taught the topic of evolution. He said that he himself does not understand the concepts well, which makes it difficult for him to teach the topic. He further commented that, "*What if a learner asks me how is it possible that we evolved from a single cell, how and what will I tell that learner? This is what makes me not to want to teach this topic*". He went on to say that evolution to him does not make sense. Furthermore, he does not believe in evolution, as he feels it is attacking God and that is why he will never teach it.

Discussion of Teacher D's Lesson:

It could be concluded from the conversation that I had with the teacher that he was not comfortable with teaching evolution because he had a limited understanding of evolutionary concepts and also because of his religious beliefs. Teacher D did not teach the concepts to the learners but instead instructed the learners to read through the textbook and instructed them to do the activities on their own. He stated to me in a conversation we had after the lesson, that he does not understand the concepts of evolution. This makes it difficult for him to teach the concepts to the learners.

According to Tatina (1989), studies have found that teachers' attitudes and views about subject matter can influence their curricular and instructional decisions. Concurring, Magnusson et al. (1999) maintain that some researchers have reported that limited knowledge of topic-specific representations can negatively impact science instruction. This was the case with Teacher D, who admitted that he could not teach evolutionary concepts to the learners, because of his limited understanding about evolutionary concepts.

6.3.5 Teacher E

Lesson (30 minutes):

After introducing me to the learners and explaining to the learners the purpose of my visit, the teacher instructed the learners to take their seats and take out their textbooks and exercise books. He then introduced the new topic of selection and evolution to the learners. He asked the learners to open their textbooks at that particular chapter.

He then asked the learners to read through the chapter and then gave them a class activity that they had to complete, which consisted of the following four questions:

1. What is selection?
2. What is evolution?
3. What is microevolution?
4. How does microevolution occur?

The learners were thereafter allowed to discuss these questions amongst each other, as they were reading and trying to answer the questions as they were ordered to by the teacher. In the meantime, the teacher was sitting behind his table completing the attendance register. The learners continued on their own until the period ended.

I tried listening to the group that was sitting closest to me, but they only discussed the first question and after that they started talking about the sports games they had the previous day. When they were discussing the first question they were discussing in English, but when they started talking about the sport, they were talking in Afrikaans.

Discussion of Teacher E's Lesson:

It could be deduced from Teacher E's lesson that he did not teach the concepts to the learners, even though he gave the learners some work to do. Giving the learners work only is not enough, as the learners need to be taught the new concepts. Vygotsky (1978) emphasises that learning takes place among the learners, with the assistance of a more experienced peer or adult. Vygotsky further emphasises that when a child enters the classroom environment, their skills and competencies within their individual ZPDs have not yet fully emerged, which means that the child needs assistance to help them to grasp or understand new concepts. For

that reason, teachers who are more experienced should provide the learners with assistance to support their evolving understanding of knowledge domains or development of complex skills. In light of this, it advisable for teachers to explain the new concepts to the learners, before they give them work to do on their own.

6.4 Concluding remarks

This chapter has provided a presentation, analysis and discussion of the data from the semi-structured interviews and lesson observations. It emerged from the interviews that religious beliefs affected the teachers' attitudes towards the teaching and learning of evolution. Additionally, the study revealed that learners were influenced by their parents, as some parents were against the teaching and learning of evolution. It also emerged from the observations that the teachers made use of a teacher-centred approach, despite the fact that the Namibian Education policy requires teachers to teach by using a learner-centred approach. Lack of resources such as textbooks, were cited as constraining the effective teaching of evolution in some schools.

In the next chapter, I present the summary of findings, recommendations and conclusion.

CHAPTER 7
SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

The aim of this study was to explore Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies when mediating learning of evolution. The study sought to answer the following research sub-questions:

- What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
- What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
- What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?
- What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?

These sub-questions helped to answer my main research question:

> What are Grade 12 Biology teachers' conceptions, dispositions and pedagogical strategies that they use when mediating learning of evolution?

This chapter thus presents a summary of the main findings of the study in relation to my above research sub-questions. This is followed with some recommendations in relation to mediation of learning of evolution. Additionally, limitations of the study and areas for further research are highlighted. Finally, the conclusion is provided.

7.2 Summary of findings

The findings from the study are presented in relation to my research sub-questions in their chronological order.

7.2.1 Research sub-question 1

- **What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?**

In response to my research sub-question 1, the quantitative and qualitative data from the survey questionnaires presented in Chapter Five and the qualitative data from the semi-structured interviews and observations presented in Chapters Six, reveals that more than three quarters of the teachers (73%) had a positive conception and disposition towards the teaching of evolution to Grade 12 learners in schools. As a result, the findings show that many of the teachers are teaching the topic of evolution to their learners. The study also reveals that although many teachers (73%) are Christian, they have positive views and attitudes towards the teaching of evolution. For example, one teacher (T_1Q_1M) commented that:

> *"It is important to teach evolution, so the generations get to understand the way life on earth has evolved since day 1. Thus, it is of great importance that evolution be included in school syllabuses as a topic".*

Notably also, was that teachers' religious views did not really negatively influence their views and attitudes towards the teaching of evolution. The findings differ from some claims made in the literature as according to Miller et al. (2006) and Nehm and Schonfeld (2007), there are several factors why evolution and its teaching constitutes a controversial issue in many countries. The dominating factor is that evolution is believed to contradict some religious beliefs, which then affects teachers' attitudes toward evolution (Miller et al., 2006). In addition, surveys have found that many high school Biology teachers reject evolution and instead identify with creationism (Moore, 2007). This then influences the teachers' views and attitude towards the teaching of evolution.

7.2.2 Research sub-question 2:

- **What factors influence Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?**

It emerged from the study that a lack of evolutionary knowledge is the main factor that influences teachers' views and attitudes towards teaching evolution. For instance, teachers in this study mention that they did not receive enough subject knowledge on evolution, both from their schools and tertiary institutions. This thus affected their views and attitude towards evolution and henceforth the mediation of the topic.

The lack of subject knowledge and religious beliefs were identified as factors that influenced teachers' comfort ability and attitudes when it comes to the teaching of evolutionary concepts. Here are some of the teacher's statements on what influences them to be uncomfortable and have negative attitude towards the teaching of evolution.

> *"No, it's really not an easy topic to teach because there are some points about it that are not so clear of (what really happened at first and why and how it happened). Different people have different views about evolution and this makes it difficult and uncomfortable to teach and explain to the learners".*

It is clear from these statements that teachers do not have sufficient knowledge of evolution. Research has proven that subject knowledge is a very important aspect in education, as it can determine teachers' attitudes towards the teaching of a subject or topic (Hawley, Short, McCune, Osman, & Little, 2010). The acceptance of evolution by teachers, their knowledge of evolution and overall attitude toward evolution, are very much related to each other.

According to Magnusson et al. (1999), some researchers have reported that limited knowledge of topic-specific representations can negatively impact teachers' views and attitude towards that topic. Furthermore, studies have found that teachers' attitudes and views about subject matter can also influence their curricular and instructional decisions (Tatina, 1989). In other words, if teachers do not have sufficient knowledge on a particular topic, it can affect their views and attitude towards teaching the topic. In this study too, the majority of the teachers (67%) indicated that limited subject knowledge is the main factor that determines their comfort ability towards teaching evolution, which results in them having a negative view and attitude towards the teaching of evolution.

Additionally, this study found that teachers with a limited understanding of evolutionary concepts were not comfortable with teaching the topic. $T_{14}Q_{14}F$ for instance, stated that "*No, I don't know the topic very well and it's uncomfortable to teach things that I don't know and there is a lack of resources to be used*". This corroborates well with Rutledge and Mitchell's (2012) findings that lack of or limited understanding of evolutionary concepts, may tend to have negative views about the topic, resulting in them spending less time teaching it effectively. This resonates with Vygotsky's (1978) socio-cultural theory which states that in order for a peer or an adult to assist the child comfortably he or she must be more experienced (more knowledgeable) than the child.

If teachers are not well-equipped with evolutionary concept knowledge, it can affect their capabilities in assisting the learners to reach their ZPD (Vygotsky, 1978; Stott, 2016). If a mediator does not have enough subject knowledge on the subject, he or she will not be comfortable in teaching it and this lack of knowledge can thus influence the teacher's attitude towards teaching the topic. T_6Q_6F explains: *"Yes, my knowledge of the topic makes it easier to teach the subject".*

This statement corroborates well with literature from Vygotsky (1978) and Stott (2016). A teacher with sufficient subject knowledge on evolutionary concepts might be comfortable with the teaching of the concepts effectively to the learners. Magnusson et al. (1999) maintain that subject knowledge is key to comfortable teaching. Additionally, these teachers may have a positive attitude towards the teaching of this topic. According to Moore, 2007), the lack of understanding of concepts, and consequently the ability to teach the concepts competently, are some of the factors that affect teachers' views and attitude towards the teaching of a topic. Teachers who understand evolutionary concepts well, tend to have positive views and attitudes towards the topic Trani (2004).

7.2.3 Research sub-question 3:

- **What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?**

The study found that the majority of the Biology teachers (73%) involved in this study do teach evolutionary concepts. The teachers use various teaching strategies to teach the topic of evolution but the common teaching methods are the teacher-centered strategies. For example, during the observations I noticed that most of the teachers that I observed were using more of a teacher-centered approach. The teachers were doing more talking then the learners during the lessons. It also emerged from the interviews that the teachers use more of a teacher-centered approach than a learner-centered approach, when teaching evolutionary concepts.

Although the Namibian Education policy requires teachers to teach their lessons by using a learner-centred approach, it also clearly emerged from the questionnaires that more teachers use more of a teacher-centred approach instead of a learner-centred approach when teaching evolution. Teacher-centred approaches are often aligned with transmission models of teaching. Within this framework, instruction is the activity in which the information is moved

or transmitted to and into the learner. Typical characteristics of teacher-centred instruction include more teacher talk and questions, than learner talk and questions, more whole group instruction, reliance on textbooks with other sources such as media used as support, recall of factual information, and a classroom in which desks are in rows facing a board with the teacher desk nearby. Here is a statement from a teacher (T_1Q_1M) about his teaching approach: *"Lessons are more of lecturing, diverted a little bit too learner-centred. This makes enough time for the teacher to give more content to the learners about the topic of evolution"*

In this study, it emerged from the questionnaires, interviews and observations that the teachers explained the concepts to the learners, without the learners being actively engaged and interacting with the teacher, or other learners. This teacher-centred approach is regarded as ineffective according to Nelson (2008) and the Namibian Education policy. In contrast, it emerged from this study that these teachers were comfortable with the teacher-centred approach when teaching evolution. This corroborates well with Kasanda et al. (2005), who clearly indicates that in Namibia, the 'empowerment' interpretation of learner-centred education (where learners determine the direction of the learning experience), is not implemented. Kasanda et al. (2005) further indicates that there is little evidence of group work and project work that would support learner-centred education. This could possibly be because of teachers not having pedagogical content knowledge on how to implement and conduct learner-centred lessons. More than a third of the teachers indicated that the teacher-centred approach they use or implement when teaching evolutionary concepts to the learners, is effective.

One can thus further conclude that the teachers use teacher-centred approaches because they feel that the method is effective and help the learners to understand the concepts effectively. This corroborates well with Kevin (2014) who opposes the idea that teacher-centered teaching strategies are ineffective. Kevin believes that teachers need to be explicit about what they teach and make better use of whole-class teaching. Kevin further says that initial instruction when dealing with new information and concepts should be explicit and direct, and thus supports teachers that teach by directly explaining concepts to the learners.

7.2.4 Research sub-question 4:

- **What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?**

The study found possible enablements and/or constraints when it comes to the teaching of evolutionary concepts to Grade 12 learners. It emerged from the study that the teachers identified more constraints than enablements. The teachers identified sufficient subject knowledge as the only enablement, when it comes to the teaching of evolution. It clearly emerged from the study that the teachers with sufficient knowledge about evolution do not have a problem with the teaching of evolution, as their subject knowledge enables them to teach the topic effectively. The teacher with a BSc degree indicated that she has a good understanding of evolution and thus she does not have a problem with teaching the topic. Based on this, one can conclude that a good understanding of evolution enables teachers to teach the topic effectively, without any problems.

The study found that there are a number of constraints that influence the effective teaching of evolutionary concepts. Amongst them are inadequate resources, lack of resources such as textbooks, projectors and access to the internet, lack of interest and discipline among some learners and inadequate time allocated for evolutionary education. This corroborates well with Kasanda et al. (2005), who emphasise that there is a lack of appropriate teaching resources in many Namibian Schools. According to Ogbu (2015), effective teaching of science subjects, instructional materials and facilities, are necessary. He further adds that instructional materials and facilities on their own, help to facilitate teaching and learning and are used to influence concrete and permanent change in technical behaviour. Additionally, he states that the utilisation of instructional aids or mediational tools by teachers, makes teaching and learning more effective and meaningful to the learners. Each teacher requires a range of tools to draw upon in order to assist, support and ensure appropriate learning. According to Kasanda et al. (2005), teaching resources play a large role in making knowledge accessible to a learner and can encourage a learner to engage with knowledge in different ways.

The lack of teaching resources in schools can generally influence teaching and learning, as it affects learners' knowledge acquisition (Ogbu, 2015). The lack of teaching resources at schools can affect teachers' motivation negatively in teaching. Ogbu further emphasises that

a lack of teaching resources hinders the effective teaching of a subject and reduces the learners' interest and participation in the subject or topic.

The study also found that teachers were complaining about the learners' attitudes towards the learning of evolution. For instance, one teacher (T_2Q_2F) commented that the problem is:

> *"The learners' attitude towards the topic, as some learners do not participate claiming that this topic is attacking their God, or it's against their religious background. Some learners are saying the concepts are difficult to understand and the lack of teaching aids is a problem".*

Attitude has one of the largest impacts on a learner's success (Miller, 2004). The learner who enters the classroom with a good attitude, eager to learn and participate, brings with him or her positive energy that makes it easier to learn. If learners come to the class with negative attitudes towards the learning of evolution, they will not want to learn evolution and this will result in them performing poorly. This clearly emerges from the interviews as according to T2, learners do not want to learn evolutionary concepts, because they feel that it is against their religion.

In addition to this, the study found that the some parents were against the learning of evolution by their children. It emerged from the interviews that some parents were discouraging their children from learning evolutionary concepts, as the parents felt that evolution is against God. Christianity in Namibia comprises more than 90% of the population, and for this reason the majority of parents are Christian. For this reason, many parents will see evolution as being anti-God, and thus would discourage it being taught to their children in schools.

Finally, the study found that the time allocated for the teaching of evolutionary concepts is not enough. The teachers involved in this study suggested that more teaching time is needed for the effective teaching of evolutionary concepts. I also observed from some of the lessons presented that some teachers were not giving the learners enough thinking time, when they pose a question. The teachers could not allow for more time because then they will not be able to finish their lessons. This is an indication that teaching time was not sufficient. For this reason, regarding time allocation for Biology lessons, the study recommends double periods in Biology to provide enough time for practical's and outdoor learning. The schools must try

to adjust the timetable in such a way that subjects like Biology is allocated with double periods. This will allow for sufficient teaching time, as teachers will spend more time with the learners. This will possibly help the learners to think longer and understand the concepts well.

7.3 Recommendations

Some of the pertinent recommendations associated with the findings of this study include the following:

7.3.1 Strengthening of the subject content and interest of teachers

The study found that some teachers involved in the study did not have enough knowledge on evolution. They attributed that to the poor pre-service training that they received when they were at tertiary institutions. For instance, most of the Biology teachers involved in the study did not receive much evolution education when they were students. The study thus recommends more comprehensive evolution education in-service and pre-service programmes for Biology teachers. The teachers need to be trained well to be equipped with deep knowledge that will enable them to teach evolutionary concepts effectively. As stated by Heggart (2016), deep knowledge is a prerequisite for critical thinking. A teacher without a good understanding of evolutionary concepts will not be able to teach the concepts appropriately. If teachers themselves do not receive enough education on evolutionary concepts, how can they be expected to teach it effectively?

7.3.2 Constraints of teaching evolution should be translated into enablements

The study found that inadequate resources, such as textbooks, was cited as the main constraint. The study thus recommends provision of teaching materials such as video clips for teaching and making available enough textbooks, so that learners can have their own textbooks, instead of sharing textbooks.

Regarding other constraints, such as the learners' and parents' attitudes towards evolution learning, the study further recommends that learners and parents should be encouraged and motivated, that the learning of evolutionary concepts is not meant to attack or affect their religion, but instead should be learnt for academic purposes.

Regarding time allocation for evolution education, the study recommends double periods in Biology to provide enough time for the teachers to explain evolutionary concepts effectively to the learners.

Biology teachers should be empowered to realise their vision of acting as agents for social change and working for the betterment of education. Finally, the study recommends that continuous professional development of Biology teachers is critical. In the next section, I discuss areas for further research.

7.4 Areas for further research

- Further research could be done on the same topic, this time including learners and parents. instead of only the teachers;
- Further research on how to help teachers to shift away from a teacher-centered approach to a learner-centered approach during mediation of evolutionary concepts, that emphasises the development of learners' positive attitudes toward science education;
- Further research can also be conducted on the importance of teacher's professional development.

7.5 Conclusion

This final chapter of the study provided a summary of the findings. Thereafter, it provided some recommendations related to the study and recommendation areas for further research. In this concluding chapter it is worth noting that the study has researched Grade 12 Biology teachers' conceptions, dispositions and pedagogic strategies when mediating learning of evolution. An analysis of teachers' responses, and lesson observations has been described in Chapter Five and Six. The findings were then discussed in Chapter Seven.

This study concludes that the lack of evolutionary knowledge amongst the teachers was a dominating factor that affected the teachers' views and attitudes towards the teaching of evolutionary concepts. That is, teachers with a limited understanding of evolutionary concepts, were found to have negative views and attitudes towards the teaching of evolution, which can constrain or hinder effective teaching of evolutionary concepts. Therefore, there is

a need for intervention from the Department of Education in the form of continuous professional development, to ensure that teachers receive the necessary support, resources and training, to be able to teach the topic of evolution effectively.

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APPENDICES

APPENDIX 1

HARDAP REGIONAL COUNCIL

Directorate: Education, Arts and Culture

Tell: 063-245735
Fax: 063-242053

Ministry of Education: Hardap Region
Private Bag 2122
Mariental

Enquiries: Mr HU Katuuo

27 May 2016

To: Mr M. Gqwede
Director of Education
Dear Mr Gqwede

Subject: Request for permission to carry out a research study at different secondary schools in the Hardap Region.

I Henry Katuuo, a teacher in the Hardap Region hereby request for permission to conduct a research study in different secondary schools in the Hardap Region, in June 2016. I am a full-time registered student at Rhodes University, Grahamstown as from February 2016 doing a Master's degree in Science Education. It would be very grateful if you allow me to conduct my research.

My topic of study is ''Exploring Grade 12 Biology teachers' conceptions and depositions towards teaching evolution and their pedagogic strategies that they use when teaching this topic''. Thus my research will focus only on the Biology teachers. The insight generated from this study will be published in a thesis form and will become accessible to decision makers in education, curriculum developers, teacher educators and biology teachers in order to bring about improvements in any short comings in Biology.

Should permission be granted, I intent to observe lessons and interview four teachers in their free time, and then distribute questionnaires to the teachers. The teachers will be assured of anonymity of information provided.

Your understanding in this regard will be highly valued.

Yours Sincerely,

……

Mr HU. Katuuo.

APPENDIX 2

KHOMAS REGIONAL COUNCIL

Directorate: Education, Arts and Culture

Tell: 061-2934350
Fax: 061-231376

Ministry of Education: Hardap Region
Private Bag 13236
Windhoek

Enquiries: Mr HU Katuuo

07 June 2016

To: Mr G. Vries

Dear Mr Vries

Subject: Request for permission to carry out a research study at different secondary schools in the Khomas Region.

I Henry Katuuo, a teacher in the Hardap Region hereby request for permission to conduct a research study in the different secondary schools in Khomas Region, in June 2016. I am a full-time registered student at Rhodes University, Grahamstown as from February 2016 doing a Master's degree in Science Education. It would be very grateful if you allow me to conduct my research.

My topic of study is ''Exploring grade 12 Biology teachers' conceptions and depositions towards teaching evolution and their pedagogic strategies that they use when teaching this topic''. Thus my research will focus only on the biology teachers. The insight generated from this study will be published in a thesis form and will become accessible to decision makers in education, curriculum developers, teacher educators and biology teachers in order to bring about improvements in any short comings in biology.

Should permission be granted, I intent to observe lessons and interview four teachers at their free time, and then distribute questionnaires to the teachers. The teachers will be assured of anonymity of information provided.

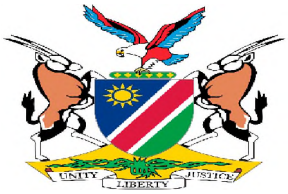
Your understanding in this regard will be highly valued.

Yours Sincerely,

.....

Mr HU. Katuuo

APPENDIX 3



Directorate: Education, Arts and Culture

Tell: 061:-612933111

Ministry of Education: Hardap Region
Private Bag 13186
Windhoek

Enquiries: Mr HU Katuuo
To: The Principals

27 May 2016

Dear Mr/Miss Principal

Subject: Request for permission to carry out a research study at your Secondary School.

I Henry Katuuo, a teacher at Mariental Secondary School and full-time master's student, is hereby requesting for permission to conduct a research study at your school during June 2016.

I am a full-time registered student at Rhodes University, Grahamstown as from February 2016 doing a Master's degree in Science Education. I would be very grateful if you allow me to conduct my research at your school.

My topic of study is ''Exploring Grade 12 Biology teachers' conceptions and depositions towards teaching evolution and their pedagogic strategies that they use when teaching this topic''. Thus my research will focus only on the Biology teachers.

The insight generated from this study will be published in a thesis form and will become accessible to decision makers in education, curriculum developers, teacher educators and Biology teachers in order to bring about improvements in the short comings in Biology.

Should permission be granted, I intend to observe lessons and interview teachers in their free time, look at their lessons plans and then distribute questionnaires to the Biology teachers to complete. To assure anonymity of information provided, no teachers' names will be mentioned.

Your cooperation in this regard will be highly valued.

Yours Sincerely,

.....

Mr HU. Katuuo

APPENDIX 4

Directorate: Education, Arts and Culture

Tell: 061:-612933111

Ministry of Education: Hardap Region
Private Bag 13186
Windhoek

Enquiries: Mr HU Katuuo

27 May 2016

To: The Biology Teachers

Dear Mr/Miss Principal

Subject: Request for permission to carry out a research study

I Henry Katuuo, a teacher at Mariental Secondary School and full-time masters' student, is hereby requesting for permission to conduct a research study at your school during June 2016. I am a full-time registered student at Rhodes University, Grahamstown as from February 2016 doing a Master's degree in Science Education. It would be very grateful if you allow me to conduct my research at your school.
My topic of study is ''Exploring Grade 12 Biology teachers' conceptions and depositions towards teaching evolution and their pedagogic strategies that they use when teaching this topic''. Thus my research will focus only on the Biology teachers.

The insight generated from this study will be published in a thesis form and will become accessible to decision makers in education, curriculum developers, teacher educators and Biology teachers in order to bring about improvements in the short comings in Biology. To answer my research topic, I need Grade 12 Biology teachers to complete a survey questionnaire. I will further need to interview and observe some of the teachers' lessons. I have thus chosen your school and you as a Grade 12 Biology teacher to participate voluntarily in this study. All interviews will be recorded. Ethical issues such as confidentiality, right to privacy, dignity, and honesty will be maintained. Your name will not be revealed anywhere in the study.

Your cooperation in this regard will be highly valued.
Yours Sincerely,

……

Mr HU. Katuuo

APPENDIX 5

Interview Schedule:

1. Could you please tell me what do you understand by evolution?
2. What are your views on teaching evolution in schools?
3. How do your views influence your attitude towards the teaching of evolution?
4. What aspects of evolution do you find easy to understand and easy to explain to the learners?
5. What aspects of evolution do you find to be complex and difficult to explain to the learners?
6. How do you teach evolution? For example, how do you get across the ideas of natural selection?
7. How effective are your teaching strategies in terms of learner understanding and performance?
8. What challenges do you experience within the classroom when teaching evolution?

APPENDIX 6

Masters Research Project: Rhodes University Education Department
Teachers' Questionnaire on the Teaching of Evolution

Dear Respondent,

I **Henry Ueitjitavi Katuuo**, student number **g16k5994,** doing a **Masters in Science Education** with Rhodes University, would like to request all Biology teachers in the Hardap, Khomas and Kharas regions teaching Grade 12 to take part in my research project by completing the following questionnaire. The purpose of this questionnaire is to explore Grade 12 Biology teachers' conceptions, dispositions and teaching strategies that they use when teaching evolution.

Your attention is drawn to the following:

- Please do not put your name on this questionnaire. The information gathered is to be anonymous.
- The anonymous data collected from this survey will form part of my thesis, which will in time be available for you and others to read.
- I am hoping that your comments and the findings will make a small but valuable contribution to our understanding of the teaching of evolution and assist us in improving the performance of students in the topic.
- I do need also to interview in detail a sample of teachers. If after you have completed the questionnaire, you are willing to be interviewed by me please include your cell number here: (.....). I will delete your number whether I select you or not for the interview. Thank you. You may contact me at this number if you have any questions: **0812171132**.

I would be most grateful if you could take a few minutes to complete the questionnaire.

PART A: DEMOGRAPHIC PROFILE

1. Gender (Tick appropriate box)

   Male Female

2. Region (Tick appropriate box)

   Hardap Khomas //Kharas

3. Home language .....

4. Religion .....

5. Age group (Tick **one** box)

20 - 25	**26 - 30**	**31 - 35**	**36 - 40**	**41 – 45**	**46 - 50**	**Above 50**

6. What qualifications do you have? .....

7. For how long have you been teaching? .....

8. For how long have you been teaching Biology? .....

PART B: CONCEPTIONS AND DISPOSITIONS

1. Indicate your view against each of the following statements. Tick only **one** of the following – **strongly agree, agree, not sure, disagree, strongly disagree.**

Statements	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
a) It is certain that the origin of life resulted from natural phenomena.					
b) The origin of life may be explained by natural phenomena without considering the hypothesis that God created life.					
c) The origin of life may be explained by natural phenomena that are governed by God.					
d) It is certain that God created life.					
e) Science and religion should be separate.					
f) Science and religion should be integrated.					
g) A person can hold a scientific view of nature and be religious at the same time.					

2. In the list below, tick **two** words that you strongly associate with the origins of humankind.

   a) Adam and Eve

   b) Australopithecus

   c) Evolution

   d) God

   e) Natural Selection

   f) Creationism

3. What are your views on the inclusion of evolution as a topic in the syllabus?

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4. What were your past experiences of <u>learning about evolution</u>?
a) When you were taught as a learner at school?

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b) When you were taught as a student at the tertiary level (College, Technikon or University)?

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5. Do you think evolution should be **included** in the Grade 11 and 12 syllabus as a topic? Tick only **one** answer in the space provided.

Strongly Agree		**Agree**		**Not sure**		**Disagree**		**Strongly Disagree**	

6. What are your views on the i**nclusion** of evolution in the school curriculum?

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7. What do you think **has influenced your views on the inclusion** of evolution in the school curriculum?

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8. How do you think your views on evolution influence your approach to teaching the topic evolution?

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9. Are you yourself **comfortable** in teaching the topic on evolution?

YES **NO**

Regardless of whether you said **YES** or **NO** to the above, what makes you **comfortable or uncomfortable** in teaching the topic of evolution?

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10. What do you think makes other Biology teachers:

a) **Comfortable** to teach the topic evolution?

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b) **Uncomfortable** with teaching the topic evolution?

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PART C: CONTEENT KNOWLEDGE AND HOW COMPLEX THE TOPIC MIGHT BE

1. How would you rate yourself in terms of your **content knowledge** and **understanding** of evolution and its processes?

A very thorough understanding of evolution		**An adequate understanding of evolution**		**Not sure of how adequate my understanding of evolution is**		**A limited understanding of evolution**		**Very limited understanding evolution**	

2. Please explain why you have rated yourself this way?

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3. What aspects of the topic do you find **more challenging** to understand?

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4. Indicate your view against each of the following statements. Tick only **one** of the following – **strongly agree, agree, not sure, disagree, strongly disagree.**

Statements about the topic evolution	**Strongly Agree**	**Agree**	**Not sure**	**Disagree**	**Strongly Disagree**
a) Evolution is a complex topic for understanding.					
b) Evolution at the Grade 12 level is a simple topic to explain adequately.					
c) The topic evolution is not explained sufficiently in the Grade 12 textbook.					
d) I am not satisfied with the depth of my own content knowledge of evolution.					
e) In my experience, evolution is best taught with mainly teacher talk and handing out notes.					
f) In my experience, evolution is best taught by adding to teacher talk, group discussions by learners on interesting questions.					

5. How would you rate your Grade 12 learners in terms of their **content knowledge** and **understanding** of evolution and its processes after they have covered the topic in class?

A very thorough understanding of evolution		**A adequate understanding of evolution**		**Not sure of how adequate my understanding of evolution is**		**A limited understanding of evolution**		**Very limited understanding evolution**	

6. Please explain why you have rated your Grade 12 learners this way?

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7. Please identify very specifically aspects of the topic evolution that you feel the Grade 12 learners in your school have difficulty in really understanding the content of the topic and evolutionary processes.

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8. Do you think the textbook explains in enough depth the processes of evolution? Please tick **YES** or **NO**.

YES **NO**

a) Regardless of whether you said **YES** or **NO** to the above, please explain your answer.

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b) Regardless of whether you said **YES** or **NO** to the above: What improvements would you suggest in the way the topic on evolution is presented in the textbook?

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PART D: TEACHING STRATEGIES

1. What approaches do you use in teaching evolution?

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2. Do you think these approaches have been **effective or not**: Please tick **YES** or **NO**.

YES **NO**

Regardless of whether you said **YES** or **NO** to the above, please explain your answer.

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3. What are the challenges:

a) Within the **classroom** in teaching evolution?

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b) Within the **school** and **community** in teaching evolution?

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PART E: GENERAL COMMENTS

Is there any other additional information you would like to share with me that I might not have asked that you think might be useful to me in understanding the issue of the teaching of evolution?

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Thank you very much for your time and contribution in completing this questionnaire!!!!!

APPENDIX 7

Semi-structured interview

Research Questions:

- What are Grade 12 Biology teachers' conceptions and dispositions towards teaching the topic of evolution?
- What pedagogic strategies do Grade 12 Biology teachers use when mediating learning of evolution?
- What are the possible enablements and/or constraints when Grade 12 Biology teachers mediate learning of evolution?

Interviewer: Could you please tell me what do you understand by evolution?

Teacher 1: Evolution is a process and at the same time is a question that is asking the new generation where do the living things that we see today come from. So evolution is a process that happens after a period of time, mostly after a long period of time. It shows how a population of an organism are changing over a period of time whereby new organisms are evolving from the previous once. Therefore, I believe we do share the same ancestors with apes. Human Evolution came a long away from, starting with the apes, until these apes started moving up right on two limbs, rather than on four limbs. There was a change in the gene frequency which lead in the formation of a new species from the previous once.
No I don't think God created or started life, as it is just a belief. If organisms were created by God, then the organism were not supposed to change, but organisms are changing shapes or are evolving. God things or the Christianity part is just a belief that was created to bring order in the society. I don't believe in the bible, but rather believe in evolution.
Teacher 2: aaaaaa from my point of view evolution is the gradual change over time on living organisms. Just change how we evolve from a single cell, to many diverse organisms living on earth. Evolution further says that we were once one prokaryotic cell, that through genetic mutation in the cell, changed to become different. Evolution beliefs that I was once or I have a common ancestor with banana or animals.

Interviewer: What are your views on teaching evolution in schools?

Teacher 1: AAAA, my views are 100 percent in supporting the teaching evolution. It should be taught to the learners in the school. It should remain part of the syllabus because evolution helps learners to become aware of how life started and how and why changes are occurring among species. Though I am in support of evolution to be taught in school, I don't really enjoy teaching evolution that much. This is because you are teaching different kids that believe in different things or have different religious backgrounds. In most cases a few learners are curios and are willing to participate and learn evolution, while the majority of learners are influenced by their parents and are not taking this topic serious as they are saying the topic is against their religious. This then results in only a few learners participating and the rest of the learners make noise, disrupt the class and make fun of the statements. This then make it un-pleasant to teach the topic.
Teacher 2: Mmmm we have different ideologies, different ways of seeing things, but as a biologist I don't oppose the teaching of evolution at all. I should equip my learners with the

evolutionary concepts, as they need to have the background knowledge on evolution. Talking about enjoying teaching evolution, it's a fifty thing. As a full born again Christian I don't enjoy the teaching of evolution, though it's something that I must do. Sometimes I enjoy talking to the learners about the evolutionary concepts, getting their thoughts about the topic. Most learners are against the topic. I teach the topic because I have to, though when am teaching the topic, I feel like am contradicting myself with my beliefs. It sometimes feels like I support evolution. But yes I do teach the theory to the learners, though I don't like it and don't believe in it really.

APPENDIX 8

Masters Research Project: Rhodes University Education Department
Teachers' Questionnaire on the Teaching of Evolution

Dear Respondent,

I **Henry Ueitjitavi Katuuo**, student number **g16k5994,** doing a **Masters in Science Education** with Rhodes University, would like to request all Biology teachers in the Hardap, Khomas and Kharas regions teaching Grade 12 to take part in my research project by completing the following questionnaire. The purpose of this questionnaire is to explore Grade 12 Biology teachers' conceptions, dispositions and teaching strategies that they use when teaching evolution.

Your attention is drawn to the following:

- Please do not put your name on this questionnaire. The information gathered is to be anonymous.
- The anonymous data collected from this survey will form part of my thesis, which will in time will be available for you and others to read.
- I am hoping that your comments and the findings will make a small but valuable contribution to our understanding of the teaching of evolution and assist in us improving the performance of students in the topic.
- I do need also to interview in detail a sample of teachers. If after you have completed the questionnaire, you are willing to be interviewed by me please include your cell number here: (.....). I will delete your number whether I select you or not for the interview. Thank you. You may contact me at this number if you have any questions: **0812171132**.

I would be most grateful if you could take a few minutes to complete the questionnaire.

PART A: DEMOGRAPHIC PROFILE

9. Gender (Tick appropriate box)

Male Female

10. Region (Tick appropriate box)

Hardap Khomas Kharas

11. Home language .....

12. Religion .....

13. Age group (Tick **one** box)

20 - 25	**26 - 30**	**31 - 35**	**36 - 40**	**41 – 45**	**46 - 50**	**Above 50**

14. What qualifications do you have? .....

15. For how long have you been teaching? .....

16. For how long have you been teaching Biology? .....

PART B: CONCEPTIONS AND DISPOSITIONS

4. Indicate your view against each of the following statements. Tick only **one** of the following – **strongly agree, agree, not sure, disagree, strongly disagree.**

Statements	**Strongly Agree**	**Agree**	**Not sure**	**Disagree**	**Strongly Disagree**
a) It is certain that the origin of life resulted from natural phenomena.					
b) The origin of life may be explained by natural phenomena without considering the hypothesis that God created life.					
c) The origin of life may be explained by natural phenomena that are governed by God.					
d) It is certain that God created life.					
e) Science and religion should be separate.					
f) Science and religion should be integrated.					
g) A person can hold a scientific view of nature and be religious at the same time.					

5. In the list below, tick **two** words that you strongly associate with the origins of humankind.

a) Adam and Eve

b) Australopithecus

c) Evolution

d) God

e) Natural Selection

f) Creationism

6. What are your views on the inclusion of evolution as a topic in the syllabus?

T_1Q_1M It is important to teach evolution, so the generations get to understand the way life on earth have evolved since day 1. Thus it is of great importance that evolution be included in school syllabuses as a topic.

T_2Q_2F To better understand biology and human race.

T_3Q_3F It is a topic learner must be confronted with to be exposed to different points of views.

T_4Q_4F Evolution is a continuous process in nature and should be included in the syllabus.

T_5Q_5M The personally don't believe in evolution so therefore I do not think the topic should be included in the syllabus. I believe God created humankind and I believe by including this topic might create a lot of confusion amongst learners from different religious backgrounds.

T_6Q_6F It is part of all natural processes that occur and should be included as a topic.

T_7Q_7F It is a very good topic informing learners of their origins and how life continue changing.

T_8Q_8F I do not see it as a problem because it does not affect my belief. I teach it accordingly to the syllabus even if I do not believe what scientist say about it. I also have not seen it having much impact on learners' beliefs since they always objected the theory- meaning they already grounded on what their religion taught them.

T_9Q_9F It is a good idea for the historical view of humans and for upcoming generations to know and understand where humans have evolved.

$T_{10}Q_{10}F$ Personally, I have no objection on including the topic in the syllabus. Future scientist need some sort of background of evolution from grass root level, school. I believe evolution is just an ideology.

$T_{11}Q_{11}F$ From a scientific point of view, it is necessary to be included because people need to know how they evolved. From a religious point of view, it is not good because it contradicts my faith.

$T_{12}Q_{12}F$ Confuse learners and they don't want to study the topic. It is unreal for them, as they only believe that God created everything.

$T_{13}Q_{13}M$ I thing that it should not be included in the syllabus as it does not make sense and confuses the learners as well as me the teacher. I am not true and should not be taught to the learners.

$T_{14}Q_{14}F$ I think the topic should not be included in the syllabus.

$T_{15}Q_{15}M$ It should be included in the syllabus.

4. What were your past experiences of learning about evolution?
a) When you were taught as a learner at school?

T_1Q_1M My teacher was not really comfortable and open to talk about evolution in depth, I understand it has to do with her religious status having known her as a strong Christian follower. She probably somehow felt she was contradicting her belief.

T_2Q_2F We had a good biology teacher but he did not teach the topic as well or good, like he was teaching the other topics.

T_3Q_3F I was never taught about evolution at school.

T_4Q_4F was explained in terms of natural selection leading to change in nature.

T_5Q_5M I never believed in anything about evolution. I simply studied because it was part of the syllabus.

T_6Q_6F As a learner at school? Grade 11 & 12.

T_7Q_7F It was a good experience to know that life does not stay the same it changes based on the activities that are happening on the environment such as natural selection and mutation.

T_8Q_8F from home I was already taught that God created heaven and earth and everything within it including human beings so evolution to me was just one of those tales.

T_9Q_9F As a teenager I was intrigued and interested to know how living organisms evolved and changed over time. Being a science learner it was an interesting topic and we could debate on topics such as natural selection.

$T_{10}Q_{10}F$ I didn't get a better understanding of evolution during my times in school.

$T_{11}Q_{11}F$ By then it was an eye opening topic because I was not really matured to compare evolution to biblical scriptures. So it was interesting that time.

$T_{12}Q_{12}F$ God created human and we are not changed by evolution. Evolution can maybe take place in animals and plant for them to adapt to their environment, but not humans.

$T_{13}Q_{13}M$ We were not taught that topic in school, as our teacher was a Christian and therefore did not teach us as she will feel that she is supporting evolution.

$T_{14}Q_{14}F$ Our teachers was giving us notes and did not explain the concepts to us. We had to study on our own.

$T_{15}Q_{15}M$ My teacher taught us very well, as I enjoyed the topic and our teacher were explaining the concepts well.

b) When you were taught as a student at the tertiary level (College, Technikon or University)?

T_1Q_1M I got to understand the whole concept and its importance. I however also had a little bit of a problem in relating evolution to my religion (Christianity) but later got the glimpse that the two actually speak of the same language but from different perspectives.

T_2Q_2F It was taught well in details.

T_3Q_3F It was only taught in first year in one module only.

T_4Q_4F Evolutionary theory was discussed in greater details.

T_5Q_5M It was not taught well at university level.

T_6Q_6F We were not well prepared in this evolutionary theory and the evidence for evolution. The biology modules that we did at university, did not specifically dealt with evolution. These modules only explained the basics of evolution only and did not go into depth.

T_7Q_7F I can't remember being taught this at the University level.

T_8Q_8F I was taught at University level, but it was not really that well explained to me.

T_9Q_9F Topic was not covered in-depth.

$T_{10}Q_{10}F$ That's where I learned more about evolution and gained a better understanding which made me to believe in evolution as a scientist.

$T_{11}Q_{11}F$ at tertiary the content was a bit deep and that is when I started knowing that it attacks what I believe in.

$T_{12}Q_{12}F$ We were not taught anything about evolution.

$T_{13}Q_{13}M$ It was taught in one module and notching much was said about it.

$T_{14}Q_{14}F$ I never took believed in evolution when it was taught to us in school, and thus I did not like it and I was only studying it because it was in the syllabus. Our teacher was also not explaining concepts well to us. This was the case as well at University level.

$T_{15}Q_{15}M$ It was taught well. As we did it as part of zoology. We also did it in introduction to biology and in genetics as well.