Chapter 1

Introduction of the study

1.1. Introduction

In 2008 the South African government introduced a new curriculum that encourages education which is based on outcomes. In order to achieve the outcomes outlined by the new curriculum, the process of teaching and learning should go beyond classrooms. This implies that the process of teaching and learning should take place at home, when watching TV, interacting with friends or members of the community, and by visiting museums and heritage sites (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003). To ensure that out-of-school teaching and learning takes place effectively, teachers should organise field trips and give learners projects which will allow learners to utilise other resources available. According to Uitto, Juuti, Lavonen and Meisalo (2006), out-of-school activities and experiences may encourage learners to develop interest in school subjects. There are several science centres and museums [1]that are visited by thousands of teachers and learners in South Africa and they include Maropeng Visitors Centre, Sterkfontein Cave, Sci-Bono Discovery Centre, Transvaal Museum, the National History Museum and others. Research has shown that science museums are regarded as suitable contexts for the teaching and learning of science because they contain different teaching models, objects and text (Chin, 2004; Tal, Bamberger and Morag, 2005). If museums can contain different teaching aids such as teaching models and objects as claimed by researchers mentioned above, then it is essential that schools and teachers can make use of these institutions.

The focus of my study is on how an informal science institution such as Maropeng Visitors Centre may influence teachers' knowledge about evolution and attitudes towards the teaching of evolution. Maropeng Visitors Centre was used in this study it is known to be an institution which contains some evidence of evolution. Maropeng is

[1] The term 'museum' will be used to cover all informal science institutions such as museums, science centres, observatory centres, zoological gardens, botanical gardens, etc.

a Setswana word which means "the place of origin". Both Maropeng Visitors Centre and Sterkfontein Caves lie within the Cradle of Humankind which was declared a World Heritage Site in 1999. The Cradle of Humankind is a 47,000 hectare region with approximately 280 businesses. This area is filled with a variety of tourism offerings such as bed and breakfasts, game farms, outdoor activities, private homes and 13 fossil sites. The Cradle of Humankind is most famous for the humanoid fossils Mrs Ples and Little Foot which are the examples of *Australopithecus africanus*. Maropeng Visitors Centre is known as the gateway to the Cradle of Humankind whilst Sterkfontein Caves is referred to as the heart of the Cradle. The Cradle of Humankind World Heritage Site consists of 40 different fossil sites of which 13 have been excavated. Maropeng Visitors Centre is located at about 75 minutes travelling time from the centre of Johannesburg and Pretoria.

The exhibition centre at Maropeng Visitors Centre consists of audiovisual displays, interpretative panels, original fossils display and much more. The original fossils on display change throughout the year, depending on the availability of fossils provided by various institutions such as the University of the Witwatersrand and Northern Flagship Institution. The Northern Flagship Institution (NFI) is an amalgamation of national museums that falls under the auspices of the Department of Arts and Culture. Furthermore, Maropeng Visitors Centre covers aspects of South African school curriculum topics in different learning areas such as Life Sciences, Geography, Natural Sciences and so on.

1.2. Background to the study

The history of life on earth and the topic "evolution" are new in the South African Life Sciences curriculum. To ensure that learners understand what they are taught, teachers[2] may want to take learners on educational tours with the purpose of exposing them to the real world. The new curriculum in Life Sciences encourages teaching which allows learners to investigate phenomena (Learning Outcome 1), constructing Life Sciences knowledge (Learning Outcome 2) and apply Life Sciences in Society

[2] In South African education policy 'teachers' are known as 'educators' and this means a professional person who teaches learners at primary and secondary school level.

(Learning Outcome 3). This means that teachers may provide learners with activities which lead to the investigation of different African fossils that made a huge contribution towards the understanding of human evolution.

In the Life Sciences policy guideline, teachers are encouraged to use informal science institutions in order to achieve the above mentioned Learning Outcomes (Nduna-Watson, 2007). This implies that learners and teachers should visit museums because it may be difficult or expensive to have different fossils in a school laboratory. Teaching the context of fossils, history of life and evolution requires a hands-on type of teaching and this can be provided by museums. A survey of literature (see chapter 2) indicates that museums played an important role in the teaching of science. However, the success of the field trip depends on the organisation of the trip in teaching learners (Tal *et al*., 2005).

As shown in the Grade 10 policy guideline (Nduna-Watson, 2007), the following are some of the key events in the history of life that serve as evidence of the history of life in Southern Africa.

- Origins of the earliest forms of life in Mpumalanga (Barberton District).
- Early land plants in the Grahamstown area.
- The coelacanth as a "living fossil", of the group that is ancestral to amphibians
- First mammals in Eastern Cape and Lesotho.
- Humans in Gauteng, Free State, Kwazulu Natal and Western Cape.

The Department of Education encourages schools to utilise the resources that are available in the informal science institutions. Based on the above mentioned key events given by the Department of Education, it is essential to investigate whether these institutions can influence the teaching of evolution. However, Stears (2006) perceives this as a challenge since there are Life Sciences teachers who were not trained on how to teach the new curriculum. Ngxola and Sanders (2008) affirm that some teachers seem to be concerned about the teaching of evolution since they were not well trained.

1.3. Motivation

The Republic of South Africa consists of many heritage sites and amongst them is the Cradle of Humankind. Most of the heritage sites in South Africa play a significant role in the teaching and learning of science as they are visited by thousands of learners (Koloko, personal. communication; Van de Venter, personal. communication).

According to the Department of Education (2003), the National Curriculum Statement (FET) has incorporated indigenous knowledge systems which acknowledge the rich history and heritage of the country. The acknowledgement of indigenous knowledge systems may expose teachers and learners to different world views and allow learners to appreciate, compare and evaluate scientific perspectives (Department of Education, 2003; Dempster and Hugo 2006). Learning Outcome 2 (construction and application of Life Sciences knowledge) allows teachers to use activities that may encourage learners to construct knowledge. This can be done by collecting information and experiences from the world around the learners and linking them with their previous knowledge (Department of Education, 2003).

The focus of my study is to examine whether Maropeng Visitors Centre promotes the teaching and learning of evolution. This centre was chosen since it is known to have the evidence of evolution. To ensure that I understand the activities that are taking place in the centre, I made arrangement with the centre management to visit them prior the workshops with teachers. One of the centre management team members took me through all activities of the centre, as well as the tour to the exhibition halls. According to the Maropeng Visitors Centre management team member, many schools across South Africa and the neighbouring countries such as Lesotho, Botswana and Swaziland visit the site (Van de Venter 2008, personal. communication).

1.4. Aim of the study and research question

The aim of the study was to determine the extent to which a visit to an informal science institution can enhance teachers' understanding of evolution. The intention of this study was to answer the following research question and sub-questions.

- How does a visit to a themed science centre influence Life Sciences teachers' knowledge about evolution and attitudes towards the teaching of evolution?
    - What is the knowledge level of Grade 11 and 12 Life Sciences teachers about evolution?
    - What are the attitudes of Grade 11 and 12 Life Sciences teachers towards teaching evolution?
    - Do the knowledge and attitudes of a sample of teachers change after a visit to the science centre? If so, how?
    - What aspects of the science centre influenced their knowledge about and attitudes towards teaching evolution?

1.5. Theoretical framework for the study

In this study, two theoretical frameworks were used as a guide in the development of the questionnaires and personal meaning mapping. The two theories are constructivism and attitudes towards science.

1.5.1. Constructivism

The word constructivism underpins six paradigms which propose that knowledge is produced by people when they interact with the physical world using their minds, bodies, materials and symbolic tools made available by their cultures (Scott, Asoko, Driver and Emberton, 1994; Hausfather, 2001). Among the paradigms, there is a theory of social constructivism which framed my study. This theory is important in informal science institutions since it supports the involvement of social, professional

and personal interaction in the construction of knowledge (Astor-Jack, McCallie and Balcerzak, 2005).

1.5.2. Attitudes towards science

This theory was used to develop some questions or statements in the pre- and post-visit questionnaires. Koballa and Crawley (1985) perceive attitudes towards science as a general and enduring positive or negative feeling about science. What ever attitude teachers have about any science topic may have a negative or positive influence on the acquisition of the scientific context. Furthermore, Koballa and Crawley affirmed that attitudes towards science may influence the future behaviour of teachers. I anticipate that teachers' attitude towards science may be reflected by the manner in which they teach the topic of evolution after the visit. Osborne (2003) confirms that there is a relationship between attitudes and behaviour. The theory of constructivism and attitudes towards science are discussed in chapter 2.

1.6. Delineation of the study

Museums as other kinds of informal science institutions, are well-respected and favourite resources that support the teaching of science worldwide (Tal, Bamberger and Morag, 2005; DeWitt & Osborne, 2007; Cox-Petersen, Marsh, Kisiel and Melber, 2003). South Africa is one of the countries which have many museums which are used by many schools to teach sciences. To ensure that my study is limited, I chose to focus on visits to Maropeng Visitors Centre only. There are many strategies that can be used to investigate whether museums can be useful in the teaching of science. In order to limit the scope of my study, only two strategies were chosen and that is questionnaires and personal meaning mapping. The pre-visit and post-visit questionnaires were administered to both Grade 11 and 12 Life Sciences teachers. The personal meaning mapping was given to the Grade 12 teachers only. The questions and statements used in these questionnaires covered the topic of evolution. The details of these instruments will be discussed in chapter 3.

1.7. The report

The report of my study is divided into five chapters. Chapter one is the introduction of the study which focuses on the background of the study, the aim of the study, research question and the motivation for the study. Chapter two focuses on the theoretical framework as well as the literature review on how educational visits to informal institutions may influence teachers' knowledge and attitudes towards learning about evolution. Chapter three contains research methodology and ethical considerations in the collection of data. This chapter also discusses how the sample of the study, data and research approaches were chosen. Chapter four contains the analysis and discussion questionnaires and personal meaning maps. Chapter five provides the summary of the research findings, recommendations and implications about the informal science institutions of learning.

Chapter 2

Literature review and the theoretical frameworks

2.1. Introduction

The new curriculum known as National Curriculum Statement (NCS) was introduced in South Africa during 1998 – 2008. The NCS is underpinned by a number of key principles and it includes a high level of knowledge and skills in learners; social transformation; valuing indigenous knowledge systems; integration and applied competence; credibility, quality and efficiency (Department of Education, 2004). The implementation of the new curriculum brought a number of changes in Life Sciences, for example new topics such as biodiversity and evolution were introduced into the curriculum. Furthermore, teachers were required to change their classroom practices so as to help to achieve the following "Learning Outcomes" (Nduna-Watson, 2007):

- Learning Outcome 1: Investigating phenomena in the Life Sciences.
- Learning Outcome 2: Constructing Life Sciences knowledge.
- Learning Outcome 3: Applying Life Sciences in society.

Amongst these learning outcomes, LO 3 requires learners to show understanding of the history of scientific discoveries, the nature of science and how indigenous knowledge relates to living systems. For example, in the concept of evolution by natural selection; evidence provided by the fossil record, similarities within groups and differences between groups, biogeography and many other kinds of evidence are explained. In order to understand and achieve this learning outcome and its concepts, the process of teaching and learning should go beyond classroom settings because such evidence is mostly found in informal science institutions such as museums.

The aim of my study was to determine the extent to which a visit to an informal science institution can enhance teachers' understanding of evolution. This chapter examines the literature on teachers' knowledge about evolution and learning in an informal context. Furthermore, the learning theories (constructivism and attitudes

towards science) which explain the data of my study are discussed. These theories are chosen since they assist in achieving the learning outcomes and the principles of the new curriculum as mentioned above. The theoretical framework developed in my study supports the belief by Matusov and Rogoff (1995) and Hein (1998) that museum visits play an important role in connecting peoples' pre-knowledge and new knowledge as they are considered to be a place where different cultures from different societies can be met. In the Life Sciences curriculum, teaching the topic of evolution may require that teachers utilise informal settings such as museums and/or heritage sites.

2.2. Teachers' knowledge and attitudes about evolution

Evolution is described as the most important concept in Biology or Life Sciences (Matthews, 2001; Rutledge and Mitchell, 2002; Rutledge and Warden, 2000; Dempster and Hugo, 2006). The introduction of this topic in Life Sciences provided learners with access to see its connection with other "biological topics, accentuating the investigative nature of science and power of scientific discoveries" (Cavallo and McCall, 2008:522). Furthermore, Dempster and Hugo (2006:106) perceive evolution as the highest ordering principle in Life Sciences since it deals with questions about "ultimate causation of form and functioning at all levels of life". The incorporation of evolution in school curriculum prepares learners for tertiary-level study and allows them to think scientifically since evolution is a scientific theory. Despite its importance, evolution has been a controversial topic in many countries (Stears, 2006). Research has shown that most Americans who are strictly creationists do not support the introduction of evolution in their schools (Matthews, 2001). During the apartheid era, the South African Education System did not accommodate evolution as it conflicted with the religious beliefs of the government of which the majority was Christianity (Dempster and Hugo, 2006; Stears, 2006). Stears (2006:177) affirmed that Christian National Education "prohibited the mention of any aspects of evolution" and such an attitude towards evolution was accepted by the majority of the population.

In 2008 the South African government introduced the topic of evolution in Grade 12 Life Sciences. After the revision of the curriculum statement, the concept of evolution was cascaded to Grade 10 and 11 respectively. Research has shown that the introduction of evolution has been a concern in many USA communities (Rutledge and Warden, 2000; Rutledge and Mitchell, 2002, Stears, 2006). According to Rutledge and Mitchell (2002), some teachers perceived the introduction of evolution as a way of disgracing their religious beliefs. A study conducted in the USA has shown that some American parents have rejected the notion of teaching evolution as it undermines their children's worldview (Meadows, Doster and Jackson, 2000). Furthermore, the study conducted by Paterson and Rossow (1999) showed that parents in Washington requested the state to remove all text books containing dinosaurs from school library since the depiction of dinosaurs contradicted with the theory of creation. The protestors argued that the existence of dinosaurs contradicted the Genesis account for creation. Furthermore, a teacher argued that teaching evolution is discriminating him as it is against his religion. Senator Bill Keith (an anti-evolutionist as it was contrary to his religious beliefs) promulgated a bill known as "balanced treatment" (Moore, 1999). This bill was designed to narrow the science curriculum. The bill required evolution to be taught side-by-side with creation science.

Research has revealed that evolution is seen as the "central and unifying theme of the discipline of Biology or Life Sciences" because it allows for the investigation of a broad spectrum of biological questions (Rutledge and Mitchell, 2002:21). Furthermore, the theory of evolution "provides a mechanism for exploration of the intriguing "whys" and "hows" we are supposed to ask concerning the diversity of life" (Rutledge and Warden, 2000:23). Matthews (2001:404) perceives evolution as "the thread that connects life forms with one another". Because of the different world views of teachers and communities, I anticipate that the teaching and learning of evolution may be a serious challenge in South Africa. One of the main challenges that may affect the teaching and learning of evolution in South Africa is a lack of proper training of teachers. According to Stears (2006), most teachers in South Africa have little or no formal education on how to teach evolution. Rutledge and Mitchell (2002) have affirmed that "teachers' academic background and personal religious beliefs may

be a contributing factor to the adequate teaching of evolution" (p25). Furthermore, the teaching of evolution may be affected by inadequate textbook coverage of the content of evolution (Rutledge and Warden, 2000). A study conducted by Ngxola and Sanders (2008) revealed that teachers in South Africa are concerned about their content knowledge level of evolution since they have never taught evolution or even learnt it at tertiary level. For Life Sciences teachers to make decisions about teaching evolution, they should have an in-depth knowledge of evolution and its role in the discipline of Life Sciences (Rutledge and Mitchell, 2002). According to Prinou, Halkia and Skordoulis (undated), the teaching of evolution may be determined by the manner in which it is presented in the curricula and textbooks.

The South African Department of Education has conducted several workshops since 2005. The purpose of those workshops was to provide teachers with different strategies of teaching the new curriculum. According to Dempster and Hugo (2006), the teaching and learning of evolution in South Africa may be possible due to the availability of rich natural resources that could facilitate the teaching of evolution in a learner-centred and experientially rooted manner. These include a wealth of biodiversity and environments, well documented fossil records, extensive geological records, active research about the mechanisms of evolution among species and a network of museums throughout the country.

Despite the availability of evidence that supports evolution, there are several barriers that Life Sciences teachers face when teaching evolution. Literature has revealed that intuitive ideas held by learners, misunderstandings and the influence of strongly held personal beliefs may hamper the acceptance and the teaching of evolution (Rutledge and Mitchell, 2002; Cook, 2009). To ensure that the teaching and learning of evolution is effective, teachers should use teaching instructions that promote learner-centredness (Cook, 2009). Such instructions or methods will allow teachers to facilitate each learner's own construction of knowledge as they themselves will be exploring new ideas. Furthermore, teachers are encouraged to explore learners' prior beliefs. Cook used a project-based learning approach to teach evolution. This approach is consistent with a social constructivist view of learning where knowledge is constructed socially. Cavallo and McCall (2008) affirmed that individuals' beliefs

may have an influence on the learning of evolution. Furthermore, they mentioned that teachers' knowledge and conception of evolution may have an impact on learners' understanding of the topic (Rutledge and Mitchell, 2002). Therefore, it is very important for teachers to have a better understanding of the content of evolution and how learners view the world before the process of teaching and learning takes place. This will assist teachers to come up with proper approaches to teach science and in particular the topic of evolution. According to Nickels, Nelson and Beard (1996), teaching the topic of evolution in high schools poses a pedagogical challenge for Life Sciences teachers. Wuerth (2004) mentioned some challenges that teachers may experience when teaching evolution:

(a) Not understanding evolution well enough to feel comfortable in discussing it in their classrooms,
(b) Lack of resources to teach evolution; and
(c) Learners may ask difficult questions that may make the teacher uncomfortable.

In some instances it becomes a challenge for teachers to find hands-on interactive resources due to their lack of knowledge about the topic of evolution.

Several approaches have been suggested that will allow learners to construct their own knowledge about evolution. Teachers are encouraged to use learner-centred instructional methods since it will encourage Life Sciences teachers to explore learners' prior beliefs. The implementation of such approaches may not be possible since the majority of teachers in South Africa seem to have no understanding of evolution as they did not do the topic of evolution in tertiary institutions. Teachers' lack of knowledge in teaching evolution was caused by the fact that this topic was not included in the curriculum of the old regime as it contradicted with their religious beliefs (Stears, 2006). However, Nickels *et al*., (1996) argued that biological evolution is a powerful scientific theory since it is supported by independent bodies of evidence. Such bodies of evidence include the existence of natural groups of organisms, a paleontological record that shows a combination of temporal succession of species and ecologically coherent fossils assemblages. To ensure that effective teaching of evolution occurs, informal science institutions such as museums and science laboratories may be used. The importance of informal institutions in teaching science subjects will be discussed in the next section.

Before I discuss the topic of learning in an informal context, it is necessary to briefly explain creationism (intelligent design) since it may have a negative impact on the teaching and learning of evolution as mentioned earlier in this topic. However, I must mention that creationism is not the focus of my study. Moore (1999) perceives creationism as a religious belief. Religious education as part of creationism has been taught in some of the South African religious institutions such as Muslim and Christian schools. In the book of Genesis, God is perceived as the creator of everything in the universe (Gauld, 1992; Gen 1: 1-31). This includes humans, animals, plants, mountains, valleys, heaven and earth. The bible explains that God created man in his own image. Some Christians believe that the universe has always been the same since it was created and hence the parents in Washington and Tennessee opposed the teaching of evolution because they believe that it contradicts with the theory of creation as taught in the bible (Paterson and Rossow, 1999; Berkman, Pacheco and Plutzer, 2008). Matthews (2001) affirmed that even though evolution is important, it opposes some basic human assumptions and religious beliefs.

As mentioned in this section, the government in Louisiana promulgated a law which allowed the biblical version of creation to be taught side-by-side with evolution. In the topic of creation, teachers were expected to teach the existence of the Divine creator as it is taught in the bible. This was done in order to balance the conflict that existed amongst the community because not all religious believers believed that evolution contradict with their beliefs (Ayala, 2000). Despite all the arguments about evolution, research shows that teachers believe that learners will learn to accept the scientific view of evolution provided they teach it well and provide enough compelling examples (Matthews, 2001). As indicated earlier in this topic, research showed that informal institutions such as zoological gardens, botanical gardens, museums and science centres may provide evidence of evolution. In the following section, learning in an informal context is discussed.

2.3. Learning science in an informal context

Informal learning plays an important role in the teaching and learning of sciences particularly if it is well used. Dierking, Falk, Rennie, Anderson & Ellenbogen (2003: 108) defined informal science learning as learning that "occurs outside the traditional, formal schooling realm". Museums as well as other kinds of informal science institutions, are well-respected and have good resources that support the teaching of science worldwide (Tal, Bamberger and Morag, 2005; DeWitt & Osborne, 2007; Cox-Petersen, Marsh, Kisiel and Melber, 2003). In South Africa, there are several science centres and museums that are visited by thousands of teachers and learners. These include Maropeng visitors centre, Sterkfontein cave, Sci-Bono Discovery Centre, Transvaal museum, the National history museum and others. These informal science institutions may assist in facilitating the teaching of evolution in a learner-centred manner (Dempster and Hugo, 2006).

Research has shown that science museums are regarded as suitable contexts for the teaching and learning of science because they contain different teaching models, objects and text (Chin, 2004; Tal *et al.*, 2005). The process of learning is referred to as an "interpretive process with new information processed only within the context of an individual's prior knowledge and experiences" (Cox-Petersen *et al.*, 2003:201). According to Dierking *et al.*, (2003), learning from museum-like settings or other comparable educational institutions includes the world of science content and processes derived from real-world experiences. These real-world experiences are found within the diversity of appropriate physical and social contexts. Chin (2004) affirmed that a science museum can be treated as a "novel environment" for the teaching and learning of science because of its richness of living things, specimens, models and posters.

In order to utilize an informal learning environments provided by institutions such as museums, schools should organize fieldtrips. Tran (2005:279) explained fieldtrips as a "break in the usual school routine and potentially takes place in locations new to the students and secondly, students and teachers have an effect on student-learning gains

from fieldtrips through activities and discussions before, during and after excursions to museums*"*. I think that the success of fieldtrips is solely dependant on how teachers organize them. DeWitt and Osborne (2007:689) mentioned four principles that can serve as guidelines for planning the visit and they are (a) consider the purpose of the trip, (b) activities used should focus on the visit, (c) activities used in the museum should support classroom activities prior to the visit and (d) resources or activities developed should encourage teamwork. Considering the above mentioned principles, it is important that the teacher must be familiar with museum or an informal science institution he or she is intending to visit (Tal *et al*., 2005; DeWitt and Osborne, 2007). This will assist teachers to be fully engaged with exhibition and also the interpretation of exhibits (Tal *et al*., 2005; Kisiel, 2006).

Lohman conducted research to examine the factors that influence teachers' engagement in informal learning activities (Lohman, 2006). The results of Lohman's study revealed that teachers claimed that characteristics such as self-efficacy, initiative, love of learning and interest in professionalism may motivate them to participate in informal learning. Melber (2007) conducted a study that was designed to prepare teachers in organizing fieldtrips. Melber (2007) organized a developmental program aimed at "providing teachers with information on how to access museum resources, information on how to connect museum visits with classroom curriculum and the methods of integrating informal learning technique into traditional classroom environment*"*(p35). Melber's study revealed that some of the teachers who participated in the program were not satisfied with the methods or strategies used by museum teachers. Therefore teachers were not convinced that the methods used during the programme will integrate informal learning with the traditional classroom environment (Melber, 2007). Melber's study also showed that 37% of teachers affirmed that they have gained knowledge on how to utilize museum resources. This implies that if museums resources are used appropriately, knowledge can be gained.

Griffin and Symington (1997) assert that providing the purpose of the visit which is related to the students' learning of content or skill is vital since it will attempt to guide the fieldtrip. De Witt and Osborne (2007:686) suggest that teachers should be encouraged (1) to know museum settings before the trip, (2) to orientate learners to

museum settings and clarify learning objectives, (3) to plan pre-visit activities that are aligned with the school curriculum goals, (4) to plan activities that support the curriculum and (5) conduct post-visit classroom activities to reinforce the school trip experience.

In 2004, Chin conducted research in Taiwan which investigated teaching strategies that teachers can use to enhance their learning to teach science. His study was based on the ability of teachers to use a variety of resources and methods to teach science. To ensure that school fieldtrips are effective, he suggested that school teachers should recognize the importance of the excursion and create ways of connecting the school curriculum with the science museum objects. He also affirmed that "the museum exhibition accompanied by text and teaching aids may assist school teachers in facilitating students' interactions with factors in the science museum" (p65). Chin's results revealed that 11 pre-service science teachers claimed that they had gained knowledge about the educational resources used by museums. His study also showed that 5 pre-service science teachers agreed that they had learned content knowledge related to the exhibits in the science museum. Based on Chin's results, I suggest that some museums and science centres may assist school teachers in teaching some science topics such as evolution, astronomy and so on. According to Chin, science learning in the museum should encourage social interaction and direct contact with objects involving all senses. Science learning in museum settings may be fruitful provided teachers systematically organize the activities.

Studies conducted by Astor-Jack, McCallie and Balcerzak (2005) and Tran (2005) revealed that through coaching, informal science institutions play an important role in providing teachers with content knowledge, pedagogy and classroom management. Tran's results revealed that teachers believed that museum lessons are designed in such a way that they accommodate the needs of individual classes and their teaching goals. Museum settings should promote learning that depends on interactions among the personal, socio-cultural and physical contexts (Cox-Petersen *et al.*, 2003). School teachers should use museum resources to develop problem-solving and hands-on activities.

In 2005 Kisiel conducted a study in which he established teachers' knowledge for conducting school fieldtrip to science museums or similar institutions of informal learning (Kisiel, 2005). His view on fieldtrips suggests that institutions such as science centres, museums or informal science learning institutions provide valuable learning opportunities for learners and teachers. Kisiel gave 115 teachers two questions examining teachers' motivations in organizing fieldtrips and his study revealed that 90% of teachers perceived fieldtrips as an opportunity to reinforce or expand upon the classroom curriculum (Kisiel, 2005). The study conducted by Tal, Bamberger and Morag (2005) affirmed that most teachers claimed that a science museum visit may stimulate the interest and motivation in learning science, developing scientific and social skills. Kisiel's study also identified eight fieldtrip motivations as follows "connection of the curriculum, provide learning experiences, promote lifelong learning, foster interest and motivation, expose to new experiences, provide a change of setting, provide enjoyment or reward and satisfy school expectations*"*(p940). Amongst these eight fieldtrip motivations, 90% of the teachers participated in Kisiel's study claim that there are connections between school and museum curricula and this was regarded as the most common motivation that encourages teachers to visit science centres (Kisiel, 2005). Kisiel's study led me to speculate whether South African science teachers are influenced by curriculum related factors when they plan fieldtrips.

The literature presented here shows that informal institutions such as museums and science centres are not always properly used by school teachers. In some instances, teachers who accompanied learners had little or no knowledge about the subject content and such teachers regarded fieldtrip as an outing. In order to understand the context of evolution which is displayed at museums, teachers should have a thorough understanding of the nature of science. Rutledge and Mitchell (2002) affirmed that if teachers do not have a thorough understanding of the nature of science, they may not be able to differentiate "scientific validity of evolution and strongly held religious views" (p25). As mentioned earlier, learners' non-scientific views should be accommodated when teaching evolution so that they can be used to construct new knowledge.

2.4. Theoretical Framework

Theoretical frameworks play an important role in designing the research and interpreting the results of the data collected. The theoretical frameworks that form the basis of my research are that of constructivism and attitudes towards science.

2.4.1. Constructivism

Constructivism is a psychological theory of knowledge (epistemology) which was attributed to Jean Piaget, who articulated mechanisms by which knowledge is internalised by learners (Hausfather, 2001; Ackermann, undated). Piaget suggested that individuals construct new knowledge from their previous knowledge through the processes of accommodation and assimilation. Ackermann affirms that Piaget's theory provide a "solid framework for understanding children's way of doing and thinking at different levels of their development". When the process of teaching is taking place, children interpret what they hear according to their own knowledge and experience (Ackermann, undated: 3). Any new knowledge that children have learned is transformed into an input. Piaget does not perceive knowledge as something that can be memorised or encoded, but as an experience which is acquired through interaction with the world and this includes people and things. Hausfather (2001) affirmed that human construct knowledge as they interact with each other and with the physical world. This occurs as people use their minds, bodies, materials and symbolic tools made available to them by their cultures.

There are four of Piaget's key concepts that are applicable to learning and those are (a) assimilation, (b) accommodation, (c) equilibration and (d) schemas (Bhattacharya and Han, undated). During the process of assimilation, an individual incorporate the new experience or knowledge into an existing framework without changing that framework (Bhattacharya and Han, undated). This implies that an individual's experience is aligned with their "internal representations of the world". Through assimilation, individuals may fail to change any faulty understanding; for example, they may not notice any misconceptions or errors presented and may misinterpret or

misunderstand inputs presented by others. In contrast, accommodation occurs when an individual's internal mental structure changes to provide consistency with external reality (Bhattacharya and Han, undated). This implies that the external world is reframed to fit new experiences. This process may be understood as the mechanism by which failure leads to learning. Accommodation occurs when existing schemas or operations are reframed or new schemas are created to accommodate new experience. In other words individuals accept the new knowledge even though it contradicts with their existing knowledge and later they reframe their previous knowledge to fit the new knowledge. The constructivist theory confirms that through accommodation, learning can take place from the experience of failure or others' failure.

Before I continue with the remaining two Piaget's key concept, it will be proper to outline four factors of cognitive development and that is; biological maturation, experience with the physical environment, experience with the social environment and equilibration (Bhattacharya and Han, undated). The first three factors are important in equilibration since it attempt to bring their state of equilibrium. Equilibration is referred to the "biological drive to produce an optimal state of equilibrium between people's cognitive structures and their environment" and such equilibrium must be present for cognitive development to take place (p2). This occurs when an individual make sense of his or her own world by assimilating new knowledge into pre-existing knowledge and accommodating it. In other words, assimilation attempts to organise existing schemata in order to understand events in the external world and accommodation changes pre-existing schemata to adapt to a new situation. Lastly, schema is defined as "the mental representation of an associated set of perceptions, ideas and/or actions" (p3). Individuals utilise schemas to recognise what they have learned or elaborate what they have seen.

There are several paradigms of constructivism and among others the theory of social constructivism is one of the six paradigms of constructivism mentioned by Hausfather (2001). The theory of social constructivism views each learner as a unique individual, complex and multidimensional. This theory is important in informal science institution since its teaching involves social, professional and personal construction (Astor-Jack, McCallie and Balcerzak, 2005). This means that through social

interaction, new knowledge may be constructed. According to Scott (2007), the meanings that museum audiences or visitors make are socially constructed since they are situated within culture. As mentioned earlier in this section, the word constructivism as it underpins all paradigms, proposes that knowledge produced by people when they interact with the physical world using their minds, bodies, materials and symbolic tools made available by their cultures, come from human activity (Scott, Asoko, Driver and Emberton, 1994; Hausfather, 2001). According to Nola (1997), our knowledge does not come from our ancestors or from our experiences but it is constructed as we interact with the world around us. Hausfather (2001) affirms that knowledge may be constructed when learners interact with different information and use it in solving problems, answer questions or discuss interpretations. To ensure that learners have gained the required knowledge, different processes which involve personal and social construction are important (Scott *et al*., 1994). This theory asserts that some information that was deemed to be important to learners may be constructed and it may be used later as a prior knowledge because knowledge does not exist in isolation (Hausfather, 2001).

The role of prior knowledge is perceived as significant in the process of learning. According to Hausfather (2001), the process of learning involves the connection of prior knowledge and new knowledge. Scott, Asoko, Driver and Emberton (1994) mention that if teachers want to teach for conceptual development; the nature and status of the existing knowledge of the learner about the subject content should be considered. Some of learners' existing knowledge is acquired from their society. This implies that the process of teaching should link school experience with out-of-school experience (Scott *et al*., 1994). Out-of-school experiences may encourage learners to work with other learners; that is to be engaged in group discussion, public reasoning and shared problem solving (Hausfather, 2001).

The concept of out-of-school experience includes learning by listening to radio, watching TV, visiting museums or scientific institutions. The construction of knowledge may occur when people are exposed to a phenomenon that is familiar to learners' culture or world around them. According to Hein (1998), museum visits may play an integral part in connecting peoples' pre-knowledge and new knowledge. His

study also asserts that the attribute of any theory of constructivism ascertains that the educational situation of learners should be associated with what they already know. Hausfather (2001) perceive knowledge as a cultural artefact. He also mentions that the process of learning should involve "social interaction that supports thinking brings prior knowledge to the surface and allows skills to be used in the context of content knowledge" (p17).

The teachers involved in my study are likely to have misconceptions or erroneous ideas. Since a visit to the museum may assist teachers in gaining new knowledge which may eradicate or reinforce misconceptions and erroneous ideas about evolution, there is need for a conceptual change theory to be used as a lens to examine teachers' knowledge about evolution. The conceptual change may occur when misconceptions or erroneous ideas are replaced by correct conceptions (Hewson, 1992). Posner, Strike, Hewson and Gertzog (1982) explain conceptual change as the process by which people's concepts are replaced by more acceptable ones. Hewson (1992) regard conceptual change as the process of giving up one idea to accommodate another. This means that learners learn by constructing new knowledge from the existing knowledge and this may take place within a context of social interaction or experiences. The existing knowledge may be in opposition to what is right and that information is labelled as misconceptions. Aikenhead and Jegede (1999) mentioned that the construction of scientific concepts may occur even when those concepts conflict with indigenous norms, values, beliefs, expectations, and conventional actions of learners' or students' life-world. Furthermore, Pintrich, Marx and Boyle (1993) pointed out that the process of conceptual change is influenced by personal, motivational, social, and historical processes. However, Duit & Treagust (2003) perceive conceptual change as a weak knowledge restructuring, assimilation or conceptual capture. Furthermore, they perceive conceptual change as the term which may be used to distinguish the kind of learning which is required when new information to be learned comes in conflict with the learners' prior knowledge. In contrast, Vosniadou (undated) argued that the theories that need to be changed are not misconceptions, but the naïve, intuitive, domain-specific theories constructed on the basis of everyday experience under the influence of different cultures. Vosniadou perceive conceptual change as a constructivist approach that assumes that knowledge

is organised domain-specifically. Since some of the science topics such as evolution, gene therapy and cloning, religious issues, science and worldview are controversial; the controversial conceptual change model which was inspired by Icek Ajzen's theory was introduced (Säther and Maridal, undated). Säther and Maridal describe controversial conceptual change as an intentional action which is caused by processes related to attitudes, control belief, developmental and contextual factors, and their interactions. According to this model; attitudes, social influences and perceived behavioural control are the factors which are involved in the reasoning process that brings about conceptual change.

2.4.2. Attitudes towards science

An attitude is defined as the manner in which people respond to things, places or ideas positively or negatively (Niewandt, 2005). It is useful to look at the theory of attitudes since it will help in understanding how attitudes may affect the teaching and learning of evolution. Ediger (2002) pointed out that a good quality attitude towards science is an important tool in teaching and learning. To ensure that the topic of evolution is taught effectively, teachers should have positive attitudes towards the topic. Koballa and Crawley (1985) perceive attitudes as a general and enduring positive or negative feeling about science. Whatever attitude teachers have about any science topic may have a negative or positive influence on the acquisition of the scientific content. They also affirmed that attitudes towards science may influence the future behaviour of teachers. Osborne (2003) confirms that there is a relationship between attitudes and behaviour. This may encourage or discourage teachers to develop an interest in working on science projects and in visiting informal institutions such as museums and science centres.

As mentioned earlier in this chapter, the South African government has introduced a new curriculum across all grades. In the subject such as Life Sciences, new topics such as evolution and biodiversity have been introduced in the FET band (Grade 10, 11 and 12). One of the biggest challenges that the country is facing is that most

teachers have never been taught evolution at some tertiary institutions as the topic was ignored by the old education system (Dempster and Hugo, 2006; Stears, 2006).

However, the topic of evolution is known to be controversial in Life Sciences due to personal and/or social beliefs of teachers and learners (Matthews, 2001; Cavallo and McCall, 2008). Due to different worldviews or fear of confrontation, many teachers may choose to ignore the topic (Nickels *et al*., 1996). Furthermore, the controversy may be caused by lack of training as mentioned earlier. Asghar, Wiles and Alters (2007) argue that exposure to evolution at the higher institutions may increase teachers positive attitudes towards teaching evolution. However, the positive attitudes may depend on how evolution is taught. Since teachers also belong to a society with different worldviews, their religious beliefs or worldview may have an influence on the pedagogical plans about teaching evolution. Despite all these challenges, research shows that some teachers and scientists believe that evolution should be taught because it is the only scientific explanation of why the universe is the way it is today.

Teachers are faced with a serious dilemma of teaching learners to accept evolution without rejecting their religious beliefs (Scharmann, 2005). To ensure that learners accept the scientific views of evolution, teachers should use instructional strategies that are learner-centred. This can be done by providing learners with examples that will make them accept the view. However, the perception may not be possible because learners come to class with some ideas about the origin of life even though such ideas are non-scientific (Matthews, 2001). In order to carry out teaching and learning which is effective and efficient, it is important to consider the pre-existing knowledge of learners and in most cases such ideas are societal or religious. This will encourage learners to compare their existing ideas with new ones. Through this comparison learners will either reject or accept the new knowledge or ideas. Asghar, Wiles and Alters (2007) assert that many learners reject evolution because they have different cognitive and affective ideas that support their existing knowledge. The understanding of evolution by learners thus depends on the attitudes and views of teachers about evolution content. This implies that lack of teachers' content knowledge may "influence their curricular and instructional decisions" (p191).

To teach a controversial topic such as evolution is challenging since both teachers and learners have their own non-scientific beliefs and misconceptions (Chuang, 2003). Such beliefs and misconceptions may have a negative impact on teachers because they may not have the basic understanding of evolutionary theory and they may choose not to teach it (Weld and McNew, 1999). According to Asghar, Wiles and Alters (2007), the conflict between religious view of creation and scientific evolution is a matter of concern. Teachers are concerned about offending learners' religious beliefs when they teach evolution. Lack of content knowledge and the incompatibility between religious and scientific view may affect teachers' attitude towards teaching evolution. Similarly, according to Chuang (2003), teachers' attitudes about evolution may affect learners if they sense that teachers are also not sure about the content. Jarvis and Pell (2004) affirm that negative attitudes towards science may contribute to the reduction of attainment in the classroom. Despite all misconceptions and misunderstandings such as (a) evolution is only a theory, (b) humans come from monkeys and (c) the concern over human origins, evolution is perceived as an important topic in biological sciences as a whole (Chuang, 2003). To ensure that effective teaching and learning about evolution takes place, teachers should possess the most up-to-date information about the subject content and some of the information may be acquired from the informal science institutions.

2.5. Conclusion

In this chapter I have discussed the literature review about the attitudes of teachers towards evolution and their knowledge about evolution. These two issues serve as a guide to my study as they unpack teachers' understanding of evolution. Since the aim of my study is to determine the extent to which a visit to an informal science institution can enhance teachers' understanding of evolution, the topic of learning in the informal context was discussed. The literature on informal science institutions discussed in this chapter showed that there is evidence of evolution that is displayed in museums. Such displays can be used to promote an effective teaching and learning of evolution. There are two theories that frame my study: constructivism and attitudes towards science. The theory of constructivism shows that learners can construct new

knowledge socially by interacting with each other and materials around them. This can occur as learners' existing knowledge is transformed into new knowledge. The research has shown that each individual has acquired knowledge from their culture and people around them. Such knowledge may determine the attitudes of learners and teachers towards teaching and learning science. The following chapter will explain and discuss the research design and methods of my study.

Chapter 3

Research design and methods

3.1. Introduction

This chapter focuses on the design and methods used to answer research questions of this study. The chapter will attempt to explain how the researcher has collected the data, where it was collected and how it was analysed. Although the research question and sub-questions are listed in chapter one, they are repeated below so that the reader can see the link between the research methods and design. The research question and sub-questions are:

- How does a visit to a themed science centre influence Life Sciences teachers' knowledge about and attitudes towards the teaching of evolution?
    - What is the knowledge level of Grade 11 and 12 Life Sciences teachers about evolution?
    - What are the attitudes of Grade 11 and 12 Life Sciences teachers towards teaching evolution?
    - Do the knowledge and attitudes of a sample of teachers change after a workshop and a visit to the science centre? If so, how?
    - What aspects of the workshop and science centre influenced their knowledge about and attitudes towards teaching evolution?

3.2. Research design

Before I explain the research methods and design, it is imperative to provide the meaning of the word "research". It is known as the process by which information is systematically collected and analysed in order to understand and explain it better (Opie, 2004). Through careful investigation research allows the researcher to establish facts or any existing practices (Fraenkel and Wallen, 1990). Bassey (1999: 38) perceives research as a "systematic, critical and self-critical enquiry aiming at contribution of the advancement of knowledge and wisdom".

To ensure that research conducted provides results which can be generalized and authentic, a good research design is important. Research design is referred to as "a specific, purposeful and coherent strategic plan to execute a particular research project in order to render the research findings which are relevant and valid" (Bergh and Theron, 2003: 21). Furthermore, research design is used to specify the conditions and ways of collecting and analyzing data. An effective research design is guided by research questions and it thus influences the researcher's choices of research methods of data collection and analysis. Bergh and Theron (2003) also explain that research design is a process which can be used by researchers to make decisions to solve what, how and why the specific research problems should be relevant, valid and unbiased. Figure 1 below shows the overall research design of my study.

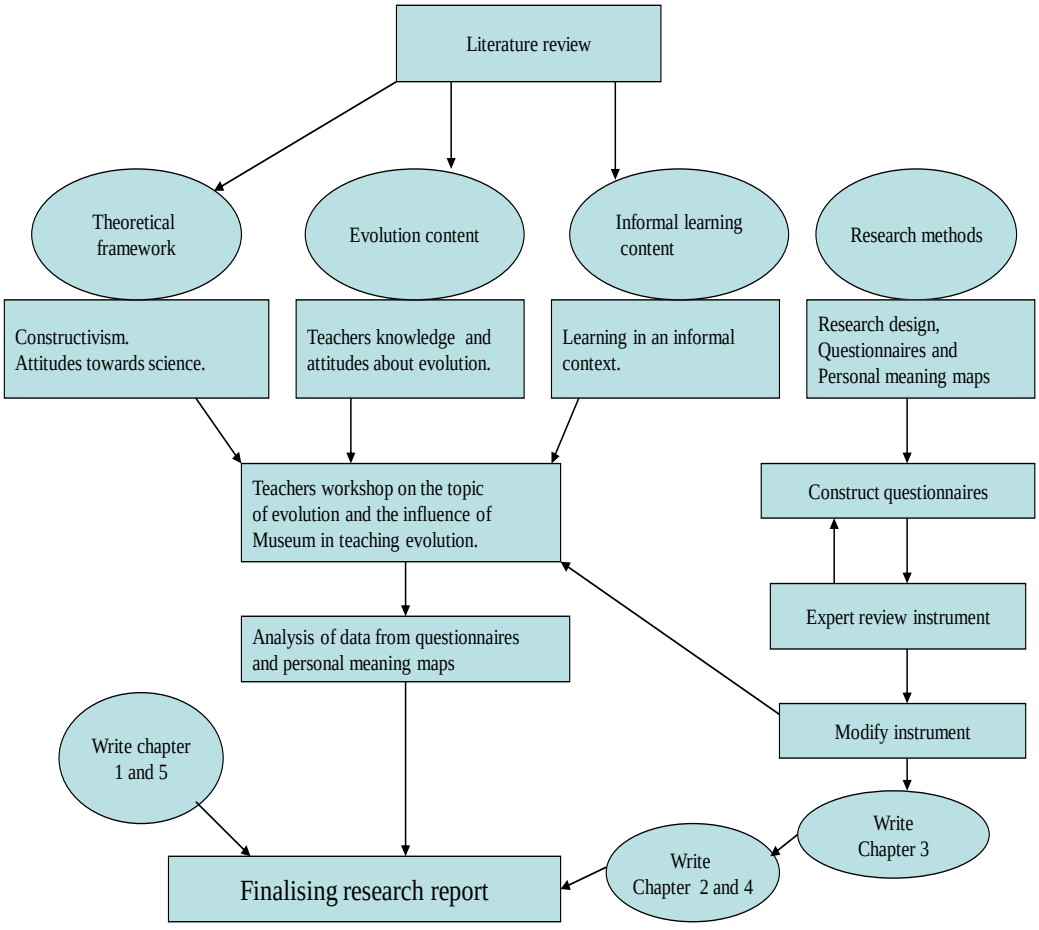

Figure 1: Flow chart showing the overall research design of the study

In order to develop the aim, the research question and sub-questions of my study, an intensive reading about informal learning and the theory of evolution was carried out.

A research question and sub-questions were used to design research instruments. Through reading different papers, I discovered that there are many misconceptions and/or erroneous ideas about evolution. Questionnaires were constructed using such misconceptions and /or erroneous ideas. Both pre-visit and post-visit questionnaires were validated by Life Sciences experts and all changes suggested were effected (refer to section 3.7). The final revised questionnaires were administered at two workshops conducted at Maropeng Visitors Centre. The first workshop was designed to unpack the curriculum of evolution in Grade 11 and how museum or informal science institutions in particular may assist in the teaching of evolution. The second workshop was developmental since it was designed to assist the Grade 12 Life Sciences teachers with content knowledge about evolution (this will be discussed in detailed in subsection 3.5.2). The data collected at these two workshops were analysed qualitatively.

3.3. Research paradigm

Researchers have different ways or preferences of designing their research models or paradigms. Research paradigm as it is used in this study is a concept which represents the thinking and practices of researchers (Bergh and Theron, 2003). Paradigm is regarded as the starting point for doing research as it provides researchers with an opportunity of exploring assumptions (Hatch, 2002). The chosen paradigm will be determined by the researcher's work and preferences and the type of data they want to collect from research instruments.

Bassey (1999:42) explains a research paradigm as a "network of coherent ideas about the nature of the world" and is used by researchers to shape their thinking. Opie (2004:18) perceives a research paradigm as a "basic set of belief that guides action". There are various research paradigms that are discussed in the literature. Table 1 offers a schematic representation of various types of research paradigm. Although interpretive is mentioned as a research paradigm, Opie (2004) argued that it is included by all researchers since research can only offer an interpretation of the world.

Table 1. The schematic representation of research paradigms.

Research paradigms	Descriptions
Positivist	It concerns realists who believe in external reality which is driven by universal and natural laws. This is used by observers who have tested their hypotheses against experimental and other quantitative methods (Bergh and Theron, 2003).
Postpositivist	Researchers believe that reality exists but never fully apprehended. Such researchers claim that reality should be closely scrutinised in order to maximise chances of being apprehended (Hatch, 2002).
Critical or feminist	The researchers of this paradigm believe that the material world is made up of historically situated structures (Hatch, 2002). Such structures have a real impact on the life chances of individuals based on race, gender and social classes.
Interpretive	The realists in this paradigm believe in internal and subjective nature of reality in human beings (Bergh and Theron, 2003). Such realities are explained by means of studies of relationship or interaction between people. Qualitative methods are used in this research.
Constructivist	This is used by researchers who believe that reality is constructed by individuals and groups. (Bergh and Theron, 2003). In this paradigm researchers and participants construct understandings and this is done by using qualitative methods. (Hatch, 2002).

The paradigms of my study are constructivist and interpretive. This was attributed by the fact that participants in my study were allowed to interact with each other. In order to seek clarity in some of the models displayed in the exhibition halls, participants also had an opportunity to ask the tour guide questions. The interaction helped the participants to construct understanding about the models and the natural settings of Maropeng Visitors Centre. Furthermore, the data were collected qualitatively using

the questionnaires. During the visit, I observed participants moving around the exhibits with an effort of making sense of what they see. As participants were moving in the exhibition halls, they interpreted the exhibits in their own way and construct new knowledge using their existing or pre-knowledge. Bergh and Theron (2003:22) affirmed that a constructivist paradigm is used by "researchers who believe that reality is constructed by individuals and groups in the way they think". In case of my study participants were requested to complete personal meaning maps (PMM) and questionnaires before and after they had observed the exhibits. I incorporated the interpretive paradigm since participants are expected to provide their thoughts about what they see in the museum. Bassey (1999) perceives interpretation as a search for deep perspectives on particular events. However, there is no guarantee that the interpretative paradigm will provide the researcher with the required product. During the visit participants were discussing and sometimes asking the researcher and the tour guide questions in an attempt to get a clear understanding of what they see. The purpose of using an interpretive paradigm is to obtain enough knowledge of participants by describing and interpreting the phenomenon of their natural settings. After the tour, the researcher asked participants to complete the post-visit questionnaire and PMMs as a way of identifying whether they have gained knowledge about teaching evolution or have changed their attitude towards teaching evolution.

3.4. Research approach

After a researcher has decided on the research paradigm, a consideration of the research approach is vital. The research approach serves as a procedure that a researcher will use to conduct research (Opie, 2004). There are different approaches that can be utilised by the researchers and amongst others they are qualitative and quantitative approaches. I chose to use a qualitative approach since my study was an empirical case study as described below.

My research was designed to investigate the influence that Maropeng Visitors Centre may have on teachers' knowledge about and attitudes towards evolution. My study was a case study and this is a data gathering approach which is "viewed as an in-depth

study of interactions of a single instance in an enclosed system" (Opie, 2004: 74). Huysamen (1997) and Opie (2004) explain that a case study involves a single person or a group of people and its data is collected systematically and methodologically. Huysamen (1997) mentioned that a single person studied in a case study can be a "highly representative of a particular population" (p168). This approach was important to my study since the study is on real people and in an environment which is familiar to me as a researcher (Opie, 2004). Denscombe (2007) states that a case study is advantageous since it can use a variety of sources, different types of data and a variety of research methods.

The data were collected at an informal science institution known as Maropeng Visitors Centre. This centre is one of the informal science institutions which contain original fossils and these fossils may be useful to the teaching of evolution. As mentioned in section 1.5 in chapter one, the purpose of my study was to determine the extent to which a visit to an informal science institution can enhance teachers' understanding of evolution and hence I chose this centre. Furthermore, this institution is situated within the geographical area of my district and I think it can be accessible by all schools within the district including teachers who participated in my study.

3.5. Samples

In case study research, the sample may involve a single person, a group of people within a particular setting, a whole class, a department within a school or a school (Opie, 2004). Huysamen (1997) define sampling as the process of choosing a small group of individuals from a larger population. Fraenkel and Wallen (1993) defines sample as any group of objects that a researcher can use to obtain information. According to Miles and Huberman (1994), sampling in qualitative research involves a small sample of people housed in their context and studied in-depth. In other words, a small number of people will be chosen from a larger population and this small sample of people will be studied in a particular place chosen by the researcher. Sampling in qualitative research involves two actions which are (a) to set boundaries and (b) to create a frame which helps to uncover, confirm, or qualify the basic processes of the

research. This implies that the researcher must define the aspects of the study which is connected to the research questions. In my study, the focus was on Grade 11 and 12 Life Sciences teachers who attended evolution workshops at Maropeng Visitors Centre. I chose these groups because the Grade 12 teachers were already exposed to the topic of evolution in 2008. However, some of these teachers did not teach the topic due to their perceived lack of content knowledge. Meanwhile the Grade 11 teachers were expected to teach evolution in 2009 or in the near future since this topic has now been cascaded to Grade 10 and 11. Furthermore, the topic of evolution was new in South African curriculum as it was introduced in 2008. Almost all teachers who participated in my study have never been taught evolution in tertiary institutions since it was not included in the South African Education system. However, all teachers have attended a five day NCS training which was organised by the Department of Education. The purpose of the training was to unpack the new curriculum, provide teachers with new teaching techniques and content knowledge on the new topics. During the NCS training, the presenters who were trained school educators mentioned that they are not going to do the topic of evolution since they do not understand it.

As a subject advisor at Gauteng West District, I invited all the Grade 11 and 12 Life Sciences teachers to the workshops. However, almost all teachers who attended the workshops were from the township and rural schools. The detailed information about teachers and workshops will be discussed in section 3.5.1 and 3.5.2 respectively. The participants who attended those workshops were expected to answer questionnaires provided by the researcher and draw a personal meaning map (PMM) about the topic of evolution. More details about questionnaires and PMM will be discussed in section 3.6.

Welman and Kruger (1999) and White (2003) define population as the study object, events or individuals with similar characteristics which are exposed to a particular condition. According to Fraenkel and Wallen (1993) population is referred to as a larger group of objects to which the researcher hopes to apply the results. McMillan and Schumacher (2006) define population as a group of elements or cases that match to the specific criteria and utilised to generalise the results of the study. Amongst the

types of sampling, random sampling is seen as one of the attractive types of probability sampling because the entire population has an equal opportunity of being included in a sample (Huysamen, 1997; Welman and Kruger, 1999). In my study, the population of Grade 11 and 12 Life Sciences teachers from the 32 high schools in Gauteng West District in South Africa was used. In order to get hold of this population, workshops were organised. Only teachers who attended the workshops were used as the sample of my study and hence the convenience or incidental sampling was used. This sampling technique was chosen since it would be difficult to project the number of teachers who will attend the workshops because in most cases not all teachers do attend workshops. Fraenkel and Wallen (1993:87) define convenience or incidental sampling as a "group of individuals who are available for the study". However, using convenience sampling may limit the information and credibility of the study. Fraenkel and Wallen (1993) assert that the limitation of convenience sampling is that the sample cannot claim to be the representative of the whole population.

My study took place at Maropeng Visitor Centre. This centre is one of the informal institutions that focus mainly on evolution. Furthermore, it has reconstructed fossils and many original fossils evidence of organisms that featured from ape-like beings to the humans such as Mrs Ples. Mrs Ples is the popular nickname for the most complete skull of an *Australopithecus africanus* specimen which was found in South Africa (Sterkfontein). She was discovered by Dr Robert Broom and John T. Robinson in 1947. The name "Ples" was derived from the scientific designation *Plesiantropus transvaalensis* which means "near-man from the Transvaal". Furthermore, the exhibits that are found in the centre may be helpful in the teaching and learning of sciences. The participants of my study attended workshops at the centre. As mentioned earlier in this section, only teachers who attended the workshop and were willing to participate in the research were the sample of my study. There in no certainty whether my study can be generalised because my study is qualitative. Furthermore, the results may differ from one district or province to another. Bassey (1999) refers to this kind of generalisation as fuzzy generalisation. Fuzzy generalisation is perceived as prediction that arises from the empirical enquiry without any measurement of its probability. This means that the chance of data being

generalised is minimal or not guaranteed. This kind of generalisation is important in the research as it does not compromise the researchers' ethics of seeking the truth. The fuzzy generalisation suggests that there is no certainty that the results of the study conducted at Gauteng West District may be similar to the study conducted at another district or province.

3.5.1. Teachers

In my study, the Grade 11 Life Sciences teachers from 32 schools were invited to attend a workshop which was part of the teacher development [see Appendix C and G for the invitation letter used to invite teachers]. Only 22 Grade 11 teachers responded to the invitation since most of them were assisting Grade 12 teachers in preparing learners' portfolios (learners' portfolio of evidence) required by provincial department of education for provincial moderation.

Teachers who attended the workshop were from different secondary schools ranging from disadvantaged schools to average resourced schools. Average resourced schools are schools that are situated in better developed areas and have enough resources such as laboratory and some equipment that are used in Life Sciences. Such schools are partially dependent on the government because learners pay school fees which assist in running day to day functions of the school. The disadvantaged schools are schools that are situated on the farms, rural and townships surrounded by informal settlements. In most cases such schools do not have laboratories and equipment to be used in Life Sciences. Disadvantaged schools are fully dependent on the government since learners do not pay school fees. Even though I invited only Grade 11 teachers, I was approached by four Grade 12 teachers who mentioned that they did not teach the topic of evolution in 2008 since they did not understand it. These teachers also mentioned that they requested other teachers from neighbouring schools to teach evolution since they did not have content knowledge. I probed further to find out whether they have attended any workshop conducted by the department of education or other organisation. The indication was that they attended a workshop organised by the Department of Education and they claim that the content of evolution was not

covered. Therefore I allowed them to take part in the project as I felt that it would help me to find out the knowledge level of Grade 12 teachers in teaching the topic of evolution.

To ensure that more data was collected, the second workshop was organised (this will be discussed in full on section 3.5.2). In this workshop, Grade 12 Life Sciences teachers were invited. Just like in Grade 11 workshop, all Grade 12 Life Sciences teachers from 32 high schools at the district were invited but only 27 teachers responded. Among these 27 teachers, at least 15 of them have taught the topic of evolution and while 20 of them had attended a training session organised by the Department of Education. Almost all teachers were experienced in teaching Grade 12 in the old curriculum and they have been involved in marking the Grade 12 Life Sciences (previously known as Biology) scripts. The total sample of Grade 11 and 12 Life Sciences teachers who attended workshops on learning about evolution at Maropeng Visitors Centre was 49.

3.5.2. Intervention

The first workshop was convened by me since I was mentoring the newly appointed Life Sciences facilitator. This workshop was aimed at (a) discussing the importance of informal science institutions in teaching science and (b) unpacking the Grade 12 curriculum to Grade 11 teachers since most of them were going to be teaching the new curriculum of Grade 12 for the first time in 2009. In this new curriculum, topics such as evolution and biodiversity are new in the South African curriculum. Furthermore, the workshop was driven by the availability of science centres within our geographical area which may be of use to teachers and learners if they are used properly.

In the examination guideline for Grade 12 Life Sciences, several organisms which showed that evolution had occurred were listed. Table 2 listed below shows the fossils evidence of organisms that featured from ape-like beings to humans. These fossils evidence are found in informal science institutions such as museums. Therefore it is

essential to utilise the informal science institutions since they contain resources that may not be available in a school laboratory.

Table 2: Part of the Grade 12 Life Sciences examination guidelines for 2009 (Department of Education, 2009)

Content	Elaborations
Trends in human evolution	• Fossils evidence of organisms that featured from the ape-like beings to the humans: ▪ Ape-like beings ▪ First apes ▪ First bipedal primates ▪ *Australopithecines* (Mrs Ples, Taung child, Little foot, Lucy) ▪ *Homo habilis* (Handyman) ▪ *Homo erectus* ▪ *Homo sapiens* (modern humans, Florisbad man)

To ensure that teachers understand how informal institutions operate and how they can assist in the teaching and learning of evolution, the importance of informal institutions was presented by the researcher. Furthermore, the executive marketing manager of Maropeng Visitors Centre (a former Life Sciences teacher) explained the services they render in the centre. She took all teachers to the museum tour where she showed them the exhibit halls with models and original fossils. To ensure that teachers understand the link between school curriculum and the type of education provided by Maropeng Visitor Centre, the Grade 12 Life Sciences examiner unpacked the examination guideline linking it with the exhibits found in the museum. As it was mentioned earlier in section 3.5.1 that the participants did not have content knowledge about evolution, a presenter (examiner) explained some of the difficult topics of evolution which were raised by teachers during the Cluster Information Forum (CIF)[3].

[3] CIF is a forum where teachers in a district share good practices and raise difficult topics that need to be done in a workshop.

The second workshop was convened by the Life Sciences facilitator at my district. The aim of the workshop was to assist teachers in understanding the content of evolution as it was a problematic topic in NSC (National Senior Certificate) examination in 2008. Furthermore, Gauteng Department of Education has requested all Life Sciences facilitators to convene workshops that cover subject content since some of the topics are new in the South African curriculum. The workshop also took place at Maropeng Visitors Centre. The presenters of the workshop were (a) a centre educationist who is an expert on the content of the centre and was a Life Sciences teacher and (b) myself (the researcher) as invited by the subject facilitator to provide the content knowledge of evolution. The duration of both workshops was three hours (i.e. 90 minutes for presentations and another 90 minutes for touring in the centre which was led by the centre educationist). During this workshop, several topics of evolution were discussed. The table below shows some of the topics that were covered during the workshop.

Table 3: Content covered during the workshops of evolution

Content	Explanations
Charles Darwin	Darwin's theory of evolution proposed natural selection or survival of the fittest. Natural selection means better adapted individuals are likely to survive for longer periods and produce more offspring There are four key elements of natural selection: ▪ **Variation:** Individuals in a population are different. ▪ **Overpopulation:** The survival of individuals to maturity depends on their variety. ▪ **Struggle for existence:** Individuals compete for the same resources. ▪ **Differential reproductive success:** Longer survival means producing more offspring.
Jean Baptiste de Lamarck	Two laws or ideas of Lamarck: ▪ **Law of use and disuse:** This law explains that individuals lose characteristics they do not require

	and develop characteristics that are useful. ▪ **Law of inheritance of modified characteristics:** This law explains that individuals inherit the traits of their ancestors. One of the examples of Lamarckism is necks of Giraffes. According to this law, the necks of giraffes stretched in order to reach leaves on tall trees. Therefore, their offspring inherited the traits of long neck.
Evidence for evolution	▪ **Palaeontology:** This is the study of fossils and the fossil record. A fossil is any trace of the past life which has been preserved in stone. Fossils are formed from the remains of dead organisms ▪ **Comparative anatomy:** This is the study and comparison of anatomical structures in different species. Many organisms have similar structures (i.e. inherited from a common ancestor). For example, bones of organisms that are similar. ▪ **Comparative embryology:** This is the study and comparison of embryology. Organisms share similar developmental pathways. That is, the developmental stages of an embryo (ontogeny) reflect the phylogenetic or evolutionary history of the organism. ▪ **Biogeography:** This is the study of the geographical distribution of species. Closely related organisms are always found in close geographical proximity (1st line of thought). The same geographical environments support morphologically similar species (2nd line of thought).

The number of teachers who attended the second workshop was 30. Amongst those teachers who attended the workshop, there were three teachers who attended the previous workshop. Those teachers were asked not to complete questionnaires or if

they want to participate they must indicate on the questionnaire that they have participated during the first workshop. Their responses to the second workshop were not included in the data.

3.6. Instruments used to collect data

It is important to determine instruments that can be used to collect data. Data is referred to as information or facts that are gathered by the researcher to obtain answers to the research questions (LeCompte and Preissle, 1993). According to Fraenkel and Wallen (1990) data is referred to the kinds of information that researchers obtain from the subjects of their research. There are various data collection methods that can be used in educational research and amongst others they are; observation, interview, document analysis and questionnaires. In this study questionnaires and personal meaning mapping were used to collect data on the sample of teachers who attended workshops which were part of teacher development.

3.6.1. Questionnaires

Questionnaires are regarded as the most used technique for gathering data (McMillan and Schumacher (2006). Opie (2004) defines questionnaires as documents that are designed to ask same questions to all individuals of the selected samples. The questionnaire is known to be a quantitative data collection method since its data can be analysed by using numbers. However, not all questionnaires need to be analysed quantitatively. Open-ended questionnaires may be analysed qualitatively. I opted to use questionnaires because the questions used are standardised, economical and can be written for specific purposes and anonymity can be assured (McMillan and Schumacher, 2006; Opie, 2004). Questionnaires can use statements and/or questions and the statements or questions used are either open-ended or closed ended. In this study, both open-ended and closed ended questions and statements were used in the questionnaires. In close ended questionnaire, teachers were given an evolution quiz which contains erroneous ideas and misconceptions. The purpose of using a quiz was to check the knowledge level of participants about evolution. Using this type of

questionnaire would save time because teachers were expected to respond by ticking on the relevant box. In order to get more information about teachers' attitudes towards teaching evolution and how the visit will influence their knowledge about and attitudes towards teaching evolution; open-ended questions were used. These questions allowed teachers to explain their views about evolution and to describe the exhibits that they have seen during the tour which they think may influence their understanding of evolution. To design the best questionnaire, the researchers must list specific objectives that must be achieved and they must be guided by the research problems or research questions (White, 2003).

To ensure that a questionnaire which is attractive and easy to complete is designed, guidelines suggested by White (2003); McMillan and Schumacher (2006) and Opie (2004) were taken into consideration.

- The items used should be clear. Researchers must avoid using vague and ambiguous words.
- Researchers must not use questions containing two or more ideas (double-barrelled questions).
- Questions should be relevant.
- Researchers must use short, simple items.
- Negative items must not be used.

I chose to use the open-ended questions and statements because (a) they allow the respondent to answer adequately, (b) they can be used for complex issues and lastly (c) they provide the respondents with an opportunity of expressing their ideas freely (Opie, 2004). However, there are several drawbacks of using open-ended questions and/or statements and those disadvantages or drawbacks are as follows:

- The respondents need much more time to complete the questionnaire.
- It may lead to the collection of worthless and irrelevant information.
- Data is not standardised and it makes analysis more difficult.

Closed-ended statements with Likert scale responses were also used to collect data that was analysed quantitatively. These types of statements allow certain responses

and data analysis which can be carried out easily and effectively. The advantages of closed-ended statements or questions are as follows:

- Their answers are standardised and can be compared from one person to another.
- The answers are easier to code and analyse.
- The chances of irrelevant answers are limited
- Questions are clearer to the respondents.

3.6.2. Preparation of questionnaires

In order to improve the rigour of the research, intensive reading was done. Literature on how to design questionnaires was reviewed during the research methods course. As part of course work the researcher participated in group discussions on how to design good questionnaires. Apart from questionnaires reviewed during the research methods course, I also reviewed different questionnaires used by other Masters students. In designing my questionnaire, some of the statements and questions used in my Honours project questionnaire were included. My Honours study was about the effect of religious beliefs and misconceptions in the teaching of evolutionary theory. The questions and statements used were thoroughly checked considering guidelines or characteristics of a good questionnaire. The whole process on how questionnaires and personal meaning maps were designed and how they were administered is summarized in Figure 2.

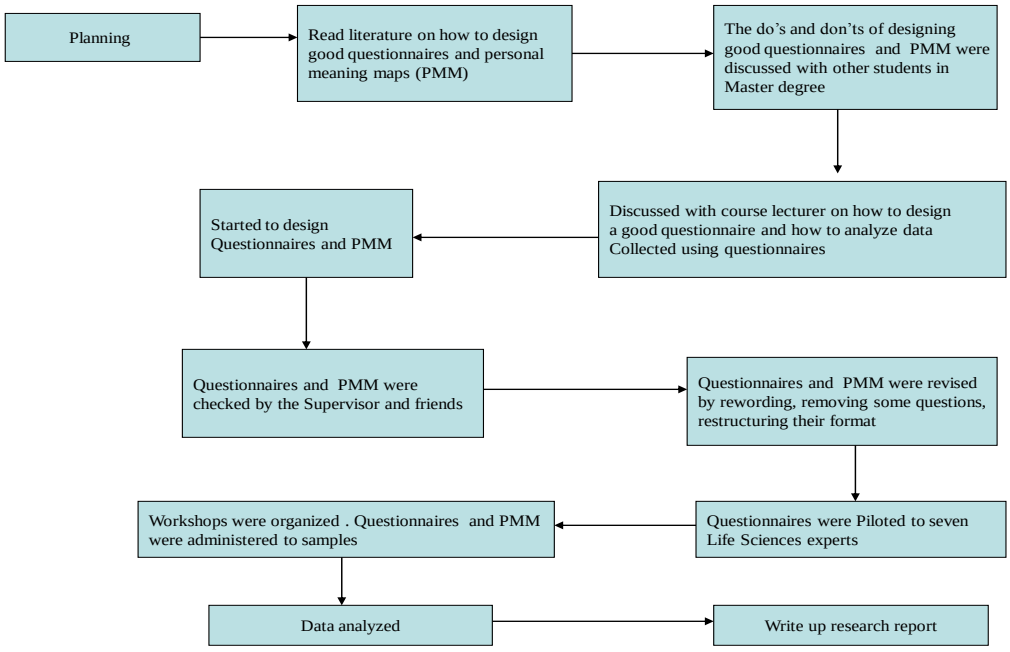

Figure 2: Diagrammatic representation on how the questionnaires were developed and used in this study

Questions and statements used were guided by common misconceptions, erroneous ideas or misinterpretations that people have about evolution. Since the data was collected at an informal science institution, a disk containing information about the centre was also used to design questionnaires. The questions such as "briefly explain how fossils are formed and briefly explain genetic drift" were taken from the disk provided by the centre. Questionnaires were designed to check (a) the attitudes of teachers towards teaching the topic of evolution, (b) the knowledge level of teachers about evolution and (c) the aspects of the centre which may assist in teaching evolution (see section 3.1 for research questions).

3.6.3. Piloting the questionnaires

Various researchers have recommended that research instruments should be piloted before administering them in the main study (White, 2003; Welman and Kruger, 1999; Huysamen, 1997; McMillan and Schumacher, 2006). In this study questionnaires were piloted by seven Life Sciences experts. This includes two Life

Sciences experts from university and five Grade 12 Life Sciences teachers who are Senior and Chief Marker. The purpose of piloting my research instruments was:

- To detect possible flaws in the instruments. This includes ambiguous instructions, inadequate time limits and so on.
- To identify unclear or ambiguously formulated items.
- To notice any non-verbal behaviour such as wrongly worded question or statement.
- To check content validity of the instrument.

The participants were asked to indicate any questions or statements they think will be difficult to answer and any vague statements. I visited participants at their schools during free time. Questionnaires were answered in my presence whilst I was checking the time spent to answer the questionnaires. Any flaws identified by the participants were altered. For example, some questions or statements were rephrased to avoid ambiguity (refer to appendix A: 129). Furthermore, the instrument I used was also reduced to ten questions or statements. One of the Life Sciences specialists at the district suggested that I need to change the format of "what is meant by fossils". According to him, such question may not allow teachers to expand their knowledge about fossils. Therefore I decided to change the format into "briefly explain how fossils are formed" because this kind of question will allow teachers to elaborate more about fossil formation. Furthermore, almost all participants of pilot study were not comfortable about the question of genetic drift. They mentioned that this question will need enough time to answer and it will be difficult for most teachers. After consultation with my supervisor, this question was dropped and replaced by the statement "evolution explains the origin of life" (refer to appendix A: 129). Just like the statement "human evolved from apes"; the statement about the origin of life poses many questions amongst religious people and hence the statement was included (refer to appendix A: 129).

3.6.4. Administration of the questionnaires

The questionnaires were administered by the researcher to all 49 teachers who attended two workshops organised by the researcher and the district (Department of Education). Before I provided participants with questionnaires, I introduced myself as a researcher, explained the purpose of the study and how the data will be used. Participants were also told that their participation in the study was voluntary. Participants were given an information sheet before they went to the tour (refer to appendix E: 159 and F: 160 for information sheet and consent form). Even though the instructions were written on the questionnaires, I explained them to the participants.

Before the presentations started, teachers were asked to complete the pre-visit questionnaire which covered their knowledge about evolution and their attitudes towards teaching it (refer to appendix A: 129). Immediately after the workshop, teachers were taken for a tour which was led by the executive marketing manager of the centre. After the tour, the participants were also asked to complete the post-visit questionnaire which was identical to the one given before the workshop commence but with an addition of two questions focused on the settings of the tour (refer to appendix A: 129). I again explained the importance and the purpose of completing the second questionnaire. The questionnaire was completed under the supervision of the researcher and the subject facilitator who assisted in distributing handouts. Participants were only given handouts on evolution after they have completed all questionnaires to avoid any referrals. This repeat of data collection was done immediately after the tour in order to prevent any influence from external factors such as magazines, TV, radio, pamphlets and handouts provided at the workshop.

3.6.5. Personal meaning mapping

The second instrument that was used to collect data was personal meaning mapping (PMM). This technique is known to be an appropriate method for museum learning as it is based on a relativist-constructivist approach and because of its relationship to creative learning (Caban and Wilson, 2004; Falk, Moussouri and Coulson, 1998; Falk,

2003). Falk *et al.* (1998) affirmed that there is an assumption that each individual brings different prior knowledge and experiences into the learning situation. The combination of individual's prior knowledge and new knowledge reshapes individual's mental structure and this is known as learning (Falk, 2003). Since each individual brings different prior experiences and knowledge in the learning situation, this implies that each individual processes his or her experiences uniquely.

During PMM an individual's knowledge and views about a particular theme or ideas is investigated before and after the visit. Visitors are asked to write down on the blank piece of paper any ideas related to a key word or phrase provided (Tunnicliffe and Moussouri, undated). This will provide visitors with an opportunity of articulating and explaining their perceptions and understandings of the phrase or key word in their own words. Falk *et al*. (1998:109) and Adelman, Falk and James (2000:39) affirmed that PMM is designed to measure how an educational experience "affects each individual's personal conceptual, attitudinal and emotional understanding". Lelliott (2009) mentioned four ways in which personal meaning mapping is conducted and that is:

1. **Prior to the museum visit (pre-visit):** a visitor is given a blank piece of paper in which a word or phrase is written in the centre. Each visitor is asked to write down anything which is related to the key word or phrase provided.
2. **A short interview prior to the visit:** the investigator held a short interview with each individual in order to investigate the ideas he or she has already written on the paper. The investigator will record any elaboration of ideas made using different colour ink from the original.
3. **After the museum visit (post-visit):** each individual is given his or her original paper and asked to make any alterations if they are any, either by adding or deleting what was written during pre-visit. The alterations may be done by using another colour of ink.
4. **A short interview after the visit:** the investigator conducts another interview with each participant. The focus of this interview is based on the alterations made. The investigator records what was said in verbatim using different colours.

In my study, participants were given a blank piece of paper which was written "evolution" in the centre. Each participant was asked to write down any ideas which are linked to evolution. The time allocated to this task was ten minutes. After completion all personal meaning maps were collected. In order to differentiate PMMs, participants were given unique numbers which were written on the top corner of the paper. After the tour which was coordinated by tour guides, all participants were given their original PMMs and asked to make any changes or additions to what was written during pre-visit. All PMMs were collected immediately after completion. Due to time constraints, short interviews were not carried out since participants were expected to complete two instruments (questionnaire and PMM) in one workshop. This implies that the researcher cannot verify the information provided by the respondents. Furthermore, the researcher could not probe further in order to get additional information that the respondents could not write on the personal meaning maps.

3.7. Validity and reliability

Validity is referred to as the degree to which the method, a test or research tool measures what is suppose to measure (Scaife, 2004; McMillan and Schumacher, 2006; Iraj, 2008). Fraenkel & Wallen (1990) refer to validity as correctness and the meaningfulness of deductions made from the collected data. This is also known as the relationship between a claim and the result of the data-gathering process. To ensure that the data is valid, my instrument was content validated by Life Sciences experts who looked at whether the content and language used in questions was appropriate, the sequence of questions was logical and whether the instrument offered relevant data that answered research questions (Sanders and Mokuku, 1994).

To ensure that the instrument measures what it is supposed to measure, the questionnaires were reviewed by Life Sciences experts and this is known as face validity. Face validity is referred to whether knowledgeable or expert judges agree that the items in the instrument appear to measure what it is supposed to measure (Kennedy, Homant and Barnes, 2008; Iraj, 2008). This implies that the experts will

provide an opinion as to whether or not the items in the questionnaires will be appropriate to the study. In my study some questions such as "What is genetic drift" were withdrawn because almost all experts thought that such questions may be difficult to teachers. Furthermore, one of the science experts suggested that the question such as "evolution explains the origin of life" should be included. The purpose of including this question was to check whether the participants would identify the difference between evolution and the origin of life. All these changes were effected before questionnaires were administered.

Scaife (2004:65) perceives reliability as a useful "indicator of goodness or quality in research". According to Fraenkel & Wallen (1990) and McMillan & Schumacher (2006), reliability is defined as a consistency and repeatability of the research findings. This implies that the same research instrument may be administered many times by different people in various situation and provide more or less same results (Miles and Huberman, 1994; Bergh and Theron, 2003). To increase the reliability of my research instruments, some of the open-ended and closed-ended questions were phrased differently but requested more or less the same answer. For example, question 3 in evolution quiz needed the same answer as question D (refer to appendix A: 129) and the questions were asked differently.

In my study several measures were taken to improve the validity of the research results and research rigour.

- The research questionnaires were content validated by experts before administered as discussed above.
- The same questionnaires were given to the same participants before and after the workshop.
- The coding of responses from both open-ended and closed-ended questionnaires was validated by my supervisor. In order to generate coding system from the data, an intensive reading was done and data was grouped according to similarity.

3.8. Ethical issues

Ethics is important in educational research since it involves people. This is an application principle that can be used to prevent harming the population where the research will be carried out (Opie, 2004). To ensure that the teaching process is not negatively affected, application forms were sent to the Gauteng Department of Education for permission for teachers to participate in my study. Furthermore, the ethics application forms were sent to the Human Research Ethics Committee at the University of the Witwatersrand. Before I continued with my study, I waited for the letters of approval from the university Ethics Committee and Department of Education. I gave the District Director a letter of acceptance to conduct research. Furthermore, letters were written to the principals of all high schools to request the release of teachers who wanted to participate in the research project (see appendix C: 157). All teachers who agreed to participate in the study where given informed consent form and information sheet. Before I took teachers to Maropeng Visitors Centre, a letter of request for permission to visit the centre for research purpose was sent (see appendix D: 158). All participants were assured of confidentiality, anonymity and their right to withdraw from participating.

3.9. Conclusion

In this chapter the research design, methods, sampling and research instrument that were used in my study have been discussed. The issues of reliability and validity were also discussed. The chapter has also justified the design choices made and steps taken to improve the quality of the research. In the next chapter, the analysis of the data collected will be thoroughly explained and discussed.

Chapter 4

Data analysis and interpretation of the findings

4.1. Introduction

This chapter presents the results and the discussion of the data generated from the questionnaires and personal meaning mapping (PMM). As mentioned in chapter three, the participants of my study were Grade 11 and 12 Life Sciences teachers in Gauteng West District. Those teachers were given questionnaires which were completed before and after the tour. In addition, the Grade 12 teachers were asked to complete a personal meaning map. This tool was given to Grade 12 teachers only because they taught new curriculum in 2008. The purpose of evaluating Grade 12 teachers with a PMM was to find out about their content knowledge level on the topic of evolution.

4.2. Biographical data of the participants

The biographical data of the Grade 11 and 12 Life Sciences teachers who participated in my study will be explained in this section. This is done in order to provide a clearer picture of their responses. For the purpose of anonymity each participant was given a code that served as a reference throughout the study. The codes were alphanumerical. The letter differentiates the grade from which the questionnaires and PMM were administered. The number represents the name of the teachers who completed the questionnaire and PMM. For example, the first group which comprised of Grade 11 Life Sciences teachers were coded A1, A2 and so on. The second group comprising of Grade 12 Life Sciences teachers were coded B1, B2 and so on. The PMM was coded B001, B002 and so on.

Of the 49 participants, 22 were Grade 11 Life Sciences teachers and 27 were Grade 12 Life Sciences teachers. No participants had studied the topic of evolution in tertiary institutions. However, 46 participants attended the National Curriculum Statement (NCS) training on evolution which was organised by the Department of Education in

2005 and 2006 respectively. The department has organized this training in order to provide teachers with the content knowledge of the Life Sciences especially the new topics. Furthermore, teachers were also taught how to teach the subject covering the learning outcomes outlined in the policy document. Teachers were also encouraged to use a variety of teaching strategies that will allow learners to construct their knowledge. To ensure that learners construct new knowledge, teaching should incorporate learners' existing knowledge as it serves as a baseline to learn new knowledge. Teachers were also encouraged to use other resources available in society and this included using informal institutions such as museums, science centres and so on.

4.2.1. Grade 11 Life Sciences teachers (Group A)

All participants in group A were qualified Life Sciences teachers. In this study qualifications of the participants were not asked for because they are not important for the purpose of the study. As mentioned in the previous chapter all teachers attended the training conducted by the Department of Education in 2005 and 2006. As the researcher was one of the attendees of the training which was held in 2005, it can be confirmed that evolution as a topic was not done because the trainers mentioned that they did not have sufficient content knowledge on evolution. Almost no teachers were teaching Grade 12 in 2008 except two teachers who were teaching both Grade 11 and 12. These two teachers were allowed to participate as they neither taught nor knew evolution.

4.2.2. Grade 12 Life Sciences teachers (Group B)

Similar to Grade 11 (group A) teachers, all group B teachers attended training organised by the Department of Education. The participants in group B taught Grade 12 in 2008 and they were still teaching the same grade in 2009. However, not all teachers who attended the workshop had taught "evolution" as a topic in 2008. Through informal discussion it was found that evolution was merely taught because it

was part of the curriculum. To ensure that this topic was covered, some teachers mentioned that they read the book to learners whilst others gave them handouts.
The Grade 12 Life Sciences workshop was attended by 31 teachers (see section 3.5.1 in chapter 3). However, the actual number of teachers who participated in the study was 27. Four teachers were excluded from participating because two of them had already participated during the Grade 11 workshop whilst the other two were teaching Physical Sciences in 2008. Furthermore they were not allowed to participate because they already participated in 2008. However, they were allowed to complete questionnaires and a PMM but their data was not analysed. Before analysing data collected from Grade 11 and 12 Life Sciences teachers, it is important to explain how the data would be analysed. The explanation of data analysis is given below.

4.3. Data Analysis

Data analysis is referred to as the systematic way of searching meaning in the collected data (Hatch, 2002). The purpose of data analysis is to reduce and organize all the data collected. The researcher organizes and analyses the data and this can be done by identifying, naming patterns and categorising the data (Hatch, 2002). Analysis of the data is solely dependent on the type of data collected.

In this study data was analysed qualitatively and quantitatively (mixed-methods). McMillan and Schumacher (2006) mention that many researchers use mixed-methods since they are an appropriate approach to answering research questions. They also perceive the mixed-method as an approach that allows researchers to incorporate the strengths of each method. By using this approach, researchers can get a more comprehensive picture of what is studied.

4.3.1. Closed-ended items

The closed-ended items were analysed quantitatively in that frequency counts were used and expressed in percentages. Numbers and graphs were used to explain the knowledge level of teachers about evolution. I have decided to use this method since

it is relatively straightforward and quick (Opie, 2004). Opie affirmed that data analysed quantitatively may provide "objectivity and an acceptable degree of reliability validity" (p151). However, Opie also acknowledges that this type of data analysis may not be used to generalise the results of the study because the sample used was small.

4.3.2. Open-ended items

The open-ended items were analysed qualitatively since they produce descriptive data (Hatch, 2002). Furthermore, qualitative data analysis is known to be an approach which can provide insight on why the findings of the research are as they are (Opie, 2004). To analyse this data, categories and patterns were identified using questions and statements used in the questionnaires as a starting point. The responses per questionnaire were clustered according to similarity. To ensure that the categories used were valid, they were referred to the supervisor in order to determine whether the categories formed cover all the ideas of the questionnaire. Figure 3 below represents a summary on how data collected was analysed.

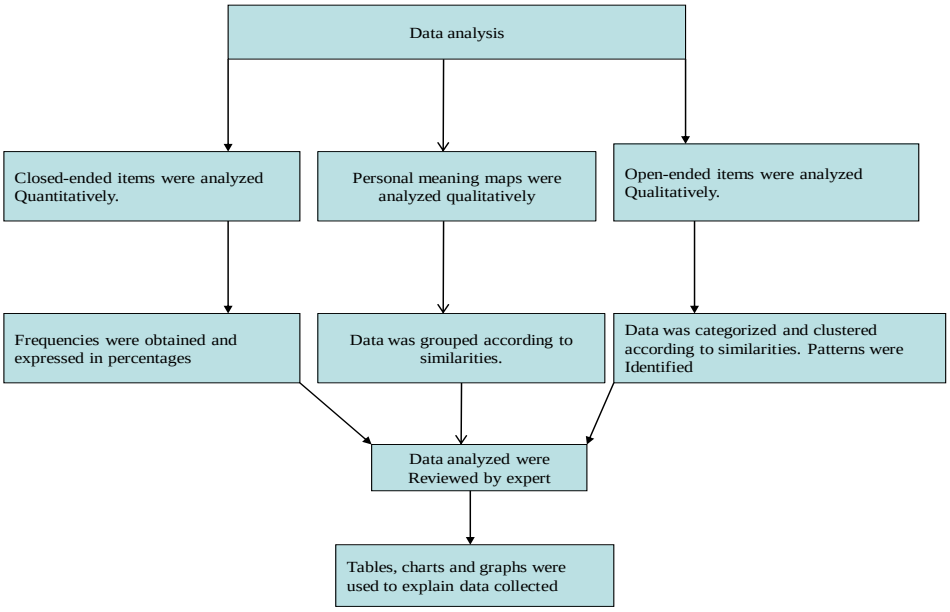

Figure 3: Diagrammatic representation on how data collected was analyzed

4.4. Research findings

As mentioned in section 4.1, the purpose of this chapter is to analyse the findings according to the responses received from Grade 11 and 12 Life Sciences teachers. These teachers were requested to complete questionnaires before and after the visit. All 22 Grade 11 and 27 Grade 12 Life Sciences teachers participated in the research completed the whole questionnaire within the stipulated time. In addition, the Grade 12 teachers were also asked to complete a personal meaning map. Both questionnaires and the PMM were collected immediately after completion. All questionnaires and PMMs were coded as part of the analysis. The data below was analysed per question comparing the pre-visit and post-visit. The analysis of the personal meaning maps will be discussed in section 5 after questionnaires.

4.4.1. Analysis of questionnaires

The data of both pre-visit and post-visit questionnaires were captured in an Excel spreadsheet. This was beneficial since it made it easy to compare the pre-visit and post-visit of each participant. Furthermore, it was also useful in that I was able to compare the data given by all participants. The questionnaires of the Grade 11 and 12 Life Sciences teachers were analysed separately. However, the categories used in both Grades were the same.

The pre-visit questionnaire contained eight items whilst the post visit questionnaire contained ten items (Appendix A: 129). The questions used were divided into three groups and that is (a) the first group consisted of questions that were designed to check the knowledge level of teachers about evolution (question A, B, C, D, E, H), (b) the second group consisted of questions that were designed to check the attitudes of teachers towards teaching evolution (question F, G) and (c) lastly, the questions that were designed to check whether teachers would be able to identify any exhibits displayed and be able to link them with the content of evolution (question I and J). The coding sheet of both Grade 11 and 12 Life Sciences teachers can be found in Appendix B (p134).

- **First question: What does the word "evolution" in Life Sciences mean?**

For the effective teaching and learning to take place it is important to know the definition of evolution and hence it was included in my study. Raven *et al*. (2008) define evolution as follows:

- It is a change in the frequency of traits in a population over successive generations,
- Individuals in a population exhibit a variety of traits which may be advantageous to the individuals; and
- Individuals produce offspring and pass their traits on to a greater number of individuals in the next generation.

In this study the above mentioned definition is accepted as the correct definition. If a participant gave all aspects of the above mentioned definition, such participant was grouped under scientifically correct category.

In order to manage the completion of the questionnaire effectively, the first question was read to participants and they were asked to write any definition of evolution as it came to their minds. The definitions provided during pre- and post-visits were analysed. The results of the analysis were put together in Table 4a shown below.

Table 4a: Results of Grade 11 teachers who provided the definition of evolution (n=22).

		Pre-visit		Post visit	
Categories	Explanation	n	%	n	%
Scientifically correct	Included all three or two criteria	2	9	3	14
Partially correct	General definition of evolution was provided with one clear criterion.	11	50	10	45
Has no idea	None of the criteria was mentioned.	9	41	9	41

The above table shows that only 9% of Grade 11 Life Sciences teachers who completed the pre-visit questionnaire provided the scientifically correct definition of evolution. However, the explanations provided were incomplete as they included two of the three bullets (the suggested correct definition) mentioned above. After the museum tour (post-visit), only 14% of Grade 11 teachers got the explanation correct. The data revealed that after the tour there was a slight increase of teachers who gave the correct definition of evolution. The results also showed that during the pre-visit, 50% of the participants gave the general explanation of evolution. These percentages decreased to 45% after the museum tour and presentations. It is thought that it is unlikely for the participants who were completing the questionnaire to give the complete definition of evolution on a questionnaire since it should be completed in a limited time. In consultation with my supervisor, I decided to combine the number of participants who provided the scientifically correct definition with partially correct definition.

The results showed that there was no change between pre- and post-visits as they both recorded 59%. This indicated that at least more than 50% of Grade 11 Life Sciences teachers knew how to define evolution. However, the results also showed that 41% of Grade 11 Life Sciences teachers who completed pre- and post-visit did not have an idea of "what evolution was" because the definitions given were either off track or did not even attempt to write the definition. The extracts below show the teachers' responses on the definition of evolution.

> A16: During pre-visit he explained "evolution as the origin of life where different organisms evolved or transformation". During post visit he/she explained "evolution as the change in structure of different organisms in order to adapt to the environmental changes".
>
> A14: During pre-visit, evolution was explained "as a traceable change in form or structure of the biotic factors as a way or act to perform a particular function or to adapt to a given situation". During post visit he/she explained evolution "as the change in form of structure of organisms as a way to adapt to environmental conditions".

Both A16 and A14 seemed to have the idea that evolution has got something to do with the change of organisms. While this is true, A16 seems to have the misconception of evolution as the origin of life. The origin of life will be explained later in this chapter. After the presentations and museum tour, the definitions of both participants were better although they were still incorrect. The extracts above showed that both participants failed to identify that "genes or traits" play a vital role in evolution.

Table 4b shows the results of the 27 Grade 12 Life Sciences teachers participated in the study. As mentioned earlier these teachers had taught Grade 12 Life Sciences new curriculum in 2008, although discussion with teachers indicated approximately 15 teachers had not taught evolution because they were not sure about the content of evolution. They also mentioned that they had asked some teachers from other schools to come and teach their learners. The twelve teachers who claimed that they had taught did not cover all sections of evolution because they mentioned that in some sections they had given learners some handouts without or with little explanation. The person who assisted in teaching evolution in most schools was the chief marker who was one on the presenters in the Grade 11 Life Sciences teachers' workshops that was held in 2008 at Maropeng Visitors Centre.

The Grade 12 group was given the same questionnaire that was given to Grade 11 Life Sciences teachers. In this question, none of the Grade 12 Life Sciences teachers who completed the pre-visit and post-visit questionnaire gave the scientifically correct definition of evolution. However, during pre-visit 7% of teachers gave a partially correct definition of evolution. This percentage increased to 33% after the presentations and museum tour. The results in the table below showed that there were considerable changes in Grade 12 compared to the Grade 11 Life Sciences teachers were the percentage remained constant even after the museum tour. This change suggests that both presentations and the museum tour had an effect on the knowledge gained by the Grade 12 Life Sciences teachers.

Table 4b: Results of Grade 12 teachers who provided the definition of evolution (n=27).

		Pre-visit		Post visit	
Categories	Explanation	n	%	n	%
Scientifically correct	Included all three criteria	**0**	**0**	**0**	**0**
Partially correct	General definition of evolution was provided with one clear criterion.	**2**	**7**	**9**	**33**
Has no idea	None of the criteria was mentioned.	**25**	**93**	**18**	**67**

The table above also reveals that 93% of the participants who completed the pre-visit questionnaire had no idea about the topic of evolution. After the participants were taken through the presentations and the museum tour, the number decreased to 67%. This was a considerable change when compared to the results of Grade 11 teachers where the results remained constant during pre- and post-visit. However, the study showed that there were still a large number of teachers (67%) who did not give the correct definition of evolution. The extract below shows some of the definitions provided by the Grade 12 Life Sciences teachers after the tour and presentation.

> B3: "Evolution explains the origin of life change in the genotype in a population".
>
> B4: "Evolution traces the developmental that have led to the present man starting from a primitive ancestor".

As in the extract of Grade 11 Life Sciences teachers above, B3 also seem to relate the origin of life with evolution. However, she brought the word "change in the genotype in a population". This statement indicates that B3 knows that during evolution the population does change. B4 mentioned the word "developmental" which was not clear. However, he seemed to have the knowledge that there is a connection between evolution and ancestor even though his definition was not clear.

The results of the first question in both Grade 11 and 12 Life Sciences teachers have revealed the following observations:

- Firstly, many teachers associated "evolution with the origin of life" and this is a misconception because it is inconsistent with the accepted conception and it may impede learning (Abimbola, 1988; Smith, diSessa and Roschelle, 1993). The accepted conception of the definition of evolution as stated above is the change in the frequency of traits in a population over successive generation.
- Secondly, a large percentage of Grade 11 Life Sciences teachers showed to have a better understanding of "what is evolution" irrespective of not being exposed to the topic of evolution before. The results of these teachers did not change even after the museum tour and presentations. It is anticipated that such teachers might have had an advanced knowledge acquired either by watching TV, interacting with friends or members of the community, or by visiting museums and heritage sites (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003).
- Lastly, there was some knowledge gain of Grade 12 teachers after the presentations and museum tour. The presentation made during the Grade 12 workshop was more subjects specific. Some of the topics of evolution such as natural selection, the formation of fossils and so on were covered. Therefore, it is anticipated that both the presentation and the museum tour had an impact on the knowledge gained because teachers were exposed to different models, objects and text (Chin, 2004; Tal *et al.*, 2005). Research has shown that knowledge can be produced when people interact with physical world using their minds, bodies, materials and symbolic tools available (Scott, Asoko, Driver and Emberton, 1994; Hausfather, 2001)

- **Second question: Do you agree with the following statement?** Evolution explains the origin of life. **Tick on the relevant box and give a reason for your answer.**

The concept of the origin of life has been controversial in the United States communities of Louisiana, Washington and Tennessee due to their different religious beliefs. As in other countries, South Africa has a community with different religious beliefs. There are different explanations of the word "the origin of life". This statement was included in order to find out whether the participants would agree with it. The statement given above is wrong because evolution is described as the change in the frequency of genes in a population over successive generation. The correct statement of the origin of life is explained by Raven *et al.* (2008) as:

- Cell is the basic unit of life and all cells come from preexisting cells.
- Life began when organic molecules assembled in a coordinated manner within a cell membrane and began to reproduce.
- Evolution of cells required early organic molecules to assemble into a functional interdependent unit.
- Life originated from early waters where meteors and cosmic dust may have carried significant amounts of complex organic molecules and gases such as hydrogen, oxygen, carbon dioxide, proteins, nucleic acids, carbohydrates and lipids to form earth

The participants who have a good understanding of evolution will disagree with question two and provide one of the above mentioned statements. Table 5a shows the results of Grade 11 Life Sciences teachers who participated in my study. The participants were expected to agree or disagree with the statement and provide the reason. The results of table 5a showed that only 41% of Grade 11 teachers disagreed with the statement but gave reasons which were incorrect. The reasons that were given were related to religious beliefs and reproduction. According to them everything in the universe is created by God. For example:

A1 said: "I believe in the creation of life by higher being (God)".

A3 mentioned that: “because according to the bible everything originated through the word”.

After the presentations and the museum tour, 14% gave the correct scientific reasons. However, there was one teacher who still maintained her religious belief. The results also showed that 55% of Grade 11 teachers agreed that evolution explains the origin of life. The number increased to 82% during post-visit. This data shows that during post visit some of the participant who disagreed with the statement chose to agree with it. The participants seemed to be confused by this statement because it may be difficult for a person who does not have content knowledge of evolution to differentiate evolution and the origin of life. This was evidenced by one person who chose both agree and disagree.

Table 5a: Results of Grade 11 teachers’ responses about evolution and origin of life (n=22)

			Pre-visit		Post visit	
Response	Categories	Reasons	n	%	n	%
Disagree	Completely correct reason	Reasons given included any of the four aspects listed above.	0	0	3	14
	Completely incorrect	Reasons given did not make sense. The reasons given were related to religious beliefs.	9	41	1	4
Agree	Incorrect	Reasons given were related to the origin of life.	12	55	18	82
Both disagree & agree		Reasons given were not clear.	1	4	0	0

The 27 Grade 12 Life Sciences teachers who participated in my study were given the same question before and after the visit. Table 5b below shows the results of the Grade 12 teachers who completed the pre- and post-visit questionnaire. The data revealed that only 18% of the participants disagreed with the statement and the

reasons given were incorrect. The reasons given were similar to the Grade 11 teachers because the explanation provided was related to their religious beliefs. After the museum tour and the presentation, at least one teacher gave the scientifically correct answer. However, there was a slightly change of participants who gave the incorrect answers as it decreased to 15%. The results also revealed that 67% of teachers agreed with the statement. The percentage increased to 81% after the visit. Furthermore they were three teachers who did not answer question two and there was also one teacher who answered both agree and disagree. After the visit, all four teachers agreed with the statement. The results in both Grade 11 and 12 Life Sciences teachers revealed that they were confused and hence more than 80% agreed with the wrong statement.

Table 5b: Results of Grade 12 teachers' responses about evolution and origin of life (n=27)

			Pre-visit		Post visit	
Response	Categories	Reasons	n	%	n	%
Disagree	Completely correct reason	Reasons given included all three aspects.	0	0	1	4
	Completely incorrect	Reasons given did not make sense. The reasons given related to religious beliefs.	5	18	4	15
Agree	Incorrect	Reasons given related the origin of life with evolution.	18	67	22	81
No answer		No answer was provided	3	11	0	0
Both disagree & agree		Reasons given were not clear.	1	4	0	0

Despite the teachers being confused the following observations were noted. Both Grade 11 and 12 Life Sciences teachers have strong religious beliefs about the origin of life. Some of the Grade 12 participants did not answer this question. After the museum tour and presentations a large number of participants agreed with the wrong

statement. This implies that the visit did not change the misconception that many people have about the origin of life. This misconception seems to have interfered with learning. Smith *et al.* (1993) have affirmed that sometimes people may hold on their mistaken ideas even after receiving instructions designed to dislodge them. The fact that some of the participants who did not answer the question during pre-visit chose to agree with the statement made me realise that their pre-existing ideas might have caused them to misperceive the demonstration made by the museum and the presenters. It is assumed that the participants did not demonstrate knowledge of the subject matter because the misconception held is strong and it is resistant to change.

- **Third question: If one of your learners asks the following question,** if a person lost an eye during an accident, why would he or she not produce a child with one eye? **How would you answer him or her?**

There are several key aspects of genetics that can explain the acquired characteristics such as lost of body organ and the development of muscles. In this study three key aspects of genetics have been chosen. The aspects mentioned below are the scientifically accepted answers for the above mentioned question.

- Human beings are born with two eyes and losing an eye is an acquired characteristic.
- Acquired characteristics are not genetically inclined.
- Therefore such acquired characteristics cannot be inherited by the offspring.

The above mentioned question is related to the topic of genetics. According to the definition of evolution given earlier in this chapter, genes play a vital role in evolution. However, not everything in genetics can explain evolution. Table 6a shows the summary of Grade 11 Life Sciences teachers' responses about the genetics related question. The participants were expected to provide the reason why the parent with one eye will not produce an offspring with one eye. The participants were given this question before and after the museum tour and presentations. In order to respond to this question, the participants were expected to give at least one of the above scientifically accepted answers because it may be difficult to provide all accepted answers when completing a questionnaire. The results in table 6a indicate that 59% of Grade 11 Life Sciences teachers who completed the pre-visit questionnaire gave the

scientifically correct answers. These results increased slightly to 64% after the museum tour and presentations. However, none of these teachers indicated that a child could not inherit one eye since it is an acquired characteristics, therefore it can't be inherited.

Table 6a: Results of Grade 11 teachers' responses about genetics related question (n=22)

		Pre-visit		Post visit	
Categories	Reasons	n	%	n	%
Scientifically correct answer	Provided answers which included at least one of the three answers.	13	59	14	64
Scientifically incorrect answer	Provided answers which are not related to genetics	8	36	8	36
	No answer was given	1	5	0	0

The extracts below showed some of the responses of teachers who did not provide the scientifically acceptable answer.

> A9 explained that "The new born baby won't have one eye because the baby is made of the combination of a sperm cell and an egg which will undergo different steps of growth until the child is visible". This argument was the same even after the presentations and the museum tour.
>
> A14 mentioned that "It takes time (or long period) to evolve a structure. Alleles develop first. Evolutionary structures develop as a way of an organism to adapt, which spread from parent to offspring over decades of development". After the tour and presentation, she stated that "the lost of an eye is not related to evolutionary change".

The explanation of the first extract (A9) was based on the topic of reproduction and nothing was said about genetics. In extract A14, the respondent mixed the concept of evolution and genetics. However, the explanation given was completely off track as the respondent said nothing about the accepted explanations mentioned above. During pre- and post-visits, 36% of teachers respectively gave the scientifically

correct answer. This implies that the participants did not gain any knowledge after the museum tour and presentation. It is important to mention that the topic of genetics was not covered by presentations. Furthermore, the tour guides did not explain anything about the model of DNA displayed in the museum. Teachers interacted with the model alone and then moved to other exhibits. The data also showed that one participant did not answer this question during pre-visit and she then gave the correct answer during the completion of the post-visit questionnaire. The overall data recorded by the Grade 11 Life Sciences teachers were very similar during pre- and post-visits.

Table 6b: Results of Grade 12 teachers' responses about genetics related question (n=27)

		Pre-visit		Post visit	
Categories	Reasons	n	%	n	%
Scientifically correct answer	Provided answers which included all the aspects.	23	85	23	85
Scientifically incorrect answer	Provided answers which are not related to genetics	4	15	3	11
	No answer was given	0	0	1	4

Table 6b above shows the results of Grade 12 Life Sciences teachers who attended the workshop at Maropeng Visitors Centre. Before the presentation, teachers were requested to complete the pre-visit questionnaire and the statement mentioned above was one of the questions. The data in this table showed that 85% of teachers in both pre-visit and post-visit respectively provided the correct answers on the above question which is related to genetics. Almost all participants mentioned that an eye loss by parents will not be passed to the offspring since it is not a genetic make-up. The data also revealed that none of the Grade 12 teachers provided all three accepted answers as stipulated earlier in this question. This implies that the data recorded in this group did not change. During the pre-visit, there were 15% of participants who gave the incorrect explanation. This percentage decreased to 11% after the museum

tour and presentations. The decrease occurred due to one teacher who did not answer the question.

The data in this question did not show any drastic change. These results may be caused by lack of explanation by both the presenters and tour guides. Furthermore, nothing was written on the display. However, the data revealed that more than 60% of teachers in both groups attempted to give the correct explanation of this question. This implies that both groups of teachers had a good knowledge of the subject matter on this respect of the topic of genetics before the field trip.

- **Fourth question: Do you agree with the following statement?** Organisms existing today are the result of evolutionary processes that have occurred over millions of years. **Tick on the relevant box and give a reason for your answer.**

The statement mentioned above is one of the common misconceptions that are found in the topic of evolution. This statement was taken from the questionnaire that was used in Ohio (Cleveland plain dealer, 2002). The purpose of asking this question was to check the knowledge level of Life Sciences teachers about evolution. Both Grade 11 and 12 teachers were expected to answer this question. The participants are expected to either agree or disagree with the statement and then substantiate their answer. The correct explanation of the above statement as explained by Raven *et al.* (2008) is as follows:

- Not all organisms existing today are the results of evolutionary processes.
- Evolution explains diversity that occurs due to the results of natural selection.
- Individual organisms do not evolve but populations evolve due to genetic variations.

Since this question is a bit challenging to people who do not have the content knowledge of evolution, participants are expected to give at least one of the three explanations given above. However, the participants may seem to be confused by the statement since it is not specific. Some people may argue that some organisms existing today are the result of evolution. This question was asked in order to find out

whether the participants would know that individual organisms do not evolve but populations evolve. Table 7a shows the summary of the Grade 11 Life Sciences teachers' responses about organisms' existence. The results show that at least 18% of the Grade 11 Life Sciences teachers who completed the pre-visit questionnaire disagreed with the statement. Amongst those teachers, only one teacher gave the correct explanation.

Table 7a: Results of Grade 11 teachers' responses about organisms' existence (n=22)

			Pre-visit		Post visit	
Response	Categories	Explanation	n	%	n	%
disagree	Scientifically correct	Explained at least one of the three explanations.	1	5	0	0
	Incorrect	The explanation was completely off track. Mentioned creationism.	3	13	2	9
Agree	Incorrect	Organisms existing today are the results of evolution	15	68	19	86
No idea	Answered both		1	5	1	5
	Not answered		2	9	0	0

After the post-visit, only 9% teachers disagreed with the statement but gave the incorrect statement. This implies that none of the teachers gave the correct explanation after they have completed the post-visit. For example, A5 mentioned that "Human beings will not change from what they are today into any other form. Other small organisms might change due to environmental and genetic factors". Furthermore, during the pre-visit 68% teachers chose to agree with the statement. This number increased to 86% after the participants were taken for the museum tour and presentations. This implies that the participants were confused by what they saw during the museum tour and presentations. The data also revealed that they were 14% teachers who seemed to have no idea about the question. One of those teachers chose both agree and disagree during two occasions (pre- and post-visit). The remaining two

teachers did not answer this question during pre-visit and chose to agree with the statement during post-visit. The extracts mentioned below showed some of the explanations given by the Grade 11 participants.

> A22 mentioned that "as a result of technology, people keep on changing their life styles, their appearance and also the environment in which they found themselves in".
>
> A12 explained that "fossils seem to indicate that. Looking at ancient animals there seems to be similarities e.g. underdeveloped limbs in certain aquatic animals".
>
> A6 mentioned that "Because through the years (in terms of millions), there had been a lot of changes in the environment, therefore organisms had to change (micro or macro) to adapt to it".

Table 7b: Results of Grade 12 teachers' responses about organisms' existence (n=27)

			Pre-visit		Post visit	
Response	Categories	Explanation	n	%	n	%
Disagree	Scientifically correct	Explained at least one of the three explanations.	1	4	0	0
	Incorrect	The explanation was completely off track. Mentioned creationism.	5	19	5	19
Agree	Incorrect	Organisms existing today are the results of evolution	19	70	20	74
No idea	Both answers		0	0	1	4
	Not answered		2	7	1	4

The above mentioned table shows the summary of Grade 12 teachers who responded to the question of organisms' existence. During pre-visit, the data presented in table 7b shows that 23% teachers disagreed with the statement. Amongst these teachers,

only one teacher gave the correct explanation while five gave the explanation which was based on creationism.

After the museum tour and presentations, 19% teachers disagreed with the statement but the explanation given was incorrect. Therefore none of the teachers who completed the post-visit questionnaire gave the correct explanation. Amongst the five respondents, two of them related their explanation with creationism. For example, B11 said: "I believe all that exist have been created by God much as there can be some evolutionary changes for adaptation purposes". During the pre-visit questionnaire, B19 stated that "the perpetual existence is the result of reproduction viz evolution is about change of original appearance". This implies that the processes that take place during reproduction may affect the existence of an organism. This teacher seems to agree that the evolutionary processes affect the existence of organisms. However, not everything which exists today is the results of evolution.

Furthermore, the data showed that they are 7% participants who did not answer the question during the pre-visit. However, one of the participants became confused after the museum tour and presentations and then chose both answers. The study also revealed that during pre-visit and post-visit, 70% and 74% of participants agreed with the statement. This implies that a large number of teachers had misconception about the existence of organisms even after the presentation and the tour in the museum.

The results of this question showed that both Grade 11 and 12 Life Sciences teachers were confused by the presentations and the museum tour. I suggest that the confusion was caused by the flawed ideas they held and what they saw in one of the exhibition halls of the museum. In that hall, the models of *hominids* were displayed. The interpretation of these models may differ from one person to another. People who do not have a good knowledge of evolution may think that human being were apes and then changed gradually. Furthermore, in the resource pack of Maropeng Visitors Centre there is an image that simplifies human evolution. When people with little or no knowledge of evolution are exposed to the image of human evolution and hominids they may be convinced that human evolved from apes. I suggest that the majority of the Grade 11 and 12 Life Sciences teachers were confused by the

statement “Organisms existing today are the result of evolutionary processes that have occurred over millions of years”. This assertion is made because the models of hominids and the image shown below may depict that a modern human was different from the old one. Figure 4 below shows the simplified scheme of human evolution. This image is more or less similar to the image in Maropeng resource pack except that the Maropeng image did not have the picture of an Ape.

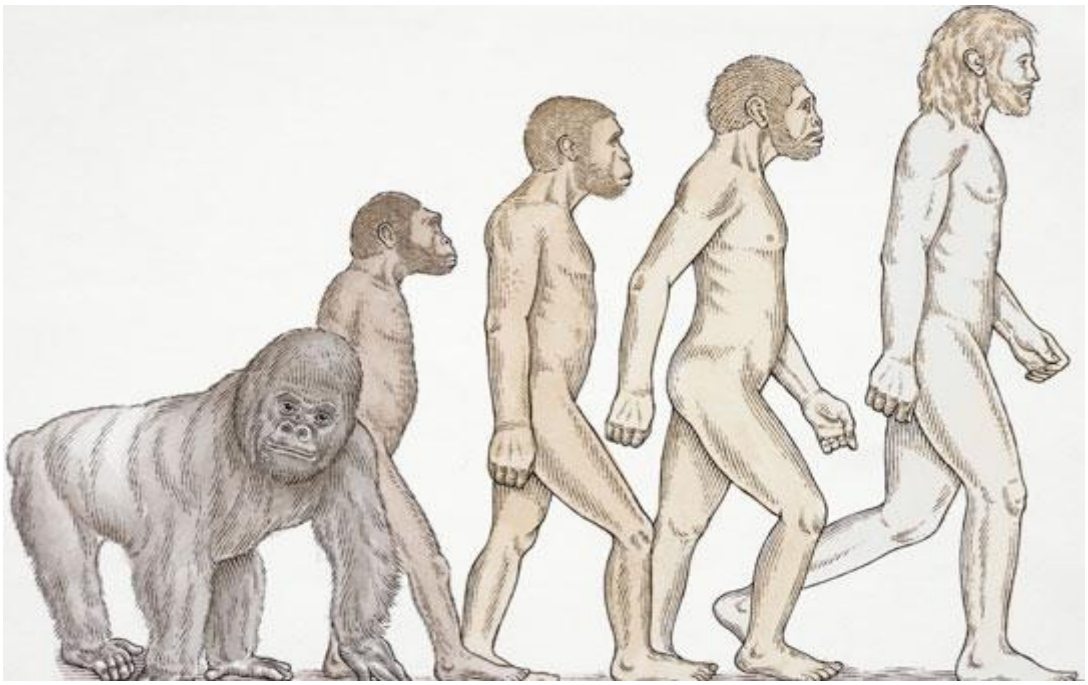

Figure 4: Simplified scheme of human evolution (Getty images)

In April 2010 my Daughter who is in Grade 4 came with an image of human evolution which was extracted from the materials of one of the museums in South Africa. The image was more or less the same as the image in figure 4. She gave me the image as she wanted to confirm whether human being were monkeys many years ago. I asked her why she is asking such a question. She mentioned that her teacher told them that human beings were monkeys before and gradually changed to who we are today. This made me realise that the interpretation of images may provide wrong ideas to teachers and learners. Such ideas may be strengthened by media and the information given in some of the informal science institutions if the tour guides are not well trained.

If a person is exposed to those models of *hominids* and the above picture, the first thing that comes into the mind is that human beings were animals many years ago and changed to who we are today. Research showed that intuitive ideas, misunderstandings and personal beliefs hamper the acceptance and the teaching of evolution (Rutledge and Mitchell, 2002; Cook, 2009). These results also revealed that not everything in the informal science institution can facilitate learning. In some instances, the exhibits may teach misconceptions if they are not well explained by the tour guides. For example, the model of *hominids* and the picture of human beings over million years might have assured the participants that organisms evolved. In this case learning did not take place since the misconceptions that the participants held were not replaced with appropriate expert knowledge (Smith *et al.*, 1993).

- **Fifth question:** Evolution quiz

Tables 8a and 9a contain correct and incorrect statements concerning evolution. In this question the participants were given a Likert scale with agree, disagree and not sure options. For analysis purposes, the column of "not answered" was included in order to accommodate participants who did not answer. The responses of both Grade 11 and 12 teachers were recorded in a separate table. Both the pre-visit and post-visit data from the same Grade were analysed in one table. The purpose of putting together the pre-visit and post-visit data of the same Grade in one table was to compare the results of each grade (Reddy, 2000). Furthermore, the statements in both 8a and 9a were categorised as true and false. Amongst the ten statements, only two statements were true and the rest were false.

The purpose of using such statements was to test the knowledge of teachers about evolution since this topic has many misconceptions or erroneous ideas. However, some of the statements may confuse the participants especially if they do not have the content knowledge of evolution. For example, it may be more challenging for a person who knows nothing about evolution to realise that the statement "humans developed or evolved from apes" is a false statement. This statement is one of the common misconceptions that exist in evolution.

Table 8a: Results of Grade 11 teachers' evolution quiz (n=22)

Statements	TQ	DA	A	NS	NA
1. Humans developed/evolved from apes. **(F)**	Prv	12	6	2	2
	Pov	7	13	2	0
2. There is no evidence for evolution, it is just a theory. **(F)**	Prv	10	7	4	1
	Pov	16	6	0	0
3. Organisms have always looked the way they look today. **(F)**	Prv	10	9	1	2
	Pov	19	2	1	0
4. Survival of the fittest means basically that "only the strong survive". **(F)**	Prv	3	17	0	2
	Pov	3	19	0	0
5. Darwin was the first person to suggest that evolution occurs. **(F)**	Prv	6	10	4	2
	Pov	10	12	0	0
6. The theory of evolution cannot be correct since it disagrees with religious accounts of creation. **(F)**	Prv	7	8	6	1
	Pov	14	5	3	0
7. Humans and chimpanzees evolved separately from an ape-like ancestor. **(T)**	Prv	7	11	3	1
	Pov	10	10	1	1
8. The age of the Earth is approximately 4-5 billion years. **(T)**	Prv	3	5	12	2
	Pov	3	12	7	0
9. Evolution has taken place in order for humans to develop. **(F)**	Prv	14	5	2	1
	Pov	9	12	1	0
10. Life appeared on Earth less than 10,000 years ago. **(F)**	Prv	9	4	8	1
	Pov	10	5	7	0

Keys to the above abbreviation are: DA: Disagree; A: Agree; NS: Not sure; NA: not answered; TQ: Type of questionnaires; Prv: Pre-visit; Pov: Post-visit; T: True and F: False.

Table 8a shows the data collected from Grade 11 Life Sciences teachers. All the false statements as reflected in the table are referred to as common misconceptions or erroneous ideas. The results on table 8a indicate that six Grade 11 teachers agreed with the statement "human evolved or developed from apes". During the post-visit, the number increased to 13. This implies that the museum tour and presentations did not remove the misconception held by teachers. As we were taken through the tour by the tour guides, teachers started to ask questions about the exhibits. Amongst others they wanted to understand the meaning of the scheme of human evolution's picture. A

person who does not understand evolution may think that a human being started as an animal (Ape) and later transform into a modern human being. According to the guide's explanation, millions years ago humans walked with four feet and later stood upright by the tour guide affirmed that human beings started as apes millions years ago and changed into who we are today due to evolution. The data also showed that there were 12 teachers who disagreed with the statement about human evolving or developing from apes. These teachers showed to have good understanding of evolution since they disagreed with the misconception statement. After the post-visit and presentation, the number decreased to seven. The data revealed that three of the five teachers chose to agree with the statement while the remaining two were not sure about the statement. This implies that at first these teachers were either not sure about their answer or they were guessing. The teachers who chose to agree with the statement showed to have developed a misconception.

In order to understand table 8a better, the data is summarised into four categories in table 8b. The first category was teachers with good understanding of evolution. This category entails teachers who chose to disagree with the false statements and agree with the true statements. The second category was teachers who showed to have poor understanding of evolution. This category consists of teachers who agreed with the false statements and disagreed with the true statements. The third category showed the number of teachers who were not sure or undecided on what to choose and lastly the number of teachers who did not answer. These categories were also used in the summary of Grade 12 teachers. The data recorded in numbers and percentages on both pre-visit and post-visit responses.

During pre-visit, the summary of the results in table 8b indicates that 39% of Grade 11 Life Sciences teachers showed to have good knowledge of evolution. However, this percentage increased to 50% during post-visit. This implies that some of the Grade 11 teachers' misconceptions were changed. Furthermore, the data showed that they were 35% teachers who had poor knowledge of evolution. During the post-visit, the percentage increased to 40%. The number of teachers who hold misconceptions increased even after teachers were taken through the museum tour and presentations. The data also revealed that during the pre-visit, 21% teachers were not sure on what to

choose and this percentage decreased to 10% after the museum tour and presentation. They were also 8% of teachers who did not answer some of the questions and this has changed after the museum tour because the number decreased to one teacher. Teachers who did not answer some questions and those who were not sure may either have gained good knowledge or poor knowledge.

Table 8b: Summary of the results for Grade 11 teachers' evolution quiz

n=22 teachers x 10 statements	Pre-visit		Post visit	
	n	%	n	%
Teachers who agreed with the true statements and disagreed with the false statements (good knowledge of evolution).	86	39	110	50
Teachers who agreed with the false statements and disagreed with the true statements (poor knowledge of evolution).	76	35	87	40
Teachers who were not sure on what to choose (undecided).	43	21	22	10
Teachers who did not answer.	15	8	1	0

Table 9a contains the responses of Grade 12 Life Sciences teachers who attended a workshop at Maropeng Visitors Centre. Even though the first statement on table 9a was challenging to people who have poor content knowledge of evolution, I anticipate that it may not be the same with Grade 12 teachers since most of them have taught the topic of evolution in 2008.

The first question of table 9a showed that during pre-visit, ten teachers agreed that human evolved or developed from apes and the number decreased to three teachers after the museum tour and presentations. The data also revealed that they were eight teachers who were not sure about the first statement and the number decreased to three during post-visit. Furthermore the results also showed that during the pre-visit, nine teachers disagreed with the statement "human evolved or developed from apes" and the number increased to 20 teachers during the post visit. These results reflect that

a large number of teachers during the pre-visit had a misconception about the statement "human evolved or developed from apes". After the presentation and museum tour, more teachers showed to have gained a good knowledge of evolution because they disagreed with the statement. However, they were four teachers who showed to have been confused by the statement and hence they chose "not sure" or did not answer this question.

Table 9a: Results of Grade 12 teachers' evolution quiz (n=27)

Statements	TQ	DA	A	NS	NA
1. Humans developed/evolved from apes. **(F)**	Prv	9	10	8	0
	Pov	20	3	3	1
2. There is no evidence for evolution, it is just a theory. **(F)**	Prv	16	6	5	0
	Pov	18	8	1	0
3. Organisms have always looked the way they look today. **(F)**	Prv	19	6	1	1
	Pov	23	3	1	0
4. Survival of the fittest means basically that "only the strong survive". **(F)**	Prv	3	23	0	1
	Pov	20	7	0	0
5. Darwin was the first person to suggest that evolution occurs. **(F)**	Prv	7	15	5	0
	Pov	23	2	2	0
6. The theory of evolution cannot be correct since it disagrees with religious accounts of creation. **(F)**	Prv	13	10	4	0
	Pov	14	11	2	0
7. Humans and chimpanzees evolved separately from an ape-like ancestor. **(T)**	Prv	7	14	5	1
	Pov	6	20	1	0
8. The age of the Earth is approximately 4-5 billion years. **(T)**	Prv	0	12	15	0
	Pov	5	13	9	0
9. Evolution has taken place in order for humans to develop. **(F)**	Prv	10	13	4	0
	Pov	16	8	3	0
10. Life appeared on Earth less than 10,000 years ago. **(F)**	Prv	7	6	14	0
	Pov	10	7	10	0

Keys to the above abbreviation are: DA: Disagree; A: Agree; NS: Not sure; NA: not answered; TQ: Type of questionnaires; Prv: Pre-visit; Pov: Post-visit; T: True and F: False.

During the old curriculum, the statement "survival is the fittest" was commonly mentioned in the topic of population dynamics. The interpretation of this statement differed as the word "fittest" was associated with "strongest". In order to see whether they are teachers who still carry this misconception, the statement was included in the evolution quiz. The results in table 9a showed that 23 Grade 12 Life Sciences teachers agreed with the statement. After the museum tour and presentation, 20 teachers disagreed with the statement and only seven teachers still agreed with the misconception statement. This implies that a large number of teachers who had a misconception before the visit have gained good knowledge.

In summary table 9b shows that during the pre-visit, 41% of teacher had good knowledge of evolution and this percentage increased to 66% after the museum tour and presentations. However, there were 35% of teachers who showed to have poor knowledge of evolution during pre-visit and the percentages have decreased to 22% during post-visit. Furthermore, the table showed that there were 23% who were not sure about the statements and at least 1% teachers who did not answer some of the statements. The percentages decreased to 12% after the tour.

Table 9b: Summary of the results for Grade 12 teachers' evolution quiz

n=27 teachers x 10 statements	Pre-visit		Post visit	
	n	%	n	%
Teachers who agreed with the true statements and disagreed with the false statements (good knowledge of evolution).	110	41	177	66
Teachers who agreed with the false statements and disagreed with the true statements (poor understanding of evolution).	96	35	60	22
Teachers who were not sure on what to choose (undecided).	61	23	32	12
Teachers who did not answer.	3	1	1	0

The results of this question revealed the following observations. Firstly, a large number of both Grade 11 and 12 Life Sciences teachers who participated in my study had misconceptions about many statements before the visit. Those teachers agreed with the misconception statements found in table 8a and 9a. Secondly, the museum and presentations played an important role to change the misconceptions held by teachers and hence the percentage of teachers who showed to have gained good knowledge about evolution increased after the museum tour and presentation. Thirdly, some teachers who disagreed with misconception statements during pre-visit questionnaire chose to agree with such statements during post-visit questionnaire. This implies that those teachers were either confused by what they saw during the visit or gained some misconceptions on some statements. For example, in the first show room, the display of hominids may depict that human being were animals before and changed to the way they look today. Those models showed an old hominid with hairy body and a modern hominid with fewer hairs. I anticipate that those models may promote wrong ideas to the visitors because some people may think that million years ago human beings looked like an animals and then changed into who we are today. Such mistaken notions may affect the acquisition of content knowledge. Clough (1994) emphasized that much of the resistance to theory of evolution was caused by mistaken notions that people have about evolution. Fourth, the study revealed that the Grade 12 teachers' improvement was better than the Grade 11 teachers. This may be caused by the fact that the Grade 12 teachers had a greater prior knowledge since they were exposed to the topic of evolution in 2008. Therefore, the construction of new knowledge about evolution might have been reinforced by the visit and workshops. According to Hausfather (2001), the process of learning involves the connection of prior knowledge and new knowledge. Nola (1997) affirmed that knowledge does not come from our ancestors or from our experiences but it is constructed as we interact with the world around us. Furthermore, Hausfather (2001) mentioned that knowledge may be constructed when learners interact with different information and use it in solving problems, answer questions or discuss interpretations. Lastly, the results revealed that some teachers were confused because they did not know whether to agree or disagree with the statements given. Such confusion may be caused by lack of knowledge or misconception that teachers have about nature of biological evolution (Nickels, Nelson and Beard, 1996).

- **Sixth question:** What are your feelings about teaching evolution?

The question mentioned above was designed to check the feeling of both Grade 11 and 12 Life Sciences teachers towards teaching evolution. The inclusion of this question was driven by the fact that every person possesses a particular belief. In most cases they affect the teaching and learning process. Rutledge and Mitchell (2002) affirmed that personal beliefs of individuals may negatively or positively affect the teaching of evolution. Therefore, in this study it was essential to check the feelings of teachers about teaching evolution. Both Grade 11 and 12 Life Sciences teachers were asked to complete this question before and after presentations and museum tour. The purpose of giving teachers this question before the presentation and museum tour was to find out whether they possess positive or negative attitudes towards the teaching of evolution. Furthermore, the same question was given to the same teachers after the museum tour and presentation in order to find out whether their attitudes will change positively or negatively. Table 10a shows the summary of data collected from Grade 11 Life Sciences teachers who participated in this study. After I thoroughly read the data, I identified three categories and that is (a) teachers who were comfortable to teach evolution, (b) teachers who were uncomfortable and (c) those who were confused. These categories were taken from what the teachers mentioned during pre- and post-visit questionnaires. They were teachers who did not answer this question. In order to accommodate such teachers, I furthermore included the category of "teachers who did not answer".

The results in table 10a showed that 32% of teachers who completed the pre-visit questionnaire were comfortable about teaching evolution. These percentages increased to 68% after teachers were taken through the museum tour and presentations. The majority of these teachers mentioned that they are prepared to teach the topic due to the availability of evidence while others mentioned that the topic of evolution is stimulating and interesting.

Table 10a: Results of Grade 11 teachers' feelings about the teaching of evolution (n=22)

		Pre-visit		Post visit	
Categories	Sub-categories	n	%	n	%
Comfortable	Evidence availability, stimulating and interesting	7	32	15	68
Not comfortable	Against religious beliefs	6	27	3	13
	No content knowledge	2	9	1	5
Confused		6	27	2	9
Did not answer		1	5	1	5

However, there were 36% of teachers who mentioned that they are not comfortable to teach evolution. Amongst that percentage, 27% mentioned that they are not prepared to teach evolution since it contradicts with their religious beliefs. The remaining 9% mentioned that they are not prepared to teach evolution because they do not have sufficient content knowledge. After the museum tour and presentations, the percentage dropped to 18%. The study also revealed that 27% showed to be confused by the content of evolution and the percentages decreased to 9% during the completion of post visit questionnaire. This implies that the presentation and the museum tour played a vital role in changing teachers who had negative attitudes towards evolution since their attitudes became positive. The data also revealed that there was one person who did not answer this question even after the presentation and museum tour. I assume that this person was confused by the explanation given or did not know what to write.

Table 10b shows the summary of Grade 12 teachers' feelings about the teaching of evolution. Unlike Grade 11 teachers, some of the Grade 12 teachers have taught the topic of evolution in 2008. When I was analysing this data I discovered that the data given by both Grade 11 and 12 teachers were similar and the categories were the same.

During the pre-visit, the results revealed that 22% of teachers mentioned that they are comfortable in teaching the topic of evolution. After the museum tour and presentations the percentage increased to 63%. This implies that the museum tour and the presentation have boosted the confidence of some teachers who were not

comfortable to teach evolution and some of those who were confused. The study also showed that there were 56% of teachers who mentioned that they are not comfortable in teaching the topic of evolution. Amongst that percentage, 45% felt that it is against their religious beliefs. The remaining 11% of the participants stated that they are uncomfortable due to lack of content knowledge. However, the percentages decreased to 18% after the museum tour and presentations. During the completion of the pre-visit questionnaire 11% of teachers recorded that they are confused because they are not sure whether the information found in the text books are true or false. After the presentations and museum tour the percentage increased to 15%. Furthermore, the data also showed that 11% of teachers did not answer this question during the pre-visit questionnaire and the percentage decreased to 4% after the museum tour and presentations. This implies that they were 7% of teachers who either gained evolution knowledge or be confused.

Table 10b: Results of Grade 12 teachers' feelings about the teaching of evolution (n=27)

		Pre-visit		Post visit	
Categories	Sub-categories	n	%	n	%
Comfortable	Evidence availability, stimulating and interesting	6	22	17	63
Not comfortable	Against religious beliefs	12	45	5	18
	No content knowledge	3	11	0	0
Confused		3	11	4	15
Did not answer		3	11	1	4

The analysis of this question showed the following observations: Despite the different beliefs, a large number of teachers have changed their negative attitudes after the museum tour and presentations because they recorded to be comfortable towards teaching evolution. This showed that not all religious believers reject the teaching of evolution. Ayala (2000) affirmed that some religious institutions such as Catholic, Lutheran, Jewish and other Christian bishops including other religious leaders deny that the theory of evolution conflicts with and threatens religious beliefs. The fact that the attitudes of teachers towards the teaching of evolution changed irrespective of their religious beliefs meant that they do not reject the teaching of evolution.

Since there was a substantial increase of teachers who claim to be comfortable after the museum tour and presentation, I anticipate that the availability of models and real fossils played an important role in changing the attitudes of teachers. Dempster and Hugo (2006) affirmed that the teaching of evolution in South Africa is possible because of the availability of rich natural resources. The data also revealed that there are some teachers who are not prepared to change their attitudes regardless of what they saw or hear during the workshop. This implies that individual beliefs may have a negative impact on the teaching of evolution (Cavallo and McCall, 2008). Despite all presentations and natural resources available, some teachers were still confused by the evidence of evolution displayed in the museum. The results showed that the evidence available in the museums may either create confusion or provide answers to many unanswered questions that teachers have about evolution.

- **Seventh question:** State briefly what influenced your attitude towards teaching evolution.

This is a follow-up question from the previous one. The purpose of asking this question was to identify the factors that influenced teachers' attitudes towards teaching evolution. Such influence may either be negative or positive. Table 11a represents the data that was collected from the Grade 11 Life Sciences teachers.

According to the data listed in table 11a, 18% of teachers who completed the pre-visit questionnaire mentioned that they will teach the topic of evolution because of their "love for learners". This percentage has increased to 23% after the participants were taken through the museum tour and presentations. The results also showed that one person mentioned that he is prepared to teach evolution since it is part of the curriculum. During the post visit that person's attitude changed as he was exposed to different natural resources that are found in the museum. Furthermore, the pre-visit results revealed that 27% of teachers were prepared to teach the topic of evolution because of their passion for teaching. This percentage increased to 32% after teachers were exposed to the real fossils and different models. Furthermore, there are 32% of teachers who were influenced by the visit to Maropeng Visitors Centre and this was revealed after the museum tour and presentations. During the pre-visit, there were no

teachers who stated that they were influenced by the museum since they have never been at Maropeng visitors centre before.

In contrast, this study revealed that 14% teachers were not prepared to teach evolution since it contradicts with their religious beliefs. After the presentations and the tour, only one teacher retained his or her notion of not willing to teach evolution. Since the topic of evolution was introduced for the first time in South African curriculum, 18% of teachers mentioned that they are not prepared to teach the topic due to lack of content knowledge and this percentage decreased to 0% after they were taken through presentations and museum tour. Furthermore, there were 18% of teachers who did not answer this question during the pre-visit questionnaire and this percentage decreased to 9% after the presentations and the tour.

Table 11a: Results of Grade 11 teachers' attitudes towards teaching evolution (n=22)

		Pre-visit		Post visit	
Categories	**Sub-categories**	**n**	**%**	**n**	**%**
Comfortable	Love for learners	4	18	5	23
	Part of curriculum	1	5	0	0
	Passion for teaching	6	27	7	32
	Due to visit	0	0	7	32
Not comfortable	Contradict with religious beliefs	3	14	1	4
	Lack of content knowledge	4	18	0	0
Did not answer		4	18	2	9

This question was also given to Grade 12 Life Sciences teachers. Although these teachers have never been at this museum before, they knew about the centre through the pamphlets send by the Department of Education. Table 11b shows the data that was collected from Grade 12 Life Sciences teachers. The table reflects that 23% of teachers who completed pre-visit questionnaire were prepared to teach evolution because of their love for learners and this percentage decreased to 11% after the post-visit. These results were similar to the Grade 11 results. 19% teachers mentioned that

they are willing to teach the topic of evolution because of their passion for teaching. After the museum tour and presentations, the number increased to 26%. Furthermore, the study revealed that 33% of teachers who completed the pre-visit and post-visit questionnaires recorded that they are willing to teach the topic of evolution because they are willing to learn. This is a new sub-category since none of the Grade 11 teachers mentioned it. Amongst all Grade 12 teachers who participated in my study, only one teacher have directly mentioned that the visit to the museum has influenced her to teach the topic of evolution.

Some of the Grade 12 teachers were not prepared to teach the topic of evolution. The results of table 11b showed that 18% of teachers were not prepared to teach evolution. Amongst these teachers 11% argued that evolution is against their religious beliefs whilst the remaining 7% blamed the old education system. After the presentations and the museum tour, only 15% teachers were not prepared to teach the topic. Regardless of what they saw and heard during presentations and museum tour, one of those teachers argued that he is not prepared to teach evolution since he does not have enough content knowledge of evolution and lack of evidence. During the pre-visit, 7% teachers did not answer this question and the number increased to 11% after the museum tour and presentations.

Table 11b: Results of Grade 12 teachers' attitudes towards teaching evolution (n=27)

		Pre-visit		**Post visit**	
Categories	**Sub-categories**	**n**	**%**	**n**	**%**
Comfortable	Love for learners	6	23	3	11
	Passion for teaching	5	19	7	26
	Eager to learn	9	33	9	33
	Due to visit	0	0	1	4
Not comfortable	Against religious beliefs	3	11	1	4
	Past education system	2	7	2	7
	No evidence and content knowledge	0	0	1	4
Did not answer		2	7	3	11

In this question the following findings were noted: There are five factors that influenced teachers to teach evolution and that is (a) love for learners, (b) it is part of the curriculum, (c) passion for teaching, (d) the visit to the informal science centre

and (e) willingness to learn. However, there are three factors that influenced teachers who are not prepared to teach evolution and that is (a) it contradict with their personal religious beliefs, (b) lack of content knowledge and (c) being perpetuated by the old education system. Dempster and Hugo (2006) and Stears (2006) affirmed that the past education system did not include the topic of evolution as they claimed that it is against their religious beliefs. Lastly, there were teachers who did not attempt to answer this question. I anticipate that these teachers may either be confused since they did not believe what they saw or did not know what they should write due to lack of content knowledge

- **Eighth question:** Briefly explain how fossils are formed

Maropeng visitors centre contains different types of fossils, most of which are original. They also show and explain how fossils are excavated. The purpose of asking the above mentioned question was to find out whether both Grade 11 and 12 Life Sciences teachers understand fossil formation. Through this question the researcher also wanted to see whether participants will be able differentiate between fossils and decomposition. Through Life Sciences meetings that were held in the district, it was realised that some teachers and learners cannot give the difference between fossils and decomposition. Before providing the results of the data, it is important to provide a correct explanation for fossil formation. Raven, Johnson, Losos, Mason and Singer (2008) explain fossils as any trace of past life which has been preserved in stone. This includes wood in plants and body parts of animals such as bones and shells. It also includes the remaining of the activity of living organisms such as burrows or footprints. There are two ways in which fossil formation is explained and that is:

- Formed from the remains of dead organisms.
- Body parts are buried in sediment before the body parts are broken down by micro-organisms.

The participants were expected to give all these two explanations. However due to time constraints there may be teachers who will give one or incomplete explanations given above. Such participants together with those who gave all two explanations will

be considered to have a good knowledge of evolution. The summary of Grade 11 Life Sciences results are given in table 12a and the Grade 12 results are in table 12b.

During the pre-visit, the data revealed that only one teacher gave the scientifically correct explanation for fossil formation. This means that such teacher gave all two explanations listed above. However, in the post-visit questionnaire none of the teachers gave the correct explanation for fossil formation. The data also revealed that 36% of Grade 11 Life Sciences teachers who completed the pre-visit questionnaire gave the correct but incomplete explanation. This percentage increased to 73% after the presentations and museum visit. These results showed that a large number of teachers who attended the presentations and went for the museum tour gained the knowledge since they managed to provide the explanation of fossil formation.

However, the data also showed that 36% of teachers who completed the pre-visit questionnaire gave the incorrect explanation of fossil formation. The percentage decreased to 18% after the museum tour and presentations. Most of the explanations given by these teachers were related to decomposition. Furthermore, there were 23% teachers who did not answer this question during pre-visit. After the presentations and museum tour, the number decreased to 9% teachers.

Table 12a: Results of Grade 11 teachers' responses about fossil formation (n=22)

		Pre-visit		Post visit	
Categories	**Explanation**	**n**	**%**	**n**	**%**
Scientifically correct	**Explained all two aspects:** • Formed from the remains of dead organisms. • Body parts are buried in sediment before the body parts are broken down by micro-organisms.	**1**	**5**	**0**	**0**
Correct but incomplete	**Explained one or two aspects:** • Formed from the remains of dead organisms or • Body parts are buried in sediment before the body parts are broken down by micro-organisms.	**8**	**36**	**16**	**73**
Incorrect	The explanation was completely off track. The explanation given is for decomposition.	**8**	**36**	**4**	**18**
Not answered	No response was given	**5**	**23**	**2**	**9**

The data in table 12b showed that none of the Grade 12 teachers who were given pre-visit and post-visit questionnaires gave the scientifically correct explanation for fossil formation. However, there were 26% of teachers who answered this question before the museum tour and presentation and gave the correct but incomplete explanation. This percentage increased to 52% after the post-visit questionnaire. This implies that the number of Grade 12 teachers who gained knowledge after the museum tour and presentations was similar to the Grade 11 teachers. Furthermore, the table showed that 70% of teachers gave the incorrect explanation for fossil formation and it decreased to 41% after the tour and presentations. This implies that more than 20% of teachers who gave the incorrect explanation might have given the incomplete correct answer. Similar to Grade 11 teachers, some of the Grade 12 teachers who gave the incorrect answers gave the explanation of decomposition. Amongst the 27 Grade 12 teachers who participated in my study only one teacher did not answer this question during pre-visit questionnaire. After the museum tour and presentations the number of teachers who did not answer this question increased to 7% and this number was similar to Grade 11 teachers.

Table 12b: Results of Grade 12 teachers' responses about fossil formation (n=27)

		Pre-visit		Post visit	
Categories	**Explanation**	**n**	**%**	**n**	**%**
Scientifically correct	**Explained all two aspects:** • Formed from the remains of dead organisms. • Body parts are buried in sediment before the body parts are broken down by micro-organisms.	**0**	**0**	**0**	**0**
Correct but incomplete	**Explained one or incomplete aspects:** • Formed from the remains of dead organisms or • Body parts are buried in sediment before the body parts are broken down by micro-organisms.	**7**	**26**	**14**	**52**
Incorrect	The explanation was completely off track. The explanation given is for decomposition.	**19**	**70**	**11**	**41**
Not answered	No response was given	**1**	**4**	**2**	**7**

This question revealed the following findings. Firstly, there are a large number of teachers who could not give the correct explanation for fossil formation and instead they gave the explanation of decomposition. This implies that those teachers did not see the difference between fossils and decomposition especially before they went for the museum tour and presentation. Secondly, there was an increase in knowledge after the tour and presentations. This implies that the museum and the presentations had a positive impact on the teaching and learning of evolution. Lastly, even though teachers were exposed to different fossils there were few teachers who did not answer this question. These teachers may either be confused by what they saw or did not believe what they saw. This assertion is stated because in the previous questions there were teachers who argued that they do not believe in evolution since it is against their religion. Those teachers did not answer most questions.

Although my study did not focus on whether religious beliefs may affect the teaching of evolution, I think it is important to highlight that the issue of religious beliefs was mentioned in four questions of my questionnaires. In most case those teachers did not

show any knowledge gain even after they were taken to the museum tour and presentations. Table 13a shows the number of teachers who mentioned that evolution is against their religious beliefs. The table showed that among the Grade 11 teachers who participated in my study, six of them had religious beliefs about the origin of life. After they have taken to the museum tour and presentations, only two teachers showed to have gained a positive knowledge while the remaining four maintained their beliefs. The data also showed that eight teachers were not comfortable to teach evolution since it contradicts with their religious beliefs. Among those teachers only one teacher showed to have gained a positive knowledge about the teaching of evolution. The remaining 7 teachers maintained that evolution contradict their religious beliefs. In summary, the data revealed that among 18 Grade 11 Life Sciences teachers who completed the pre- and post-visit questionnaires, only six teachers showed to have gained knowledge as their negative attitudes of teaching evolution have changed to positive.

Table 13a: The summary of Grade 11 teachers who had strong religious beliefs

Question number	Religious beliefs	Positive knowledge gain	Maintained their religious beliefs
B	6	2	4
D	1	0	1
F	8	1	7
G	3	3	0

Table 13b shows the number of Grade 12 Life Sciences teachers who mentioned that the teaching of evolution contradicts with their religious beliefs. The data showed that they were few teachers who had very strong religious beliefs. During the pre-visit questionnaire five teachers showed that they are against the notion that "evolution explains the origin of life". During the post visit questionnaire, only two teachers showed to agree with the statement. However, the data also showed that they were three teachers who did not change from their beliefs irrespective of being taken through the museum tour. Teachers were also asked tell their feelings about the teaching of evolution. This question revealed that 12 teachers showed that religious

beliefs may negatively affect the teaching of evolution. The number decreased to six after the museum tour and presentations. However, they were six teachers who still maintained their religious beliefs.

Table 13b: The summary of Grade 12 teachers who had strong religious beliefs

Question number	Religious beliefs	Positive knowledge gain	Maintained their religious beliefs
B	5	2	3
D	2	0	2
F	12	6	6
G	3	0	3

In spite of evidence displayed in the museum and the information given during the presentation, there were a few teachers who did not gain knowledge as they maintained their religious beliefs. The data in both Grade 11 and 12 revealed that 12 Grade 11 Life Sciences teachers and 14 Grade 12 Life Sciences teachers maintained their religious beliefs. This implies that the availability of information and evidence may not change teachers' attitudes and views towards the teaching of evolution. These results showed that teachers' existing knowledge may influence their readiness to accept the new knowledge (Matthews, 2001).

- **Ninth question:** Describe up to three exhibits you have seen during the tour that you think may have an influence on your understanding of evolution. What influence did you have?

The above mentioned question was given to both Grade 11 and 12 Life Sciences teachers after they went for the museum tour. The purpose of asking this question was to check whether the participants can identify any exhibits that they think it has influenced their understanding of evolution. Teachers were expected to provide three exhibits that they have seen during the tour and provide the influence they had towards the teaching of evolution. However, teachers gave the name of the exhibits only.

Table 14a: **The number of Grade 11 teachers' responses about the centre's exhibits**

Name of exhibits	n
Fossils	6
Did not mention any exhibits	5
DNA structure	5
Evidence of dinosaurs eggs	5
Hominids	4
Skulls	3
Moving with a boat	3
Extinct species	3
Clock	3
Rock found when digging the cave	1
Geographical features	1
Changes about the species	1
Diversity of human beings	1
Mind game	1
Lake	1
Characteristics of endangered species	1
Different species	1
Underground part of the earth	1
Animals existed some years ago	1

Table 14a mentioned above represents the names of exhibits given by the Grade 11 Life Sciences teachers and the number of teachers who gave the names of those exhibits. Teachers managed to give at least 18 exhibits that they saw during the museum tour. However, they were five teachers who did not answer this question. I anticipate that these teachers may either have forgotten the names of the exhibits they saw (since they were many) or could not complete the questionnaire since it was very late. The data showed that there were several exhibits they saw during the tour. Some of the exhibits were related to evolution while others were games. There were seven exhibits that were mentioned by at least 3 to 5 teachers and that are (a) hominids, (b) fossils, (c) evidence of dinosaurs' eggs, (d) extinct species, (e) clock, (f) skulls and (g) DNA structure. Furthermore, there were seven teachers who gave the information which is not related to evolution. This include information such as moving with a boat, underground part of the earth, mind game, lake and rock found when digging the cave. It is anticipated that these teachers were unable to associate what they saw during the museum tour with the content of evolution.

Table 14b shows the names of the exhibits and the number of teachers who gave the names of those exhibits. During the museum tour the Grade 12 teachers managed to identify at least nine exhibits. However, they were 13 teachers who did not answer the

question. This percentage is far much higher than the Grade 11 teachers. However, there are several factors that might have led to this response. Among others it may be due to lack of time since the tour took place after hours, lack of content knowledge or they did not answer because they were not interested on what they saw since they do not believe it. As I was analyzing I realized that teachers who claimed that evolution contradict with their religion are the once who did not answer this question. This made me realize that it may be possible that they chose not answer this question as they think that what they saw during the tour contradicts with their religious beliefs.

Amongst those exhibits mentioned by the Grade 12 teachers they were four exhibits that were mentioned by three to eight teachers and those are (a) hominids, (b) fossils, (c) continental drift and (d) different skulls. The Grade 12 teachers who answered this question mentioned only two features which are partially involved in the topic of evolution and that are volcanic eruption and ice bags. These results showed that the smaller number of Grade 12 teachers were convinced that the exhibits in the museum may assist towards teaching the topic of evolution since 40% of teachers did not answer this question.

Table 14b: The number of Grade 12 teachers' responses about the centre's exhibits

Name of exhibits	n
Did not mention any exhibits	13
Continental drift	8
Hominids	6
Fossils	4
Different skulls	3
DNA structure	1
People around the world	1
Volcanic eruption	1
Ice ages	1

The findings of this question showed that there were five exhibits that were mentioned by the majority of teachers in both Grade 11 and 12 and those exhibits were (a) the structure of DNA, (b) hominids, (c) fossils, (d) skulls and (e) continental drift. I am convinced that if these teachers were given enough time to complete the questionnaire, more exhibits would be mentioned. However, there were many teachers who did not answer this question especially the Grade 12 teachers. This may imply that some teachers who participated in the study did not believe what they saw or they did not have sufficient time to complete the questionnaire.

- **Tenth question:** Do you think what you have seen during the tour will assist you towards teaching evolution?

This question was designed to find out whether all teachers who went to the museum tour will be able tell if what they saw during the tour will assist them towards the teaching of evolution. Furthermore, the researcher wanted to see whether these teachers will be able to associate the exhibits with the topic of evolution. This will be noticed if they are able to agree with the above statement and provide reasons to their answers.

Figure 5 shows the percentage of the Grade 11 teachers' preparedness of teaching evolution. This data showed that 81% of the Grade 11 Life Sciences teacher agreed that they are prepared to teach evolution after they saw the exhibits. These teachers mentioned reasons such as the availability of original fossils, hominids and DNA structure. There were no teachers who disagreed with the above question. However, the data revealed that there were 19% of teachers who did not answer this question.

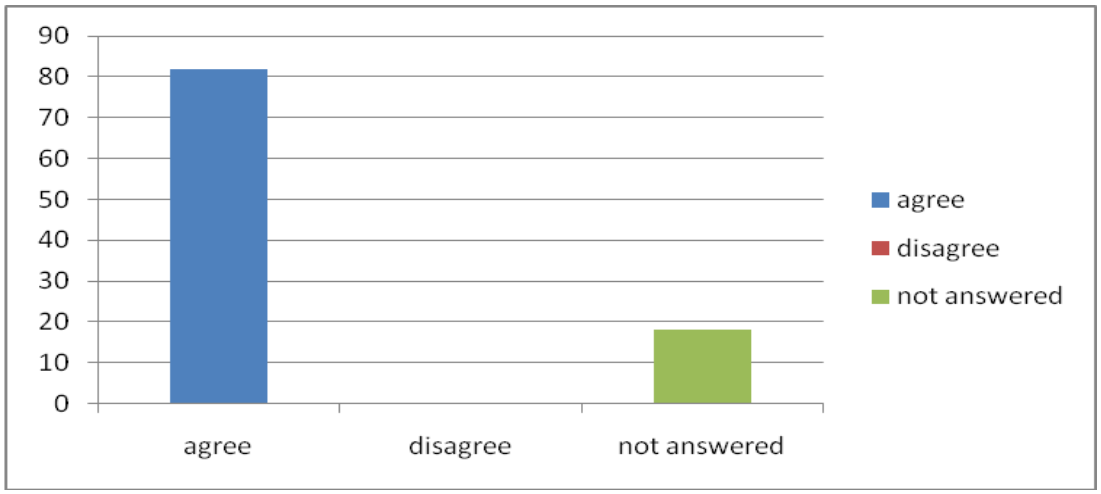

Figure 5: The percentage of Grade 11 teachers' preparedness of teaching evolution (n=22)

Figure 6 represents the percentage of Grade 12 Life Sciences teachers' preparedness towards teaching evolution. This figure revealed that 70% of the Grade 12 teachers have agreed that the exhibits they saw during the museum tour can assist them towards teaching the topic of evolution. Unlike the Grade 11 teachers, there were 4% of teachers who disagreed that the exhibits that are available in the museum can assist them towards teaching evolution. Furthermore, the data revealed that 26% of teachers did not answer this question and this percentage is much higher than the Grade 11 teachers. It is anticipated that the Grade 12 teachers did not answer this question because they did not have sufficient time as the post visit questionnaire was administered very late during the day. Furthermore, it may be possible that they chose not to answer this question because they did not know what to say since they do not believe on the evidence they saw. I am making this assumption because some of the Grade 12 teachers kept on mentioning that evolution is against their religious beliefs.

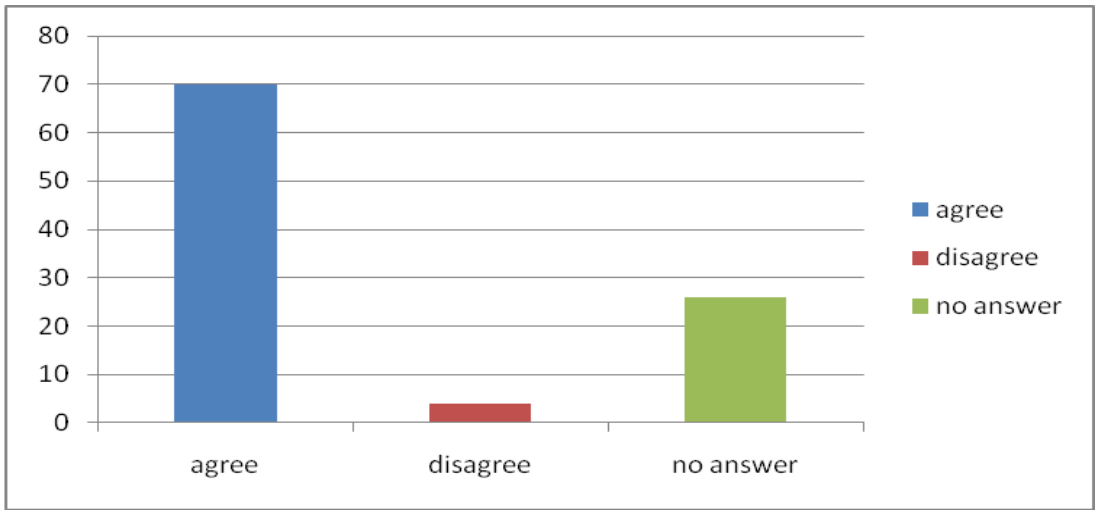

Figure 6: The percentage of Grade 12 teachers' preparedness of teaching evolution (n=27)

The findings of this question recorded that the majority of both Grade 11 and 12 Life Sciences teachers believed that the exhibits in the museum can assist in the teaching of evolution. However, they were a large number of teachers in both Grades who did not answer this question. This may imply that they are teachers who may either be confused by what they saw in the museum or they do not believe that the museum can assist them towards the teaching of evolution. They were also few teachers who literally disagreed that the museum can assist them. This question also revealed that people have different perception on what the museum can provide in the teaching of evolution.

4.5. Personal meaning mapping

Personal meaning mapping (PMM) is a new constructivist assessment tool (Falk and Dierking, 2000). This instrument was given to Grade 12 Life Sciences teachers who attended the workshop that was held at Maropeng Visitor Centre in 2009. The Grade 11 teachers did not complete the personal meaning map because it was introduced after their tour which took place in 2008. Unlike in the questionnaire, 30 Grade 12 Life Sciences teachers completed the personal meaning map (PMM). The number increased because three teachers who participated in 2008 were allowed to participate in the PMM since it was only introduced in 2009. The purpose of using this instrument in this group was to investigate an individual's knowledge and views about

the topic of evolution before teachers entered the museum (Lelliott, 2009). Furthermore, it was intended to find out whether teachers would show any knowledge gain after the museum tour and presentations.

4.5.1. How personal meaning mapping (PMM) was conducted

The Grade 12 Life Sciences teachers were given personal meaning maps after the pre-visit and post-visit questionnaires were completed. All teachers were given a sheet of paper on which the word "evolution" was written in the centre. They were asked to write any information which was related to evolution. Teachers were given five minutes to complete the task and all papers were retrieved after completion. After the visit, teachers were given their original papers and then asked to make changes or additions to what they had already written using another colour of a pen. All teachers did not have another colour of a pen and therefore they were allowed to use the same colour but draw a circle or line in order to differentiate what was written during pre- and post-visit.

To ensure that teachers understood what I wanted them to write, they were asked whether they knew the structure of a concept map. As all teachers seemed to know the structure of the concept map, I then told them that the structure of PMM is more or less the same as the concept map. To ensure that they all understood the structure of personal meaning map, I asked them to draw an oval at the centre of the blank paper provided. I asked them to write the word "Krugersdorp" at the centre of the page. There after they were asked to write anything which is related to the town "Krugersdorp". The example in figure 7 showed the structure that was drawn by many teachers.

After this exercise, I then handed out the PMM sheet that I had prepared with a prompt word "evolution" in the middle. Although Falk cited in Lelliott (2009) recommended that the prompt should be thoroughly piloted before the main study, I could not pilot my prompt due to lack of time. However, the prompt was discussed with my supervisor. During the main study, I asked the teachers to write anything they

thought was related to prompt word “evolution”. Teachers were given five minutes to complete the instrument prior to the presentations and the visit. The papers of personal meaning maps were collected. All teachers were taken through the presentation and then to the museum tour.

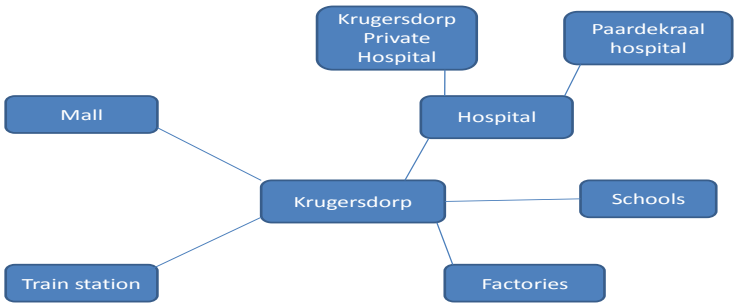

Figure 7: Example of the PMM drawn on the paper

After the tour, teachers were given back their PMM sheets. I asked them to either delete anything that they thought was irrelevant to the prompt word “evolution”. They could also add any information that they thought was related to the prompt. They were given five minutes to complete this task. Although an interview was mentioned as another way of probing the ideas that were written by the participants in the personal meaning maps (Lelliott, 2009), I opted not to use it in my study due to time constraints. Furthermore, the PMM was used as a follow-up of the questionnaires and it was designed to measure the effects that the museum might have brought each individual’s knowledge and (to some extent) attitudes towards the teaching of evolution. Although an interview was not used in my study, in retrospect I think it was essential since teachers were not given enough time to write down all of their ideas on the PMM. Furthermore, interviews would have been the best technique of checking the breadth of the individual’s knowledge about evolution (Falk, 2003). After all teachers had completed the personal meaning maps, I then collected the instruments. The instruments were coded by writing a unique number on each personal meaning map. This was done in order to ensure anonymity.

4.5.2. Analysis of the PMM

The personal meaning maps were analysed qualitatively. As I was analysing the maps, I discovered that all teachers did not differentiate what was completed during pre- and post-visit. Due to this challenge it was anticipated that it would be difficult to compare teachers' prior knowledge and the new knowledge they constructed during the museum tour and presentation. To ensure that this challenge does not affect the findings, the personal meaning maps were regarded as post-visit.

After I thoroughly read all the maps, I discovered that the data given differed from one map to another. The data given showed that individuals learn differently because some teachers provided a lot of information while others did not attempt to complete the map. Due to the amount of data given, I decided to count the correct words the teachers provided, and all participants were given codes to ensure anonymity. After I carefully analysed the data, I discovered that the data could be divided into three categories and they were identified as follows:

- Partially correct ideas: This category included teachers who gave between one and six correct key words. The words given were not explained.
- Correct ideas: It consisted of more than six correct words. The key words given in this category were thoroughly explained.
- Irrelevant ideas: This included words that were not related to the prompt "evolution".

In order to accommodate teachers who did not complete the PMM, I included the category of "not answered". The data in table 15 shows the percentages and the numbers of the correct words that were given by the Grade 12 Life Sciences teachers who completed the PMM.

Table 15: Summary of Grade 12 Life Sciences teachers who completed the PMM

n= 30		
Categories	Number of responses	%
Not answered	3	10
Partially correct ideas	16	53
Correct ideas	9	30
Irrelevant ideas	2	7

The data in this table revealed that 10% of teachers did not complete the tool. Amongst those teachers who completed the tool, 7% gave totally irrelevant ideas. One of these teachers gave the example I mentioned in figure 7. This showed that he or she did not understand the instruction given by the researcher. The data also revealed that 53% of teachers gave few relevant ideas (partially correct ideas) whilst 30% gave more relevant information (correct ideas).

Amongst the 27 personal meaning maps completed by the Grade 12 Life Sciences teachers, six maps were chosen. These maps were used to demonstrate some of the information provided by teachers. The maps were categorised into three groups and that is (a) teachers who showed knowledge gain, (b) teachers who attempted to give relevant information but not enough and (c) teachers who gave completely irrelevant information. Table 16 below shows the categories of the six maps I chose.

Table 16: Categories of the six personal meaning maps selected

Categories	Number of PMM
Personal meaning maps of teachers who showed to have gained knowledge after the post-visit. This teachers were against the teaching of evolution and had a strong religious beliefs	2 Letsatsi John
Personal meaning maps of teachers who attempted to give relevant information but not enough.	2 Sara, Kgabo
PMM of teachers who completely gave the irrelevant information.	2 Des, Mafika

4.5.2.1. Letsatsi's knowledge about evolution

Figure 8 shows the personal meaning map drawn by Letsatsi during the post-visit. Letsatsi is one of the representatives of nine Grade 12 Life Sciences teachers who gave relevant data about evolution. This teacher was chosen because she is one of the teachers who did not agree with most of the correct statements in the questionnaires and she was teaching Grade 12 Life Sciences for the first time in 2009. Furthermore, in both pre-visit and post-visit questionnaire she also claimed that evolution is against her religious beliefs. Although Letsatsi did not answer many questions in both questionnaires, she managed to give at least five key words that explain evolution.

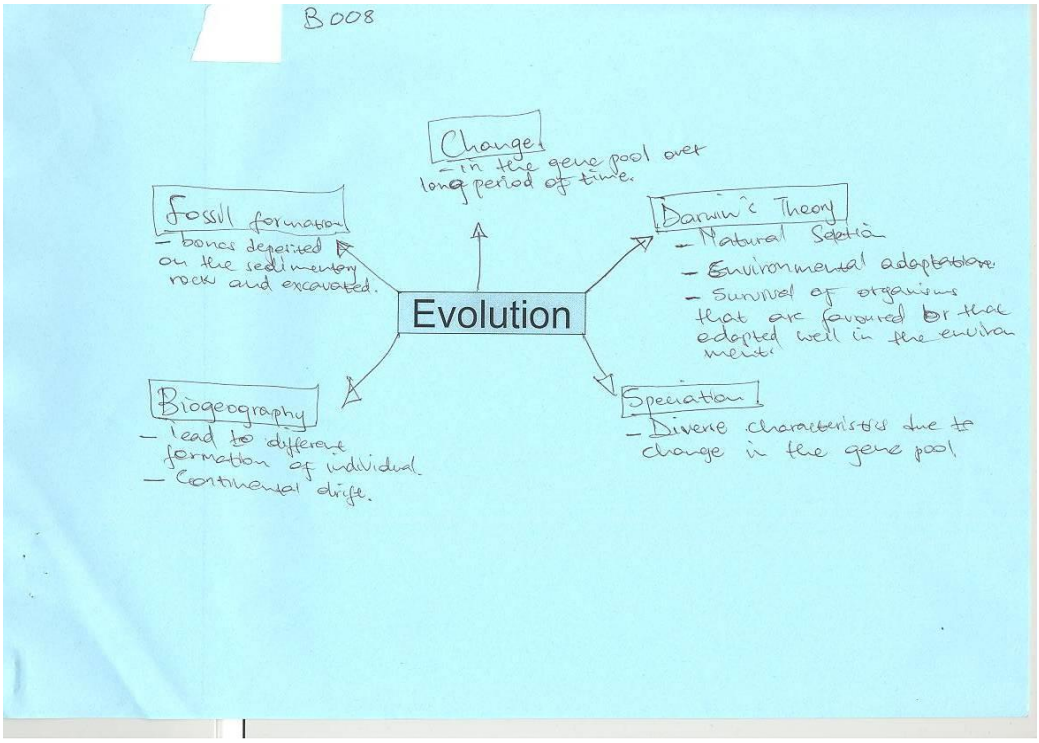

Figure 8: Letsatsi's personal meaning map

On the walls of the corridors, the history of Darwin was pasted. The information written was further explained during the presentation. On Letsatsi's personal meaning map, the words such as natural selection, environmental adaptation and survival of organisms were written below the key word "Darwin". This implies that she knew some information that is associated with Darwin. Furthermore, Letsatsi associated evolution with "change of gene pool over a long period of time".

In the passage leading to the exhibit halls, there was a display of how continental drift occurred. Continental drift is a topic that falls under biogeography. Although the information given was limited, Letsatsi showed an understanding of continental drift. As we enter the exhibit hall, different fossils were displayed and the formation of fossils was explained. The explanation made by Letsatsi suggests a knowledge gain after the presentations and museum tour. This assertion may be influenced by the quality of data she gave. I anticipate that had Letsatsi a pre-knowledge of evolution; she might have provided even more information.

Although Letsatsi was a religious person, she showed to have constructed the knowledge of evolution after the museum tour and presentation. Hein (1998) mentioned that museum visits plays an important role in connecting peoples' pre-knowledge and new knowledge. However, this does not necessarily mean that Letsatsi has accepted the information she acquired from the museum. Rutledge and Mitchell (2002) and Cook (2009) revealed that the influence of strongly held personal beliefs may hamper the acceptance and the teaching of evolution.

Through what was written on the fossils and displays, it became possible for Letsatsi to assimilate new experience even though it contradicted with her personal beliefs. Although the acceptance of the new knowledge may not occur immediately, I think she will reframe her previous knowledge to fit the new knowledge as she connects what she learnt from the museum visit with the information found in the text books.

4.5.2.2. John's knowledge about evolution

John is one of the experienced teachers who claimed to have taught the topic of evolution in 2008. In the questions of attitudes towards teaching evolution, he frequently mentioned that evolution contradict with his religious and cultural beliefs. Furthermore, he is one of the teachers who did not answer the last two questions of the post visit questionnaire where he asked to answer whether he saw any exhibits which will influence him to teach evolution. Figure 9 shows the personal meaning map of John during the post visit.

The data given in John's PMM was very limited. However, most of the data given was related to the topic of evolution. Firstly, John managed to associate the theory of evolution with Darwin and Lamarck. Furthermore, he also mentioned that Lamarck associated the theory evolution with environmental changes and Darwin was associated with natural selection. This information was available on the walls of the museum and it was also presented before teachers were taken to the museum tour.

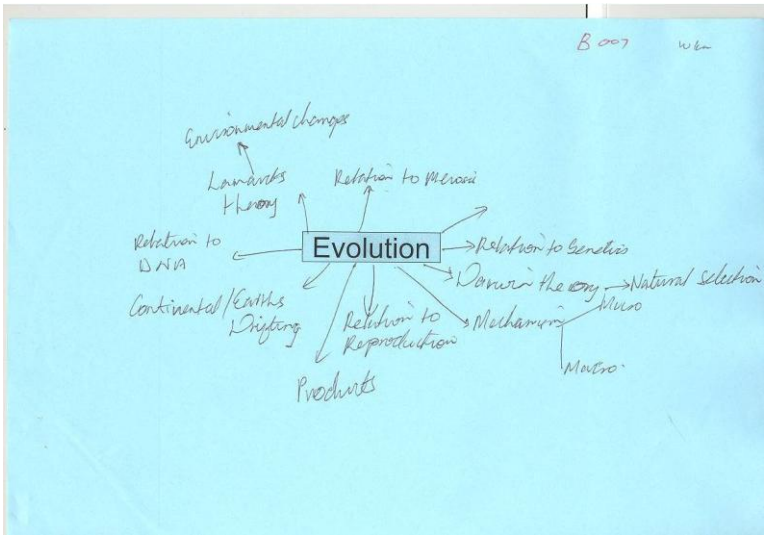

Figure 9: John's personal meaning map

John mentioned that evolution is related to genetics, reproduction and meiosis. Although he did not explain much, the information given suggests that John gained some knowledge especially during the presentation and partly during the museum tour. Although they were many exhibits displayed in the showroom, John could not mention much about that information except the continental drift. However, I acknowledge that the time factor might have played a role on the limited information given or he could not associate the exhibits with the topic of evolution. This assertion is made because John did not answer the last two questions of the post visit questionnaire. Regardless of the fewer points given on the PMM, John showed knowledge gain since he managed to give information which is related to the prompt word "evolution".

4.5.2.3. Sara's knowledge about evolution

Sara is one of the best Life Sciences teachers in Gauteng West District as she has been producing good results in Biology or Life Sciences as it is known today. Furthermore, she is one on the teachers who taught the topic of evolution in 2008. She also assisted

other Grade 12 teachers who struggled to teach this topic. In 2008, she attended the Grade 11 workshop that I conducted since she was teaching both Grade 11 and 12. In 2009, she was only allowed to participate on the PMM. The data given on the personal meaning map showed that she had a pre-knowledge of evolution since she taught the topic in 2008. Figure 10 shows the personal meaning map that was completed by Sara during the post visit.

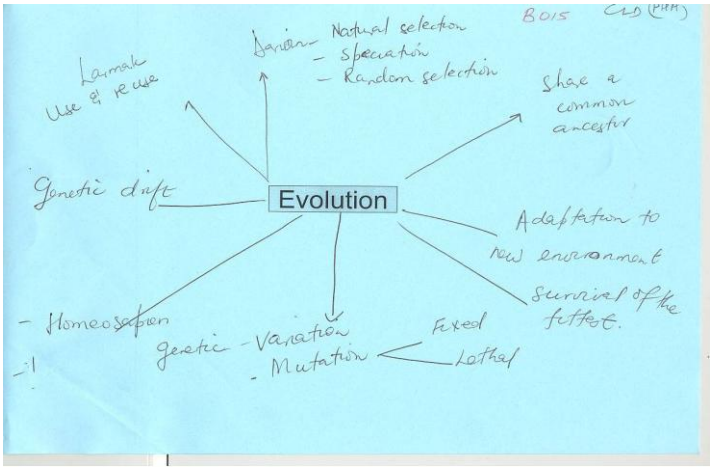

Figure 10: Sara's personal meaning map

In her PMM, the prompt "evolution" was associated with Darwin and Lamarck and these are some of the people who came up with the topic of evolution. She associated Darwin with natural selection, speciation and random selection. Furthermore, she associated Lamarck with use and re-use and this was one of the techniques that Lamarck used to explain evolution. Although she did not give the definition of evolution, she mentioned that evolution is related to the sharing of common ancestors. This statement is one of the correct ideas that teachers who do not have content knowledge may not mention or know. I assume that Sara mentioned this statement because she understood the topic of evolution. Another statement that she mentioned was "survival of the fittest". This statement is one of the common misconceptions in the topic of evolution. However, the statement has been used in the topic of population dynamics and it has been interpreted wrongly by most teachers. Among all the PMM analysed, Sara is the only teacher who mentioned this statement. Just like other teachers who completed the PMM, she also mentioned genetic drift and Homo sapiens and these were some of the displays in the exhibit halls. She also mentioned genetic variation and mutation. Although Sara had the pre-knowledge of evolution, I anticipate that the museum tour and presentation also played an important role in the construction of knowledge.

4.5.2.4. Kgabo's knowledge about evolution

Kgabo was a novice Life Sciences teacher in Grade 12 and she never taught the topic of evolution before. When she was asked to give her feeling about teaching evolution she mentioned that it is difficult to teach it since it is against her religious belief. Furthermore, she mentioned that although what she saw and the information given seemed to be convincing, she does not believe it. After the post visit, Kgabo also completed the personal meaning map. Figure 11 represent the personal meaning map of Kgabo.

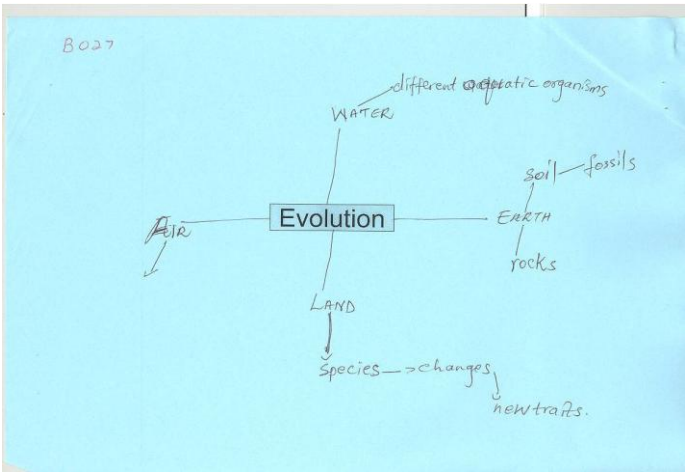

Figure 11: Kgabo's personal meaning map

The data given by Kgabo were completely irrelevant to the prompt word "evolution". She mentioned words such as air, water, land, earth, rocks, soil and different aquatic organisms. The words such as fossils, changes and new traits related with evolution but they were wrongly connected. The findings of the data presented by Kgabo revealed that did not show any knowledge gain. This may be influenced by the fact that she did not believe the information presented and the exhibits displayed.

4.5.2.5. Des's knowledge about evolution

Des was one of the teachers who were teaching Grade 12 Life Sciences for the first time in 2009. Just like some teachers in my study, Des did not have sufficient content knowledge of evolution. This assertion is supported by the fact that he did not answer many questions during the pre- and post-visit. Des was also asked to complete the personal meaning map. Figure 12 represent his personal meaning map which was completed during the post visit.

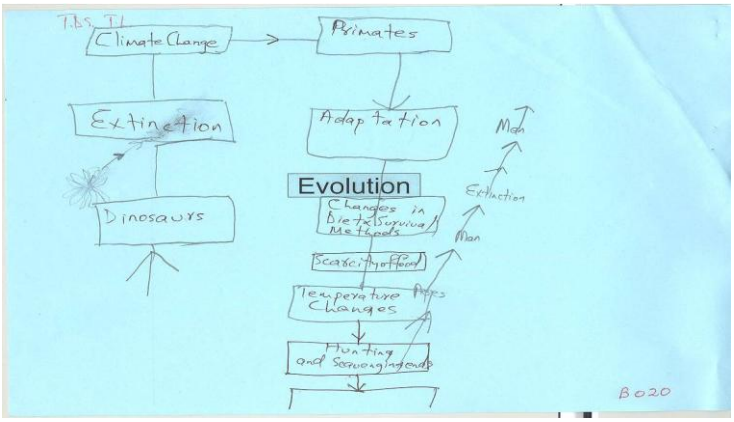

Figure 12: Des's personal meaning map

The personal meaning map of Des was completely different from other teachers because he drew a flow diagram. I assume that he did not understand what he was expected to do. Although he did not connect his data to the prompt word, I continued to analyse the data provided. The data given were not explained and therefore it was difficult to conclude whether Des has gained knowledge. Although there was no explanation, they were some words which were slightly related to evolution and those words were dinosaurs, extinction, climate change, primates and adaptation. These words were related to what was displayed in the exhibition halls. For example, different fossils of dinosaurs were displayed in the exhibition hall. I anticipate that the museum tour influenced Des to remember these words. Des also mentioned words which were not related to evolution and this includes words such as "changes in diet and survival methods, scarcity of foods and hunting and scavenging ends".

The finding of this PMM revealed that pre-knowledge is essential for a person to make sense of what is displayed in the museum. In this case Des could not connect what he saw during the museum tour with what was done during the presentation. However, I acknowledge that the presentation that was made before the museum tour was not enough for teachers who did not have the pre-knowledge of evolution since it was very short.

4.5.2.6. Mafika's knowledge about evolution

Mafika is one of the teachers who affirmed that they did not teach evolution in 2008 due to lack of content knowledge. During the post visit Mafika completed the personal meaning map. Unlike other teachers who wrote little information or nothing,

Mafika attempted to give enough information. However, most of the information given was irrelevant to the prompt word "evolution". Figure 13 showed below represent the personal meaning map of Mafika.

As I was analysing the data, I discovered that Mafika attempted to write four key words such as:

- Macro evolution.
- Microevolution.
- Bush man feet.
- Modern African.

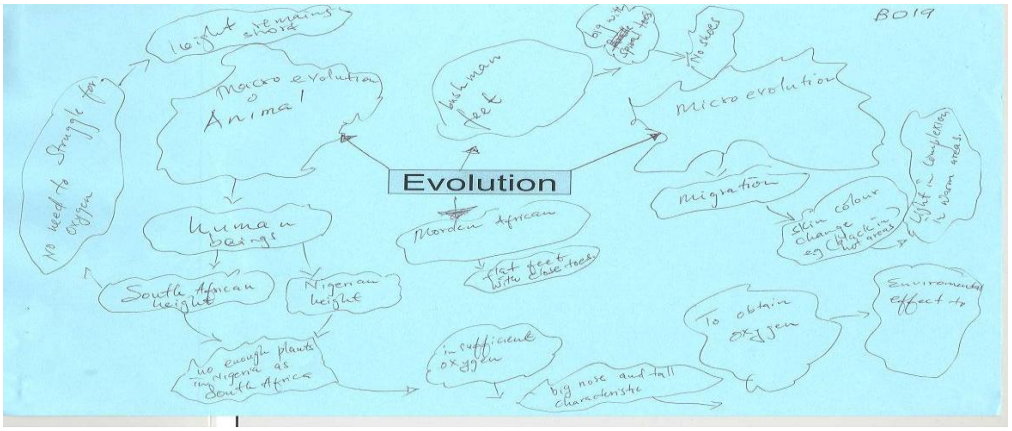

Figure 13: Mafika's personal meaning map

The above mentioned key words were related to the prompt word "evolution" except the bushman feet. One of the key words that Mafika tried to give enough information was macroevolution. He associated this key word with human beings. According to Mafika the word macroevolution explains the height of human beings and the availability of oxygen. The information given was completely irrelevant since macroevolution is the study of common ancestry and its type of evidence cannot be seen (indirect evidence). They were many original fossils that were displayed in the showrooms. The availability of these fossils would have triggered Mafika's mind if he had the content knowledge or pre-knowledge.

The second key word that he tried to explain was microevolution. The immediate word that Mafika connected to microevolution was "migration" and this word is

relevant to evolution. Raven, Johnson, Losos and Singer (2008) explain migration (gene flow) as the movement of alleles from one population to another. Mafika also gave an example of a skin colour change or human complexion. This example is relevant to microevolution since the change may be caused by changes in the gene pool of a population. In this key word Mafika showed to have gained a little knowledge about microevolution since this topic was also covered during the presentation. In one of the showrooms, a picture of people with different colours was displayed. I assume that this picture might have triggered Mafika's memory and easily related it with what he has learnt during the presentation.

The third key word was "bushman feet" On this key word I assume that Mafika wanted to write about the fossil of "little foot". Although he managed to identify this key word, the information that he gave irrelevant. However, I acknowledge that the information given in the museum would not be enough to elaborate unless the person had the pre-knowledge. The fact that Mafika remembered that (although he wrote it incorrectly) shows some limited knowledge gain.

The fourth key word was "Modern African". According to him, the modern African had flat feet with close toes. I anticipate that Mafika associated this key word with the hominids that were displayed in one of the showrooms. These models show the physical appearance of a homo sapiens and a modern human being. Mafika managed to see that physical appearance of the models that they were different and hence he mentioned the flat feet with "close toes". Although he could not explain much about the hominids, the information given showed that he has constructed the new knowledge about evolution.

The data written on Mafika's PMM revealed that he did not have much pre-knowledge of evolution and this made it difficult to connect the fossils with macroevolution irrespective of being through the topic during the presentation. As suggested by Piaget cited in Hausfather (2001) that for the person to construct new knowledge, the previous knowledge is essential. In this study, it was difficult for Mafika to accommodate and assimilate the learning which was presented and seen during the visit. Furthermore, the information he gave showed that he seemed to be

struggling to put his thoughts together hence he mentioned words such as oxygen and height. The personal meaning map showed that due to lack of knowledge Mafika failed to differentiate the scientific validation of evolution (Rutledge and Mitchell, 2002).

In summary, the personal meaning maps showed that the Grade 12 Life Sciences teachers who had strong religious beliefs showed to have gained knowledge after they were taken through the museum tour and presentation. This was attributed by the fact that teachers gave some of the exhibits displayed in the exhibition halls. However, they were teachers who maintained their religious beliefs even after they were taken through the presentation and museum tour. The findings also reflected teachers who did not have a content knowledge about evolution provided irrelevant information on their personal meaning maps.

4.6. Conclusion

The results of this study show that the acceptance of evolution in both Grade 11 and 12 Life Sciences teachers who participated in this study was affected by their intuitive ideas and personal beliefs. Although there was some proof of knowledge gain in other questions or statements of the questionnaires, the concept of evolution still appears to be difficult for some teachers as they did not answer some of the questions or statements. The study reveals that the museum tour and presentation changed the attitude of some teachers who were not prepared to teach evolution. After teachers were exposed to different original fossils and models, their attitudes towards teaching evolution became positive.

The Grade 12 teachers also completed personal meaning maps which were designed to check their pre-knowledge about evolution and whether they had gained knowledge after the visit. This technique revealed that some teachers did not have the pre-knowledge about evolution.

In chapter five, all the data collected analysed will be summarised and conclusions will be drawn from the findings. Furthermore, the recommendations and implications of the study will be discussed.

Chapter 5

Conclusions, Recommendations and Implications

5.1. Introduction

This chapter presents the conclusions, recommendations and implications of my study. The findings and the recommendations of this study are particular to Gauteng West District which is situated in Gauteng province (South Africa).

5.2. Findings

The Grade 11 and 12 Life Sciences teachers who attended the workshops that were held at Maropeng Visitors Centre were given pre-visit and post-visit questionnaires. During the pre-visit questionnaire, teachers were expected to answer eight questions and those questions covered the first three sub-questions mentioned above. The first five questions and question eight were designed to check the knowledge level of teachers before and after the museum visit. Questions six and seven were designed to determine the attitudes of teachers towards teaching evolution.

After the museum tour and presentation, teachers were expected to answer the same questions that they answered during pre-visit with an addition of two new questions. The last two questions were intended to answer the fourth sub-question which was designed to check whether teachers would identify any exhibits that they think will assist them towards teaching evolution. In addition, the Grade 12 teachers were asked to complete personal meaning maps as discussed in section 3.5.

5.2.1. What is the knowledge level of Grade 11 and 12 Life Sciences teachers about evolution?

Good subject content knowledge of Life Sciences teachers about evolution is essential as it will assist teachers to deliver the subject matter with confidence. Furthermore, teachers' prior knowledge is needed to ensure that the resources that are found in the museums are used effectively. The literature revealed that prior knowledge is essential

as it will assist in connecting with the new knowledge provided by the museum (Matusov and Rogoff, 1995; Hein, 1998). The findings listed below are deduced from the data collected during the pre-visit questionnaire.

- In order to check the knowledge level of both Grade 11 and 12 Life Sciences teachers, the participants were asked to define the word "evolution". During the pre-visit, the findings of my study revealed that 59% of the Grade 11 teachers gave a correct definition of evolution while only 7% of the Grade 12 teachers gave the correct definition. Furthermore, the finding also revealed that 41% of the Grade 11 and 93% of the Grade 12 Life Sciences teachers gave the incorrect definition of evolution. Although the Grade 11 teachers had never taught the topic of evolution in their teaching careers as discussed in section 3.4, I assume that they had an existing knowledge which might have been acquired from text books, newspapers, magazines, and other informal sources (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003).
- Teachers were also given a misconception statement "evolution explains the origin of life". As mentioned in section 4.4.1, a misconception statement is a statement which is inconsistent with the scientifically accepted conception. The purpose of using this statement was to check whether teachers will agree or disagree with it. Furthermore, teachers were asked to substantiate their answers. The findings of this statement revealed that 55% of the Grade 11 and 67% of the Grade 12 Life Sciences teachers had a misconception about the origin of life. This was attributed by the fact that they agreed with the misconception statement. The study also revealed that 41% of the Grade 11 and 18% of the Grade 12 teachers who disagreed with the statement had strong religious beliefs. These teachers have explained that life is created by God. The findings of this question revealed that lack of subject content knowledge and individuals' religious beliefs may impede their knowledge level about evolution. According to Rutledge and Mitchell (2002), teachers' academic background and personal religious beliefs may be seen as a contributing factor towards the teaching of evolution. Furthermore, Stears (2006) revealed that lack of content knowledge was a serious concern in the teaching of evolutionary theory. Matthews (2001) has affirmed that the teaching

of evolution in New York was rejected by teachers since most Biology (Life Sciences) teachers hold non-scientific views about the origin of life.

- Question three on the questionnaire was based on the topic of genetics. The topic of genetics was included in the South African old curriculum. Therefore, I assumed that almost all teachers would have existing or prior knowledge as they should have taught the topic of genetics or heredity before. This assertion was guided by the fact that the Life Sciences teachers who participated in my study have been teaching Life Sciences or Biology for the past five years. During the pre-visit questionnaires, the findings of my study revealed that 59% of the Grade 11 and 85% of the Grade 12 Life Sciences teachers gave the correct explanation of genetics. However, there were 36% of the Grade 11 and 15% of the Grade 12 Life Sciences teachers who provided answers which were not related to genetics. This implies that most of the teachers who participated in my study had some content knowledge of genetics or heredity.
- Another misconception statement was "organisms existing today are the result of evolutionary processes that have occurred over millions of years". The study revealed that 68% of the Grade 11 and 70% of the Grade 12 Life Sciences teachers had misconceptions during the pre-visit. The study also revealed that more than 20% in both Grades held religious beliefs view. I assume that the misconceptions or erroneous ideas and religious beliefs views that teachers had may be caused by lack of content knowledge. Literature has shown that parents at Washington and Tennessee believed that the universe has been the same for many years ago and therefore they opposed the teaching of evolution as they believe it contradict their religious beliefs (Paterson and Rossow, 1999; Berkman, Pacheco and Plutzer, 2008). In my study, both Grade 11 and 12 Life Sciences teachers seemed to believe that organisms do not change and hence their argument was based on religious beliefs. Furthermore, these were the same teachers who mentioned that they are not prepared to teach evolution as it contradicts their religious beliefs.
- Question five consisted of an evolution quiz with ten statements of which eight were misconceptions. During the pre-visit questionnaire, the findings revealed that only 39% of the Grade 11 and 41% of the Grade 12 Life Sciences teachers had good content knowledge. The data also revealed that there were 35% teachers in

both Grades who showed lack of content knowledge and such teachers agreed with the misconception statements. Therefore, I assume that they had misconceptions or erroneous ideas about the topic of evolution. For example, during the pre-visit questionnaire 77% of the Grade 11 and 85% of the Grade 12 Life Sciences teachers agreed with the misconception statement, Survival of the fittest means basically that "only the strong survive". The findings also revealed that there were more than 20% Life Sciences teachers who chose undecided. I assume that these teachers may be confused by the statements given as they do not have sufficient content knowledge. One of the common misconception statements that cause conflict among the community is "Humans developed/evolved from apes". This statement contradicts with many religious believers such as Christians as they believe that everything in the universe including man was created by God (Gauld, 1992). The interpretation of the statement "Humans developed/evolved from apes" may imply that humans were apes before and changed into who they are today. The findings of my study revealed that 37% of the Grade 12 and 27% of the Grade 11 Life Sciences teachers have agreed with the statement. However, there were 55% of the Grade 11 and 33% of the Grade 12 teachers who disagreed with the misconception statement. During the pre-visit questionnaire it was difficult to conclude that teachers who disagreed with the misconception statement had good content knowledge of evolution since there was no explanation made. This assertion was attributed to the fact that teachers who had religious beliefs would still disagree with the statement since they believe that humans are created by God.

- In question eight teachers were asked to explain fossil formation. The findings of the pre-visit questionnaires revealed that 41% of the Grade 11 and 26% of the Grade 12 Life Sciences teachers gave the correct explanation of the fossil formation. However, there were 59% of the Grade 11 and 74% of the Grade 12 teachers who could not give the correct explanation of fossil formation. This implies that a large number of Life Sciences teachers who participated in my study did not know how fossils are formed.

5.2.2. What are the attitudes of Grade 11 and 12 Life Sciences teachers towards teaching evolution?

The attitude of teachers may either affect the teaching of evolution negatively or positively. According to Ediger (2002), a good quality attitude towards science is an important tool in teaching and learning. Whatever the kind of attitudes teachers may develop towards the teaching of evolution may either encourage or discourage them towards teaching the topic. Osborne (2003) confirms that there is a relationship between attitudes and behaviour.

In order to identify the attitudes of teachers about the teaching of evolution, they were asked to tell how they feel about teaching evolution. Furthermore, they were also asked to elaborate what influenced their attitude towards teaching evolution. The study revealed that the 68% of the Grade 11 and 78% of the Grade 12 Life Sciences teachers were not prepared to teach evolution. The results also revealed that 27% of the Grade 11 and 45% of the Grade 12 teachers were negatively influenced by their religious beliefs. Furthermore, the results showed that 27% of the Grade 11 and 11% of the Grade 12 teachers mentioned that the topic of evolution confuses them. This implies that the personal religious beliefs and lack of content knowledge of teachers may affect the teaching of evolution. Research has shown that teachers' personal and/or social beliefs may interfere with the acceptance and understanding of evolution (Matthews, 2001; Rutledge and Mitchell, 2002; Cavallo and McCall, 2008). Furthermore, Stears (2006) also mentioned that poor understanding of evolutionary theory was perceived as another factor that may influence the acceptance of the theory. The results mentioned above revealed that the attitudes of teachers did not change as they mentioned that they are not willing to teach evolution. Chuang (2003) affirmed that teachers' attitudes about evolution may affect the process of teaching and learning. Jarvis and Pell (2004) also mentioned that negative attitudes towards science may contribute to the reduction of attainment in the classroom.

However, the findings of my study also revealed that 32% of the Grade 11 and 22% of the Grade 12 teachers were willing to teach the topic of evolution. The positive

attitude of these teachers is influenced by their love for children and passion for teaching. This made me to speculate that some of the teachers who taught evolution in 2008 did it not because they had sufficient knowledge but because they had to complete the work schedule or syllabus. The study conducted by Matthews (2001) also revealed that some teachers supported the idea of evolution irrespective of different ideas and controversy. The findings of my study also revealed that 32% of the Grade 11 and at least 4% of the Grade 12 Life Sciences teachers were willing to teach evolution and that attitude was influenced by the visit. This implies that the exposure of teachers to different exhibits and presentations made teachers to change their attitudes. Asghar, Wiles and Alters (2007) affirmed that exposure to evolution may increase teachers positive attitudes towards teaching evolution. Ediger (2002) mentioned that a good quality attitude towards science is an important tool in teaching and learning

5.2.3. Do the knowledge and attitudes of a sample of teachers change after a workshop and a visit to the science centre? If so, how?

After the museum tour and presentation, both Grade 11 and 12 teachers were given the post-visit questionnaire containing the same questions as the pre-visit questionnaire. The data collected during the post-visit questionnaire revealed several findings which are either positive or negative; they are listed below and they are put in order of questions.

- Both Grade 11 and 12 Life Sciences teachers have gained a considerable knowledge about the definition of evolution. This finding was guided by the fact that 59% of the Grade 11 and 33% of the Grade 12 Life Sciences teachers managed to give a proper (scientifically correct) definition of evolution. However, there were 41% Grade 11 and 67% Grade 12 teachers who gave the incorrect definition of evolution irrespective of the presentations and museum tour provided. This may imply that the construction of new knowledge gained during the museum tour and presentations may not be possible unless a person has existing or previous knowledge of the subject content. Research has shown that individuals construct new knowledge from their previous knowledge through the

processes of accommodation and assimilation (Hausfather, 2001). The data of my study showed that the majority of both Grade 11 and 12 Life Sciences teachers gave wrong definitions and in some instances misconceptions ideas. Due to the presentations made and the exhibits displayed in the exhibition halls new knowledge was constructed as they provided the correct definitions. Hein (1998) affirmed that museum visits may play an integral part in connecting peoples' pre-knowledge and new knowledge. His study also asserts that the attribute of any theory of constructivism ascertains that the educational situation of learners should be associated with what they already know. This may imply that the construction of new knowledge may be a challenge visitors do not have the existing or prior knowledge.

- The Grade 11 and 12 Life Sciences teachers who participated in my study maintained their misconceptions or erroneous ideas and religious view about the statement "evolution explains the origin of life". These teachers were taken through the museum tour and presentations. The results revealed that 82% of the Grade 11 and 81% of the Grade 12 teachers agreed with the misconception statement. Furthermore, they were 4% of the Grade 11 and 15% of the Grade 12 teachers who maintained their religious beliefs view about the statement. However, there were 14% of the Grade 11 and 4% of the Grade 12 Life Sciences teachers who showed to have gained knowledge about evolution as they disagreed with the statement and provided the correct explanation mentioned in section 4.4.1. This implies that the availability of evolution evidence at the museum and the information provided during the workshop may not change the belief of teachers about the origin of life. I assume that this may be caused by lack of content knowledge, misconceptions ideas and religious beliefs view of teachers. Literature has affirmed that intuitive ideas, misunderstandings and the influence of strongly held personal beliefs may affect the teaching of evolution (Rutledge and Mitchell, 2002; Cook, 2009).
- During the post-visit questionnaires, the findings of question three revealed that the Grade 11 Life Sciences teachers who gave the correct explanation about the aspects of genetics increased to 64% whereas the Grade 12 results remained 85%. Furthermore, the findings revealed that 36% of the Grade 11 and 15% of the Grade 12 Life Sciences teachers did not show any knowledge gain about

evolution. This implies that teachers who participated in my study had a good knowledge about aspects of the topic of genetics. However, there were teachers who mentioned that the acquired characteristics may be caused by evolution.

- The findings of question four which is a misconception statement "Organisms existing today are the result of evolutionary processes that have occurred over millions of years" revealed that 86% of the Grade 11 and 74% of the Grade 12 Life Sciences teachers agreed with the misconception statement. The findings also revealed that 9% of the Grade 11 and 19% of the grade 12 teachers had a religious view about the existence of organisms. This implies that the museum visit and the presentation did not change the religious view and misconceptions ideas that teachers held about the existence of organisms. Although the museum had different exhibits such as hominids, the individuals' beliefs seemed to have affected the learning of evolution and hence the construction of new knowledge was impossible. Literature has shown that individuals' beliefs may have an influence on the learning of evolution (Cavallo and McCall, 2008). This may imply that when the process of teaching is taking place, visitors may interpret what they hear according to their own knowledge and experience (Ackermann, undated: 3). During the process of assimilation, an individual incorporate the new experience or knowledge into an existing framework without changing that framework (Bhattacharya and Han, undated). Through assimilation, individuals may fail to change any faulty understanding and hence teachers in my study could identify misconception statements.
- After the museum tour and presentation, the findings of the evolution quiz consisted of eight misconception and two conception statements revealed that 50% of the Grade 11 and 66% of the Grade 12 Life Sciences teachers have gained knowledge about evolution. These teachers have agreed with conception statement and disagreed with the misconception statements. For example, 59% of the Grade 11 Life Sciences teachers agreed with the misconception statement "humans developed/evolved from apes". In contrast, at least 74% of the Grade 12 Life Sciences teachers showed to have gained knowledge about evolution as they disagreed with the misconception statement. I assume that social interaction with the exhibits and tour guides including the presenters has brought the prior knowledge to the surface and allowed teachers to construct new knowledge

(Hausfather, 2001). However, teachers as members of society have particular misconceptions or erroneous ideas about evolution. Therefore a visit to the museum may assist teachers in gaining new knowledge which may eradicate (or reinforce) misconceptions and erroneous ideas about evolution. This implies that some misconceptions may not be changed by the museum visit and/or presentations.

- During the post-visit questionnaire, the findings of question six revealed that at least 68% of the Grade 11 and 63% of the Grade 12 Life Sciences teachers were willing to teach the topic of evolution. In contrast, 13% of the Grade 11 and 18% of the Grade 12 teachers mentioned that they are not prepared to teach evolution as it contradicts their religious beliefs. In summary, the number of teachers who are willing to teach evolution and those who were not prepared to teach evolution due to their religious beliefs has decreased. This implies that the topic of evolution may be accepted if teachers could have enough content knowledge. Ayala (2008) affirmed that other religions such as Christianity, Islam and Judaism have accepted evolution. He also mentioned that Pope Pius XII, Pope John Paul II and the current Pope Benedict XVI have denied that evolution contradict with religious beliefs.
- After the Grade 11 and 12 Life Sciences teachers completed the museum visit and presentation, the findings of question seven revealed that 87% of the Grade 11 and 74% of the Grade 12 teachers were prepared to teach the topic of evolution. These teachers mentioned that their positive attitude towards the teaching of evolution was influenced by museum visit, love for learners, eager to learn and passion for teaching. I assume that these teachers might have seen the importance of evolution in Life Sciences. According to Weld and McNew (1999), teachers at Oklahoma in USA were prepared to teach evolution as they perceived it as a unifying theme in Biology (Life Sciences). However, the findings also revealed that 4% of both Grade 11 and 12 teachers were not prepared to teach evolution since it is against their religious beliefs. Furthermore, 11% of the Grade 12 teachers mentioned that their negative attitude towards the teaching of evolution was influenced by past education system, lack of content knowledge and lack of evidence.
- During the post-visit questionnaire, the findings of question eight revealed that 73% of the Grade 11 and 52% of the Grade 12 Life Sciences teachers gave the

correct explanation of fossil formation. This may imply that the availability of fossils in the exhibition hall and the explanation thereof had led teachers to gain knowledge about the fossil formation and evolution in particular. Dempster and Hugo (2006) affirmed that informal science institutions may assist in facilitating the teaching of evolution. Therefore, the explanation of fossil formation enhanced knowledge gain as teachers were exposed to the real world experience (Dierking *et al.*, 2003).

- Lastly, the Grade 12 Life Sciences teachers were asked to complete a personal meaning map (PMM). The findings revealed that 83% of Life Sciences teachers have gained knowledge about the topic of evolution after they were taken through the museum tour and the presentation. However they were 10% of teachers who did not complete the PMM. Furthermore, the study also revealed that 7% of teachers gave irrelevant information. This implies that 17% of Life Sciences teachers who attended the Grade 12 workshop did not gain knowledge about evolution and hence they gave incorrect information about the topic of evolution. Although the findings cannot be compared to the knowledge that teachers had before the museum tour and workshop, it is evidence that the museum and the workshop had a positive influence on the knowledge gained by teachers. Chin (2004) affirmed that a science museum can be treated as a "novel environment" for the teaching and learning of science. Therefore the well organised museum visit may assist teachers to be fully engaged with exhibition and also the interpretation of exhibits (Tal *et al.*, 2005; Kisiel, 2006). The studies conducted by Astor-Jack, McCallie and Balcerzak (2005) and Tran (2005) revealed that informal science institutions play an important role in providing teachers with content knowledge.

5.2.4. What aspects of the workshop and science centre influenced their knowledge about and attitudes towards teaching evolution?

In order to identify whether teachers have acquired knowledge about the teaching of evolution from the exhibition halls, they were asked to identify some few exhibits that they think may have influenced their knowledge about evolution and attitudes towards teaching evolution. The findings revealed that teachers believe that the visit to

museum has influenced their knowledge and attitudes towards teaching the topic of evolution. This is evidenced by the fact that 77% of the Grade 11 and 52% of the Grade 12 Life Sciences teachers gave several exhibits displayed in the museum. Amongst others they mentioned exhibits such as hominids, evidence of the fossils, the slides of continental drift, DNA structure and skulls. This showed that the museum contained resources that can be used to teach evolution. Dempster and Hugo (2006) have affirmed that the teaching of evolution in South Africa can be possible due to the availability of rich natural resources. Furthermore, research has shown that informal science institutions may assist in facilitating the teaching of evolution since it contains different teaching models, objects and text (Chin, 2004; Tal *et al.*, 2005; Dempster and Hugo, 2006).

5.3. Implications

The purpose of this study was to determine the extent to which a visit to an informal science institution can enhance teachers' understanding of evolution. As it was mentioned in chapter 2, South Africa is rich with natural resources that can be used to facilitate the teaching of evolution in a learner-centred and experientially rooted manner. Those natural resources are located in the institutions such as museums, zoological gardens, botanical gardens and so on. It is important for teachers to utilise informal science centres. In the policy guideline of Life Sciences, teachers were encouraged to utilise the informal science centres that are available to teach topics such as evolution. This is due to the fact that they contain different specimens, models, objects and text (Chin, 2004; Tal *et al.*, 2005).

To ensure that the resources that are available in the informal science centres are used, teachers should organise educational tours. The purpose of organising educational tours is to expose learners to the real objects and specimens that cannot be brought to the classroom settings. The tour should be well planned in such a way that it is linked to the content which is already done or what the teacher is doing. This may assist learners to assimilate and accommodate new information which may be linked to their pre-knowledge. The pre-knowledge may be in the form of what they already learnt or learning in the classroom context. Teachers also play an important role in providing

learners with activities that may compel them to learn as they are socialising. Furthermore, teachers are expected to have the discussion with learners before the fieldtrip. The purpose of that discussion is to explain the purpose of the excursion, the materials they should bring along and to orientate learners about the settings of the centre. It is essential that the organiser knows the settings of the centre to be visited. Teachers who accompany learners should have the content knowledge as he or she will be part of the discussion when learners are interacting with different objects. Furthermore, teachers may also play a role in answering some of the questions raised by learners.

The informal science centres may provide misconceptions or erroneous ideas to teachers or visitors if the tour guides do not have sufficient content knowledge. To ensure that the information given to the visitors are not misconceptions or erroneous ideas, the tour guides should be well trained. The training will assist tour guides to be more confident when they are asked questions by visitors. Although science centres are known to have good resources that can assist in teaching sciences, it is essential that those resources are thoroughly checked since they may be interpreted differently by visitors. For example, the findings in the previous section showed that some of the teachers' misconceptions could be changed since the resources displayed in the museum reinforced them.

According to Matusov and Rogoff (1995), a museum is a place which is visited by different people with different cultures and/or beliefs. Each culture or society may have a different interpretation of what is displayed in the museum. This implies that museum visitors participate in wider cultures, institutions and practices (Scott, 2007). Therefore, what ever learning that occurs in the museum is guided by previous insight and experience of visitors. As mentioned in section 5.2.3, the religious beliefs of visitors may negatively have an impact on the assimilation and accommodation of new knowledge about evolution. To ensure that the centre does not contradict with the religious beliefs of visitors, I suggest that the tour guides should include some information about creationism when they explain the concept of evolution. The purpose of bringing in creationism is to try to alleviate the fear of evolution being contradicting with creationism. However, I acknowledge that explaining evolution

parallel with creationism may be a challenge if a tour guide is not well equipped. This suggestion may be possible provided the tour guides are given a proper subject content training as it will assist them to participate in any arguments that emerge.

5.4. Recommendations

The recommendations listed below were drawn from the analysis of the study, literature related to this study and my own experience.

- An intensive content-based workshop is essential before teachers visit the museum or informal science institutions. This will provide teachers with the content knowledge which may be required during the museum tour. The knowledge gained during the workshop may also be stimulated as teachers interact with the models displayed in the exhibition hall.

- The curriculum should encourage teachers to use the natural resources available in the informal science institutions such as museums. Some of the assessment tasks should encourage teachers to use out of school learning since it may promote learning which may lead to the development of inquiry and interpretation skills.

- It is essential that the informal science institutions should visit schools and district offices. The purpose of the visit should be to inform teachers and subject advisors about the educational information available at those centres. Furthermore, the visit will assist schools with first hand information especially those schools that do not have an access to internet. The information given may assist teachers in planning the field trip as they will be having sufficient knowledge about the settings of the centre. Teachers will be encouraged to participate when they visit informal institutions because they will be having enough information about the centre.

5.5. Limitations

The study was conducted with the Grade 11 and 12 Life Sciences teachers who managed to attend the workshop that was held at Maropeng visitors Centre. The

majority of Life Sciences teachers who were teaching at the ex model C[4] schools did not attend the workshop. Therefore, the results of my study could not be generalised because only 49 Life Sciences teachers attended the workshop. Furthermore, the teachers used in this study were from one district in Gauteng province. The outcome of my study cannot be generalised because it focuses on one museum in South Africa and in particular Gauteng province. The personal meaning mapping technique that was administered to the Grade 12 Life Sciences teachers was not well conducted since I could not identify the pre- and post-visit maps. This made it difficult to compare the knowledge that teachers had before the museum tour and presentations with the knowledge that teachers might have gained after the museum tour and presentation. Furthermore, teachers who completed the personal meaning maps were not interviewed as this would have helped me to probe further the information that they could not write due to lack of time. Both Grade 11 and 12 Life Sciences teachers were given pre- and post-visit questionnaires. Some of the statements in both questionnaires were ambiguous. For example, it would be difficult for person who does not have enough content knowledge of evolution to provide a correct answer to the statement "humans evolved/developed from apes". Therefore, it is important to check the type of questions or statements used in the instrument before implementation.

5.6. Conclusions

In this study I have investigated the extent to which a visit to an informal science institution can enhance teachers' understanding of evolution. This study was driven by the fact that the topic of evolution was new in the South African curriculum. Furthermore, teachers were lacking content knowledge since many of them did not do evolution at tertiary institution such as colleges (Stears, 2006; Ngxola and Sanders, 2008). The intention of my study was to find out whether a visit to a themed science centre influences Life Sciences teachers' knowledge about evolution and attitudes towards the teaching of evolution. I used four sub-questions to design the research instruments. These instruments were given to the Grade 11 and 12 Life Sciences

[4] Ex model C: refers to schools which are located in towns and were accommodating white learners only.

teachers who attended a workshop which was held at Maropeng Visitors Centre. This study has revealed that lack of content knowledge may prevent visitors to acquire new knowledge.

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APPENDICES

Appendix A: Pre- and post visit questionnaire

A. What does the word "evolution" in Life Sciences mean? **CODE: _____**

B. Do you agree with the following statement? Evolution explains the origin of life.

Tick on the relevant box and give a reason for your answer.

	Reason
Yes	
No	

C. If one of your learners asks the following question, if a person lost an eye during an accident, why would he or she not produce a child with one eye? **How would you answer him or her?**

D. Do you agree with the following statement? Organisms existing today are the results of evolutionary processes that have occurred over millions of years. **Tick on the relevant box and give a reason for your answer.**

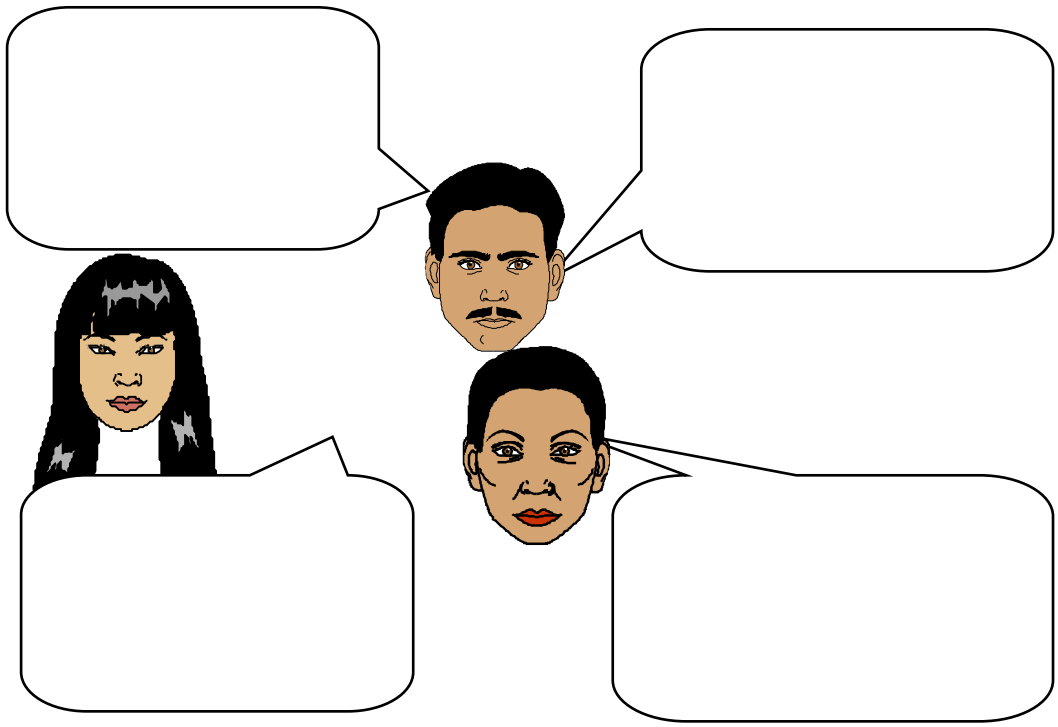
	Reason
Yes	
No	

E. Evolution Quiz

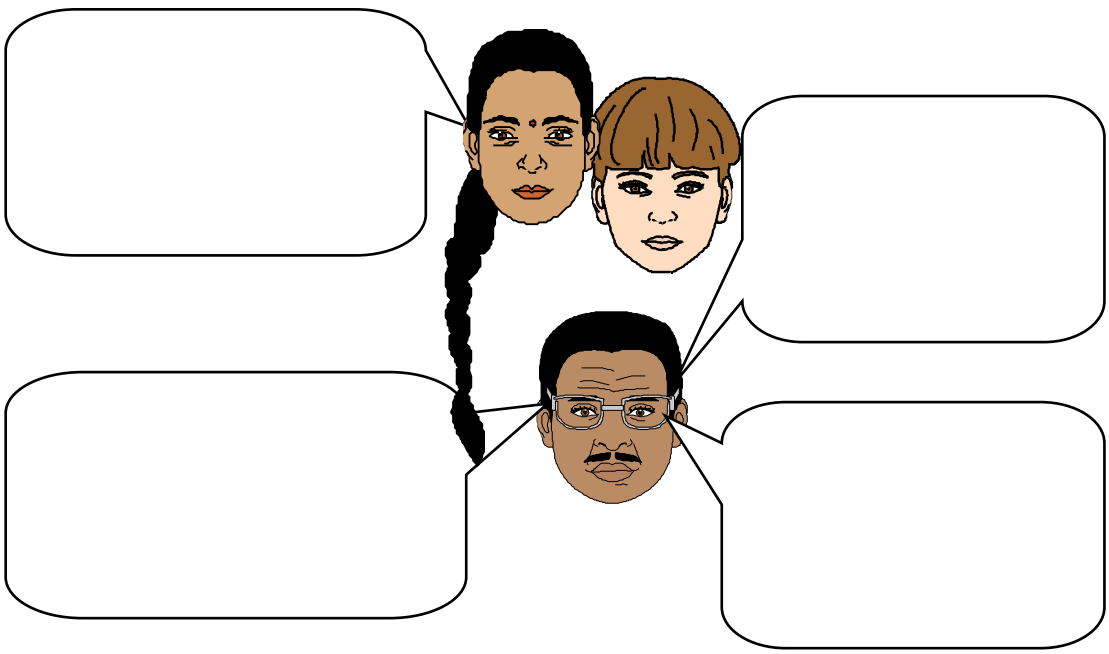
Statements	**Disagree**	**Agree**	**Not sure**
1. Humans developed/evolved from apes.			
2. There is no evidence for evolution, it is just a theory.			
3. Organisms have always looked the way they look today.			
4. Survival of the fittest means basically that "only the strong survive".			
5. Darwin was the first person to suggest that evolution occurs.			
6. The theory of evolution cannot be correct since it disagrees with religious accounts of creation.			
7. Humans and chimpanzees evolved separately from an ape-like ancestor.			
8. The age of the Earth is approximately 4-5 billion years.			
9. Evolution has taken place in order for humans to develop.			
10. Life appeared on Earth less than 10,000 years ago.			

Attitudes

F. What are your feelings about teaching evolution?

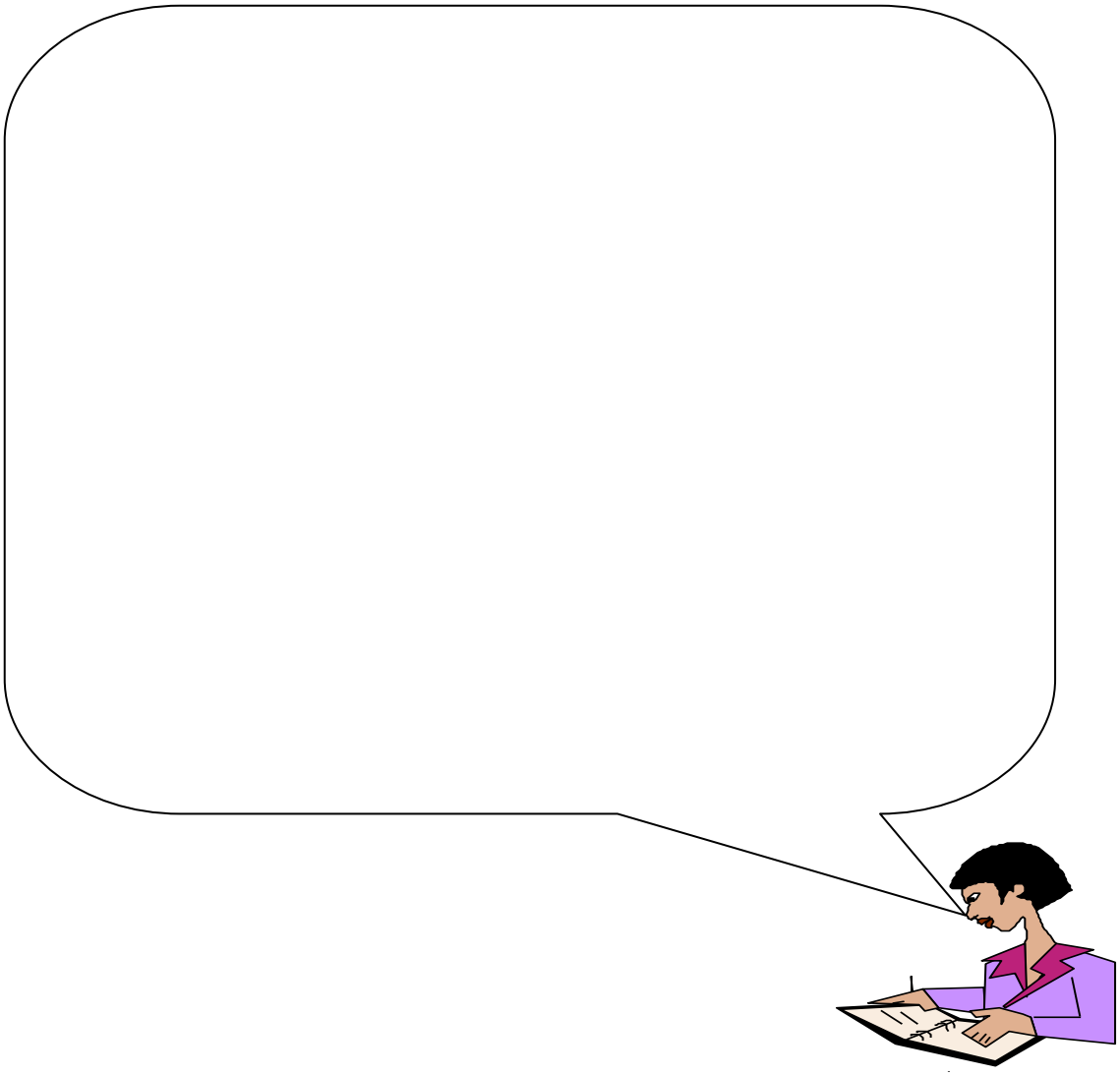


G. State briefly what influenced your attitude towards teaching



H. Briefly explain how fossils are formed.

I. Describe up to three exhibits you have seen during the tour that you think may have an influence on your understanding of evolution. What influence did you have?



J. Do you think what you have seen during the tour will assist you towards teaching evolution?

	Reason
Yes	
No	

Appendix B: **Data completed by participants during pre- and post visit**

A. What does the word "evolution" in Life Sciences mean?

CODE NO	PRE-VISIT	POST VISIT
1	It means change of organisms over a long period (millions of years) of time.	• The change of organism over millions of years • Adaptation of organisms to new environment
2	Origin of life	The origin of life where diverse individual came about
3	The process whereby modification or changes of ancient organism to the present organisms to adapt to their environment	The existence of old organisms from the old ones
4	Evolution is the origin of life or the study of life	Evolution is the origin of life
5	Life science take the word evolution to mean that all living things have "evolved" i.e. are what they are today due to changes which they have undergone either due to the environment in which they live or genetically	Means that organisms have changed slowly each time as a result of environment or genetically.
6	Gradual changes that happen within different species, resulting in new form of life (evolved) species, which will be adaptable to the changing environment. These changes are random and only those features which will advantage a particular species will be dominant for survival purposes	The gradual changes that take place within different species in order to survive within the forever changing environment. Organisms evolve due to natural selection, and survival of the fittest. Organisms evolve because there's a need for it, not that they want to evolve.
7	The change in anatomy and the physiological process that place in living organisms from time to time and how it affects our behavioral patterns, interaction and natural selection coupled with adaptation	It means changes taking place with regard to our anatomy; physiology; behavior interaction
8	Gradual change of organisms due to genetic changes or environmental factors	Changes that occur gradually in species due to changes in the environment and genetic make up
9	Change of from that takes place over the period of time	The change that occurs over the period of time

10	The beginning of life, how life or organisms originated and gradually changing with time	Adaptation and (human) life changes(physical) due to day to day environmental changes
11	The concept has to do with the origin of life and the changes that occur to the living organisms over millions of years due to physical factors	Theory that indicates how species changed over a million years
12		The change of organisms from pre-historic age to today's organisms due to environmental changes
13	A process of change that living organisms undergo over a long period	Evolution means the changes which take place in living organisms over many years
14	Evolution is a traceable change in form or structure of the biotic factors as a way or act to perform a particular function or to adapt to a given situation	Is the change in form of structure of organisms as a way to adapt to environmental conditions
15	It means changes	The changes that occurs
16	The origin of life. Where different organisms evolved or transformation	It means change in structure of different organisms in order to adapt to the environmental changes
17	Gradual change that took place in life forms that occurred over a long period(millions years) of time	The gradual change of(organism) life forms to other forms that occurred over a billion years
18	Evolution means then exact origin of life and mankind. From the stone-age life was not "civilized" as it is now. Due to certain changes and developments in man resulted in modern life	The change in the development of mankind and the change in life itself over a period in given time
19	Evolution is a change which take place over a long period. Meaning that species have changed since they originated. When you look at them today they are different to the original species	Organisms belong to the same ancestor and they evolved to different organism. These organisms became different because of them adapting to different environment with different climate
20	Evolution – change; adaptation of organisms to changing demand of environment. Various definitions exist – some varying from others	Evolution – adaptations on change in relation to changing environment and demands

21	The change in genetic make-up of a population through time. E.g.: modern humans becoming taller through succeeding generations or the changes that life forms have undergone over long periods of time	It means change that take place one time and this changes lead to diversity
22	The view that all species on earth today are descended from a common ancestor through a process of gradual change over millions of years	Development of organism from another organism e.g. human beings are from the apes

B. **Do you agree with the following statement?** Evolution explains the origin of life. **Tick on the relevant box and give a reason for your answer.**

CODE NO	PRE-VISIT	POST VISIT
1	(NO) I believe in the creation of life by the higher being(god)	(No) Explains how some changes took place in certain organisms
2	(NO) Not how man was created because we do not originate from monkeys	(Yes) It is a theory
3	(NO) Because according to the bible everything originated through the word. I don't know if god is also originated from a living thing	(Yes) Modification takes place million of years for organisms to adapt to their environment not to die out
4	(Yes) As it explains the year of the earth(how old is the earth), when the earth is started	(Yes) Because it explains the change in the gene pool of a population overtime
5	(Yes) It is just an attempt to explain how life originated contrary to religion	(Yes) A theory which is trying to explain the origins of human kind
6	(Yes) It shows us how organisms were naturally selected to adapt to the present environment, and explains where different organisms originated from.	(Yes) It shows us how diversity of organisms came about. It shows us through the timelines, where we all originated
7	(Yes) Because we actually experience how we are related to one another	(Yes) Because it shows how we developed with time in all fundamental features of structure and function
8	(Yes) Because one can follow the development of different species e.g. human from the ancestors to the present day and the development can be clearly observed	(Yes) Because it enables us to see how we became what we are through studying transformation of species over time
9	(Yes) Because all living organisms go through different forms of their	(Yes) All things go through the process of

	structures and shapes	change
10	Yes and No	(Yes) Based on the changes that occurs everyday in life, people need to adapt to this environmental changes in the way they live
11	(No) Because this cannot be easily proven especially when you believe in Christianity	(Yes) After the sight seeing and evidence
12	(No) Biblically these was creation of man and animals including plants	(Yes) Evolution deals with the changes that occurred in the past and are still happening e.g. Viruses
13	Yes	(Yes) It explains the origin of life because there is evidence to prove it
14	(Yes) Conglomeration of the aquatic microbes, which is reflected in some cells of some organisms because of structure and function. Traceable change in mineralogical character on some rocks and stones "others can be mentioned".	(Yes) Since it shows the structural change and genotypical information with different lineages of life
15	(Yes) It informs us about the changes i.e. occurred	(No) It explains the changes that occurred over the years
16	(Yes) It is because I believe that for everything to occur there must be an origin. As the environmental conditions are occurring then the organisms develops traits to adapt to the environmental changes	(Yes) It tells how different species evolved
17	(No) Not all life forms originate from those in existence before	(Yes) According to it all life forms have a common origin
18	No	(Yes) Years ago there was evidence of species that existed before and due to genetic pulling, we experienced some physical changes
19	(No) There is no valid evidence that life have started here. And other things have evolved from this origin	(No) If they can show a real evidence of the first cell. We have seen evidence in the form of egg, bones etc. If it can be the case with origin
20	(No) Religions belief creation	(No) Too many missing

		links
21	(Yes) This is shown clearly by the laboratory investigation by scientists	(Yes) It indicates to us how things and/or organisms came into origin
22	(Yes) All the developmental stages of a human beings are the as that of apes	(Yes) It is the origin of life because we are told that we are from the apes

C. If one of your learners asks the following question, if a person lost an eye during an accident, why would he or she not produce a child with one eye? **How would you answer him or her?**

CODE NO	PRE-VISIT	POST VISIT
1	Because that is an outward or characteristic change that took place not a change in the genes. Genes determine what the child will have or not have.	Because the genes did not change
2	The eye has been lost it cannot be passed from one generation to another, it is not inherited because he had an eye originally	An is the part of the body, it cannot be past or inherited
3	No	No
4	To lose an eye is just an accident, not a heredity thing, for example, a disease like sugar diabetes is a heredity disease, it can affect the child	Losing an eye is not a heredity, it is just an accident
5	Loss of an eye is not inherited. The eye was lost due tom an accident. It is not genetically inherited from parents	A disability from the accident cannot be inherited
6	Because the injury is only physical, it is not genetic, therefore it cannot be passed from that particular individual to the offspring since only genetic features(e.g. abnormalities) can be passed from one generation to another	Because the injury is just a physical deformation but not genetic. Only genetic trends can be passed from one generation to another, from parents to offspring
7	Because the person was not born without an eye e.g. losing an eye is not in his or her genes	Losing an eye is not part of the genes that can be transmitted to the offspring
8	He/she would not produce a one eyed children because a human being's genetic make up which would be transferred to the children is in the sex gametes and these are not affected by the loss of one eye. So the genetic make up is still the same	No because, genes for human parts are in the sex genes. Removing an eye will not have an impact on the child produced
9	The new born baby won't have one eye because the baby is made of the combination of a sperm cell and an egg	The number of eyes is not determined by the physical appearance but the fusion

	which will undergo different steps of growth until the child is visible	of an egg and the sperm cell
10	I will refer him/her to genetics (on how we as human beings inherit from our parents based on the fact that there was no any genetic order (mutation)). Number of chromosomes responsible does not change	Based on genetics and heredity its not possible
11	For a child to be born with both organs this is informed by the genes so in case of an accident heredity has no role to play	Accident is not hereditary, therefore no child could be produced with one eye because he was not born with one eye
12	Due to genes, man has two eyes. The child will always carry original information from the parent	My answer will be based on genetics
13	The loss of the person's eye is not inheritable since it does not involve any genetic changes(or mutation)	This is because his loss/change is not inheritable, since it did not affect the genes(no mutations took place)
14	It takes time (or long period) to evolve a structure. Alleles develop first. Evolutionary structures develop as a way of an organism to adapt, which spread from parent to offspring over decades of development	A lost eye is not an evolutionary change i.e. a change to adapt to environmental condition but accident. So it cannot be reflected into the genotypic information transferred to offspring. It can, it will be recessive and may perish with time
15		Refer them to genetics
16	The child will have both eyes because that is not a disability. He has the genes for developing both eyes	Because the dominant genes in his/her are right/do not have any problem. Unless there is a problem with gene mutation (harmful one). His/her genetic code does not have traits of disability
17	It all lies in the genetic composition of the adult	DNA determines what one would be like, it's all in the genes
18	I would explain that accident resulted in the disfiguration of that individual who was not born in that nature	Being born complete human being and involved in an accident does not mean your disfiguration can influence the change in

		the offspring. i.e. you were born complete not one eyed
19	That's phenotypical, this person has one eye but he or she have genes of two eyes	That's how we look like/ our appearances are not the only make up that we have. Some where in our bodies we have genes which contributes to our make up. The person with one eye can't have children with one eye because he/she have genes of two eyes
20	One would have to use the knowledge of reproduction, meiosis and genetics to explain	You would probably use the knowledge of reproduction, DNA; genetics and meiosis to explain/ distinguish between inherited and acquired characteristics
21	The disability in the body of a parent will not affect the child's body, unless there is a genetic problem in one of the parents. There is meiosis taking place in the sex organs of both parents which enables the parent to produce offspring s which are genetically different to their parents	A child is the product of the mother and the father's gametes. If the eye of the mother is lost it will not affect the development of the child
22	She or he will not produce a child with one eye because is not heredity. He or she can produce one eyed child if the child can inherit from him.	Because it is not heredity. He can produce one eyed child if that particular person was born having one, but it also depends on heredity. He can also have one eye if he had inherited one of his or her parents. It depends on the dominant gene, either from the father or from the mother

D. Do you agree with the following statement? Organisms existing today are the result of evolutionary processes that have occurred over millions of years. **Tick on the relevant box and give a reason for your answer.**

CODE NO	PRE-VISIT	POST VISIT
1	(No) Only if the term evolution refer to the change that took place over years. Not if it means organisms	(No) Organisms have similarities but it does not mean they come from

	evolved(developed) into something else from the initial organism	same ancestor. There are differences; although have DNA
2	(Yes) Some organisms were present in the past e.g. dinosaurs	Yes
3	(Yes) So that the organism should adapt to the environment	(Yes) Because some of organisms have changed million years ago
4	(Yes) Because organisms are from other organisms	(Yes) Organisms are from other organisms
5	(No) Human beings will not change from what they are today into any other form. Other small organisms might change due to environmental and genetic factors	(Yes) Because of the similarities
6	(Yes) Because through the years(in terms of millions), there had been a lot of changes in the environment, therefore organisms had to change (micro or macro) to adapt to it	(Yes) Because of all the changes that had happened to the environment, organisms had to adapt to it, therefore evolved
7	(Yes) Looking at the development, you can see all the changes taking place step by step with time	(Yes) Because of many similarities between us all
8	(Yes) Because for example, we trace human changes that have occurred and the evolutionary processes that have taken place since millions of years ago	(Yes) Because we can trace the development of each species over time
9	(Yes) Since all organisms which we all see today have a different form, it shows that some organs that we used have shown the loss of some cells from them	(Yes) Because of how they look like
10	Yes and No	Yes and No
11	(Yes) As a theory	(Yes) They have changed due to the change in climate and other factors
12	(Yes) Fossils seem to indicate that. Looking at ancient animals there seems to be similarities e.g. underdeveloped limbs in certain aquatic animals	(Yes) There are similarities between the two
13	(Yes)	(Yes) This is true because there are some features which that link modern organisms with their ancestors
14	(Yes) Traceable changes are observable from the previous ones	(Yes) There are traceable information within the different lineages of life
15	(Yes) It was proved scientifically	(Yes) Observed that when

		we were doing the rounds
16	Yes	(Yes) As evolution occurs, organisms change in structure but they are coming from the same origin they do that to develop traits so that they adapt to the changing environment
17	(No) Some might be, but most have been created as they are	(Yes) According to this theory all organisms have a common origin
18		(Yes) The evidence of species existed and the development through time and climate influenced today's species
19		(Yes) Only those who are fitter have been able to survive/ to adapt to the changes or situation
20	(No) Creationist views	(No) Creationism has compelled evidenced to suggest that although organisms can adapt to different circumstances they do not share a common ancestor
21	(Yes) Early life forms followed different pathways of modification with each branch leading to one or more different species.	(Yes) As organisms live, they evolve due to changes that take place in an environment. Organisms develop features that will help them adapt to new changes
22	(Yes) As a result of technology, people keep on changing their life styles, their appearance and also the environment in which they found themselves in	Yes

F. What are your feelings about teaching evolution?

CODE NO	PRE-VISIT	POST VISIT
1	• Don't really know how to teach it. • Don't have a problem teaching it, if I know how.	• Should teach theory and not a • If one can change the attitude towards

	• Won't necessarily make it a religious aspect; but still need ways on how to present to learners	the topic it can be taught effectively • Could see that changes definitely took place over years
2	• Uncertainty • Discouraged • Confused	• Much better • Looking forward to explaining it next year • Clarity given positively
3	• Confusing • Frustrating • Difficult • Boring	• Interesting • No more boring
4	• The theories of education • The age of the earth • How did the life on earth start? • When did the life start?	• Evolution being a new chapter in a syllabus
5	• Its yet another view which looks at how the earth could have originated • It's an evil way of looking at things trying to discredit the existence of god • It agrees with religion because they both agree that the earth started as a big ball of gases • My religion does not require me to teach about it	• Knowledge has nothing to do with my religion • There is more beyond what the scientists have yet discovered about evolution • It is still very difficult to fit all the pieces of evolution to convince the origin of man
6	• Stimulating since it helps me to work through different views of evolutionists • Wow; cause some information that I did not really know is unfolding e.g. that embryos of different organisms are the same at some point • Enriching- since it helps me to reason, compare, study, explore more about my origin • I, at times feel uncomfortable because there is a lot of unfounded contradictions about	• Challenging, since we have a lot of controversial issues around the whole the thing "evolution" • Skeptical, since I have to be passionate about the whole of them before I can effectively pass the info to my learners

	the whole thing	
7	• It is good to trace back your origin	• It is interesting and educative and traces our origin
8	• I believe that some aspects of evolution are correct but some are not • It is difficult to believe because it's a very slow process which takes millions of years to occur • It sometimes clashes with biblical believes therefore it is difficult to believe • It gives us an explanation as to why we are different from our ancestors who were there millions of years ago	• It is against religious beliefs • Evolution is a very slow process hence it is difficult to believe its occurrence • It enables us to know where we come from as humans
9	• It is not good because learners get confused as to who created a human being • It is a good feeling because learners are engaged on diversity about life	• It is interesting and challenging since it addresses the challenges of life • It is interesting and provokes the thinking ability of the learners
10	• Since well we are talking about life and origin, I think it is okay due to the fact that one needs to understand where exactly he/she comes from	• People need to know(learners) how life started not only basing on one theory(Genesis) but understand other aspects of their originality
11	• Frustrating • Unsure • Confused • Sometimes very doubtful	• Interesting • Challenging • Exciting • Thought provoking
12	• It creates a sense of wanting to know the human were able to adapt to environmental factors • It reflects on what happened before the existence of man • It is a base for what is happening today and what may happen in the future	• Basic to human creation. It is good • Every person should be exposed to evolution as a theory • It can help us to deal with future organisms that threaten/destroy

		mankind
13	• It is important because it allows people to know where they come from, also to understand where other living organisms come from	• It is very important since it allows people to know where they come from
14		• It is a good topic to be taught so as to make learners trace their evolutionary path way and realize their ancestral forms • Quite interesting
15	• The attitudes of our learners • Our learners are ignorant • It is a challenge because our learners are from different backgrounds • Different believes	• Learners are inquisitive, they will like new information • First hand information • It is a new interesting topic • Career path for my learners
16	• It is against other people's believes(Christians) • Our learners are ignorant, they no longer want to learn and also lazy	• It is challenging And full of theories, Lamarck and Darwin and some of them are not proven • It is against other learners beliefs • It is also quiet interesting and achieved a lot from this workshop
17	• There are certain forms of life, some as a result of formation of fossils which are now there • It is a challenge to me to change from my belief/religion to view this as a real possibility, where it concerns man	• It surely would allow me to show learners origins of some species from others
18	• Little difficult because some learners will come with a Christian view and others with the big band theory	• Complex because some people bring in their religious theories and you have to bring everyone on board

		about evolution
19	• It is against my religious belief	• Although it is against my religion, it is interesting to know the scientist's version of evolution
20	• Difficult and challenging • Boring- too much technology and reading • Not so passionate therefore lack enthusiasm	• Challenging- balance between faith and science • Difficult to keep learners motivated • Complicated, confusing for learners
21	• In originality, it verses biblical perception but in human physical and mental development, it is realistic • Human are changing and discovering things(new things are invented based on technology) • I think evolution is still continuing e.g. human evolution- wisdom, knowledge and understanding • People are interpreting evolution in different ways according to their beliefs	• I don't feel comfortable in teaching this topic because I don't understand it clearly
22	• Evolution is confusing because I am not really sure whether it is true or not	

G. state briefly what influenced your attitude towards teaching

CODE NO	PRE- VISIT	POST VISIT
1	• the questions learners asked that I did not really know how to answer • I was not confident with content	• not having much information made me doubt how to teach the topic
2	• belief • it is too complex to understand • not having enough information about the topic	• explanation given about evolution • trip to Maropeng • how to approach the topic
3	• not sure of myself	• misunderstanding

	• contradicting • beliefs • not having enough information	and confusion • after listening, the frustration is gone
4	• evidence of evolution • the history of evolution • the different beliefs of learners(the Christianity) • the different theories of theorists	• the scientific evidence • the trip to maropeng influenced me to like and understand the evolution
5	• it is another school of thought on how life started • evolution will never give us a clue about origins	• the study of the close relationship which organisms have in common
6	• explore- there is nothing stimulating than seeing a child grow to the better horizons and you know they are your products • passion- I love to be in contact with the learners, help and watch them growing to be better citizens	• watching the learners grow into a deeper and better understanding of critical issues like evolution • passing on the knowledge of what I have to the learners
7	• the love of a child	• the love of the child
8	• the need to tell learners that evolution can help explain human origins • the need to make a difference in the community and make learners aware of their role as future leaders	• the need to import knowledge to learners • to teach learners about their origins and those of their ancestors
9	• I have been influenced by old teachers who loved being with children • high demand of job opportunities	• it makes teaching interesting and innovates
10	• working with people and getting to know different backgrounds everyday • the fact that one is learning each and everyday	• working and wanting to help people to become better people • passion for the learning area/subject since it talks about life(human/animals and plants) and their development
11	• Because of the lack of confidence • Because of the sensibility about	• after visiting Maropeng I learnt a lot about it

	the chapter • Lack of evidence to prove to learners	
12		• it opened my horizon • my beliefs to god have been enhanced as this shows how god made sure that the change is there • I can teach it without any doubt • there is a lot of integrations that can take place during the lessons
13		
14		• change young growing citizens minds from the wanted unwanted attitude to the society and making them meet the wider country's demands of the labour force • development of young people into reliable, active, participating, and responsible citizens of their country
15	• To make a difference in our society • Jesus Christ was a teacher himself	• making a difference in my society • to be a valuable member of the community • to be a life long learner
16	• teaching learners about things that they do not know at the same time learners some of the things from them • it influences me to find or do research and come up with concrete solutions you always learn	• learning more and doing scientifically research and come up with the evidence
17	• it is part of the curriculum and learners must be motivated to	• build the nation that can manage its own

	learn it • some of the concepts stimulate once the idea about it compared to various religions	activities • make sure that I instill in learners positive attitudes about life and the diversities in life
18	• learn more and understand some aspects I did not know	• that people come from different backgrounds and the new development coming in brings about positive challenges
19		• if the subject is interesting • if I want to know more
20	• passion to work with children • I enjoy making work easy and/or fun • I always liked to teach my classmates	• passionate about working with children • enjoyed teaching classmates • sense of satisfaction in making knowledge; skills easier; funnier and more understandable
21	• human beings changing from time to time(physically and mentally) • new technological inventions that were not there before • my observations on what people think about evolution • life is too fast, people are dying at an early age previously they used to live longer depending on e.g. the type of food they eat	• if I can have a thorough knowledge of evolution I will teach the topic confidently
22	• that passion of teaching influenced me to be a teacher • to help fellow citizens to be educated and to stand for themselves in their lives	

H. Briefly explain how fossils are formed.

CODE NO	PRE – VISIT	POST VISIT
1	The remains of organisms that stay	The remains of plants and

	behind in sedimentary rocks e.g. skeletons	animals that are found in rocks. It existed millions of years ago
2	Leaves decaying forming rocklike structure that hardens	Plants and animals decompose and dried up forming sedimentary rock. Calcium from the bones hardens up forming a rock which has been compressed for many years
3	From the ancient imprint of organisms that maybe are extinct due to death because they were unable to adapt to changes of the environment	From the remaining of the strong bones where there is no skin, hair and veins. The bones are strong because of the decomposition of calcium
4	Fossils are formed from biomes	• fossils are the remaining of the plants and animals • mineralized remains of plants or animals that lived in the past
5	Formed when the remains of organisms are washed by water and deposited. They were compacted in between soils which hardened, forming rocks	Fossils were formed when the remains of organisms were embedded between rocks which compacted them
6	They are formed when an organism dies, and the bones or the remains are stuck in between sedimentary rocks, which are very strong and the remains will be there for many- many years because there is nothing to disturb it	They are bones that are trapped in between very strong rocks (sedimentary), due to the calcium level they contain; they are able to stay there for many-many years as long as there in absence of oxygen, they remain in tack. the softer tissues of the body will decompose and only the hard bones remain
7	1. Plants or animals; more especially in the oceans, are buried deep under soil deposits. when the water dries, the bones become exposed 2. when an animal is buried in a tar pit e.g. America 3. when germ has covered an ant or a fly and hardens to become	1. When a plant or an animal is covered by very deep deposits of soil which hardens and preserved in tar pits 2. plants and animals preserved in tar pits 3. gum trapping

	amber 4. if an animal is buried in ice or glacier for year and when ice melts it becomes exposed	insects and hardening up to form amber 4. animals covered by ice or glaciers only to be exposed when the melts after a very long time
8	The Remains of animals and plants can be compressed together in-between rocks. Gradually they become hardened after the flesh part (in the case of animals) has rotten and are permanently imprinted on the rocks. They are preserved that way for millions of years until they are discovered.	Formed when the remains of plants and animals are subjected to pressure in between rocks and devoid of oxygen. Overtime they become hardened and remain like that until they are discovered
9	They are formed by the remains of the dead organisms	They are formed by the dead remains of plants and animals
10		
11	They are formed after organisms that are dead millions of years ago solidified an the ground	They were formed over a million years ago. Dead plants and animals fossilized on the ground tom form them. On the bones of animals formed this fossils because of the calcium present in them
12		• It starts with the existence of living things in their environment • The death thereof • The destruction of the fleshy part • The bones surviving due to the presence of calcium • The press up of the bones by sedimentary rocks for millions of years
13	Animals/plants die and they are buried underground and over many years they become computed and form fossils	Animals and plants die, buried and become calcified to form fossils over millions of years
14	Over the decades as deposits on the ground	Are formed as deposits of organisms over a period on

		earth. These dead materials buried will sink down on earth with the soil mineralogical character change, together with the organisms tissue change will develop to form a hard material of rock and organisms tissues(unable to decompose) and act as fossils(organisms tissues)
15		It is formed by remains of plants and animals
16		They are formed from old strong bones
17	• Dead organisms material collects and build up over a period of time • It can be from parts of plant or animal material	Fossils are formed from remains of dead plant and animal materials that collects on sedimentary rocks
18	When dead material of plants and animals are covered by soil/mud and compressed and form a hard rock	The preservation of animal or plant remains which are covered by soil and compressed forming a rock
19	Fossils are formed from the remains of plants and animals that existed millions of years ago. Because the remains have absorbed salt which turn them into stones	Remains of bones were pressed between rocks. These bones didn't receive oxygen and they became fossilified
20	Dead organisms, decaying leave imprints on rocks, soil and other surfaces and become buried there	
21	Fossils are formed from the remains of dead organisms. For a fossil to be formed, a body part (or the whole organisms) has to be buried in sediment before there is time for its body to be broken down by microorganisms. Once an organism's remains are buried in sediment, they can stay there for a very long time without decomposing. As the layers of sediments form on top of the old, the lower sediments become compressed. Water is squeezed out and the sedimentary particles are forced closer together.	Fossils are formed by the remains of living organisms
22	Normally, the dead bodies of plants and animals are rapidly decayed by bacteria	Fossils are formed from the dead plants animals mixed

	and fungi and leave no trace of their existence. Sometimes, however organisms die under circumstances where the process of decay is slowed down allowing them to be preserved as fossils. Organisms can be preserved as fossils by freezing or by being entombed in the hardened resin. In such a way most fossils are formed. An organism dies and sinks to the bottom of a river or lake; here the soft parts quickly decay leaving only the hard parts behind. Soon the sediments like mud or sand cover the skeleton. This helps to reduce the oxygen levels and slow down decay. After burial, the bones undergo mineralization. This is a combination of the original inorganic bony matrix (calcium phosphate) and the new minerals from the sediment. Over time, more and more layers of sediment are added resulting in the build up of large pressures. These pressures cause the minerals in the bones and sediments to be compacted and cemented together to form sedimentary rock	with old stone and sand

I. Describe up to three exhibits you have seen during the tour that you think may have an influence on your understanding of evolution. What influence did you have?

CODE NO	POST VISIT
1	• The differences between the skull of a human and that of an ape do not look the same. Meaning we did not evolve from an ape. • Human are the only ones that can communicate through speech
2	• Human and apes share a common ancestor. • Homosapiens evolved from other species. Advantages of bipedal creatures: ✓ DNA structure and theory ✓ Diversity of human beings ✓ Extinction of species, the story of Dodo and the quagga ✓ How fire has been used in different ways ✓ Existence of Dinosaurs in South Africa
3	That some of the thing I teach about are reality
4	• The different evidence

	• The fossils structure • Organisms that come from other organisms
5	1. The DNA structure 2. The gradual changes which have taken place among humans and other related organisms
6	1. The different types of homids, different brain capacities versus the skull sizes and body masses 2. The 9 special characteristics which the homo sapiens have; making them so different from the other hominids 3. The evidence of dinosaur's eggs that were found in the Free State. Indicating clearly that organisms became extinct and they indeed existed
7	Very interesting and educative with true and real samples. I liked it and can encourage other people to come here(Maropeng)
8	1. The fossils found in different parts of South Africa e.g. Taung baby. It enabled me to realize that indeed evolution occurred since there is a similarity between these fossils and present day human. 2. Eggs of the dinosaurs made me agree to the fact that they were in South Africa but became extinct due to climatic exchanges 3. Tour through the tunnel- The different climatic conditions experienced there showed me that evolution took place as different animals responded to different climatic conditions in different ways
9	1. Pictures of homosapiens and Mrs. Ples 2. The models or bones of dinosaurs and the eggs 3. The rocks they found when they dug the cave
10	
11	Moving with a boat in the tunnel observing the stalaglites and stalagmites was exciting. All the geographical features were educative. All the changes about the species from one period to the other to name a few Australopithecus to the homosapiens.
12	
13	• The • The DNA model • The fossils
14	1. Caves reflecting previous information 2. Apes reflecting the previous man 3. Ancestral forms of the living things like dodo
15	1. "Lake" 2. Human origin 3. "Mind game"(the iron bar was stable…)
16	
17	• DNA exhibits that show possibilities of one to have certain characteristics above others • Characteristics of some endangered species like Kudu • Step by step evolutionary changes in humans that resulted into what we are today, which occurred over a period of Billions

	years
18	• That certain animals existed some years ago • Underground part of the earth • Different animals, species
19	• Real feeling of evolution • To see real fossils • To see real skulls, eggs etc
20	1. Dinosaur fossils – never knew dinosaur …… South Africa – excited to shame with learners. 2. Extinct animals – reminded me about over selfish, careless attitudes towards our nature environment which would …… 3. Boat ride – made me …… periods easier to understand ……real experience – easier to……..
21	The structure of DNA
22	

J. Do you think what you have seen during the tour will assist you towards teaching evolution?

CODE	**POST VISIT(Answer and reason)**
1	(Yes) Definitely
2	(Yes) Able to explain theories and concepts much better than before
3	(Yes) Because I will refer back to my learners that in Maropeng I have seen this and that
4	(Yes) It makes evolution very easy and interesting
5	(Yes) The information obtained was very relevant to enhance learners understanding
6	
7	(Yes) It makes it very easy
8	(Yes) I now strongly believe that evolution took place unlike before, hence I a going to have a positive approach I teach the topic
9	(Yes) To transfer the knowledge to the children
10	(Yes) Because one now understands the concept better
11	(Yes) It would have been more empowering if done from January and continuously
12	
13	(Yes) Because I now know how I should teach the topic
14	
15	(Yes) First hand information
16	
17	(Yes) • The approach will be a more motivated one • Preparations will be much easy
18	(Yes) Simple observations
19	(Yes) Will be able to tell learners of my experience more than theory, and has advantage of taking them here for I experienced
20	(Yes) Better understanding of some concepts enforces better practice

	in classroom
21	(Yes) But I still want to have an insight of what happens in evolution
22	(Yes) I have seen from my learners because now I understand, because I will be able to explain everything

Appendix C

Matome David Mokgobanama
04 5th Avenue
Finsbury
Randfontein
SOUTH AFRICA
06 June 2008

The Principal

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO INVOLVE GRADE 11 LIFE SCIENCE TEACHERS FROM YOUR SCHOOL IN MY STUDY

I am a Master of Science student at Wits University undertaking a research project on learning in museums or informal science institutions. The objective of the project is to determine the extent to which a visit to an informal science institution can change teachers' knowledge about and attitudes towards teaching evolution.

I would be grateful if you would grant me the permission to take your Grade 11 Life Science teachers to a visit at Maropeng visitors centre. These teachers will undergo a workshop which is scheduled to take place second week of October after school. The workshop will cover the topic of evolution and the role of teachers in guided educational tours. Questionnaires will be administered before and after the workshop. I will request permission from teachers separately.

I would greatly appreciate your favourable response and I am happy to discuss my project with you if you so wish.

All the information will be treated according to the University ethical policy on confidentiality. The workshop will be conducted after school hours. I will not disclose the name of your institution unless you give me permission to do so.

For any clarifications please don't hesitate to contact me.

Yours sincerely

David Mokgobanama_____ (Researcher)
04 5th Avenue
Finsbury
Randfontein
06 June 2008
Phone: +27 11 693-3681, Cell: +27 73 270 3251
Email: Mathome.Mokgobanama@gauteng.gov.za

Appendix D

Matome David Mokgobanama
04 5th Avenue
Finsbury
Randfontein
SOUTH AFRICA
06 June 2008

The Director
P.O. box 1426
Rant en Dal
1751

Dear Sir/Madam

RE: REQUEST FOR PERMISSION TO VISIT YOUR CENTRE FOR RESEARCH PURPOSE

I am a Master of Science student at Wits University undertaking a research project on learning in informal science institutions. The objective of the project is to determine the extent to which a visit to an informal science institution can change teachers' knowledge about and attitudes towards teaching evolution.

I am hereby requesting the permission to visit your centre for research purposes. The participant of my research will be Grade 11 Life Sciences teachers. These teachers will be attending an hour workshop conducted by the researcher (myself), your Education Marketing Executive and a Grade 12 Life Science Chief Examiner. The workshop will take place second week of October at 14h00. I have already made some arrangements with Magel van de Venter (Education Marketing Executive) for the presentation and tour guide.

All the information will be treated according to the University ethical policy on confidentiality. I will not disclose the name of your institution unless you give me permission to do so.

For any clarifications please don't hesitate to contact me.

Yours sincerely

David Makgobanama _____ (Researcher)
04 5th Avenue
Finsbury
Randfontein
23 September 2008
Phone: +27 11 693-3681, Cell: +27 73 270 3251
Email: Mathome.Mokgobanama@gauteng.gov.za
Dr. Anthony Lelliott _____ (Supervisor)
Head, Division of Maths and Science Education

Appendix E

INFORMATION SHEET

RESEARCH ON LEARNING ABOUT EVOLUTION: THE INFLUENCE OF AN EDUCATIONAL VISIT ON TEACHERS' KNOWLEDGE AND ATTITUDES

My name is David Mokgobanama. I am a Master of Science student at Wits University undertaking a research project in museum or informal science institution learning. The objective of the project is to determine the extent to which a visit to an informal science institution can change teachers' knowledge about and attitudes towards teaching evolution.

I would like to invite you to participate in my study. If my invitation is accepted, I would like to inform you that this study will take place at Maropeng Visitors centre. A workshop about evolution and the role of teachers in guided educational tours will be conducted. Participants who are willing to take part in this project will be given questionnaires that will be completed before and after the visit. The completion of questionnaires will take at least 30 minutes. Please take note that transport and site payments will be done by the researcher.

Kindly be informed that participation in my study is absolutely voluntary and no harm will come to you. I will treat all the conversations with confidentiality and anonymity. If you choose to participate, you may withdraw from the study at any time. I hope to publish the results of my study in academic journals and conference proceedings. To protect confidentiality, all names I use will be fictitious.

Thank you

Appendix F

Informed consent form – Teacher

Research project: Learning about evolution: The influence of an educational visit on teachers' knowledge and attitudes.

I, _____, a Grade 11 Life Sciences teacher at _____consent participating in the study to be conducted by Mr David Mokgobanama for his research on the influence of educational visit on teachers' knowledge and attitudes at Maropeng visitors centre, Krugersdorp. I fully understand the following points

1. The study will cause no harm to me and that the study is being conducted for educational purposes.

2. Even if verbatim quotes from me are used in the research report, they will be reported so that my identity is anonymous. I understand that the results of the study may be published, but my identity will be anonymous.

3. Everything I say will be kept confidential by the researcher. I will only be identified by a pseudonym in the transcript.

4. I participate voluntarily and understand that I may withdraw from the study at any time.

Name _____

Contact No _____

Signature _____

Date _____

Appendix G

UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

GAUTENG WEST

Enquiries: David Mokgobanama

MEMORANDUM 340/2008

TO : PRINCIPALS OF HIGH SCHOOLS (INFORMATION)
LIFE SCIENCES HOD (INFORMATION)

FROM : MS E.E. FRONEMAN
ACTING DISTRICT DIRECTOR

DATE : 25 SEPTEMBER 2008

RE : INVITATION TO GRADE 11 AND 12 LIFE SCIENCES TEACHERS' WORKSHOP

The topic of evolution is new in South African Life Sciences curriculum. Furthermore most of our educators have little knowledge about this topic since evolution was not taught in most colleges. In order to address some of the challenges that life science educators may experience, you are invited to a workshop scheduled as follows:

Date: 16 October 2008
Time: 14H00
Venue: Maropeng Visitors Centre

Please take note that educators will be asked to complete questionnaires as part of the research (for more information please find the attached information sheet about the purpose of the research). You are also informed that there will be a guided tour immediately after presentations. You are kindly requested to wear comfortable shoes.

Educators who are interested in participating to the research are requested to submit the consent form attached to **Greenhills Office** or fax to **011 693-3683,** for attention **David Mokgobanama.** For transport arrangements and direction please contact David at **0732703251**

Your cooperation will be highly appreciated.

Yours faithfully

Intiaz Moosa
Acting CES: CDS

Ms E.E. Froneman
Acting District Director