An investigation into the attitudes of teachers and learners towards evolution, the conceptual changes that occur when learners are taught evolution, and the factors that influence this conceptual change.

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ABSTRACT

Evolution is considered a controversial topic and has been met with much debate, concern and conflict in its inclusion in the school curriculum. The aim of his investigation was to determine what conceptual change occurs when learners are taught evolution and what factors influence this change looking in particular at learners' conceptual ecologies and the role that religious beliefs play. The attitudes of the learners, teachers and school community towards evolution were also investigated. A mixed methods approach was used because it obtains a fuller picture and provides a deeper understanding of a phenomenon by combining the strengths of qualitative and quantitative research. Learners were given a pre- and post-instruction survey and concept mapping task, and a sample of learners were interviewed post instruction. Results showed that learners made significant conceptual changes and that religious beliefs are the main contributing factor to learners' conceptual ecologies and the conceptual changes that occurred. An overall negative attitude was initially experienced from learners, but this developed into curiosity and interest. Teachers had a positive attitude towards teaching evolution. This study also highlights the notion that conceptual change theory is not sufficient in explaining how all learners learn evolution. Learners that experience cultural conflict follow various other learning paths explained by collateral learning. Collateral learning is considered because it more accurately explains how religious learners learn evolution. Collateral learning puts emphasis on the importance that learner cultures have in learning and highlights the importance of teaching for cultural border crossing

Declaration of own work

I, Debra Daphne Schroder declare that,

1) The research reported in this dissertation, except where otherwise indicated, is my original work.

2) This dissertation has not been submitted for any other degree or examination at any other university.

3) This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Signed: _____

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11 June 2010

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Dear Mrs Schroder

PROTOCOL: An investigation into the attitudes of teachers and learners towards evolution, the conceptual changes that occur when learners are taught evolution, and the factors that influence this conceptual change
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I take this opportunity of wishing you everything of the best with your study.

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cc: Dr. E Dempster (Supervisor)
cc: Ms B Jacobsen

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My husband and Dad, your interest alone is reason to work harder, try harder and succeed!

Dedication

This project is dedicated to my loving husband and darling daughter. You are my inspiration and motivation. You encouraged me continuously on this journey and held my hand and pulled me through the tough times! Thank you for helping me be the best I can be!

Everything I do is in honour of you,

Let my faith be strong,

Let my spirit hold firm,

In honour of you, I will do....

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Chapter 1

INTRODUCTION

1.1 INTRODUCTION

1.1.1 Focus of the Study

The focus of the study is the conceptual change of South African learners' ideas when taught evolution, and the influences that affect this conceptual change. Conceptual change refers to a way of learning. It involves the change of learners existing understanding to the development of new concepts. The development of new concepts is achieved through the restructuring of existing concepts by revising specific beliefs and concepts used to formulate those beliefs (Schwartz, 2009). Conceptual change is achieved when learners become dissatisfied with their existing understanding, and find the alternative explanation offered by the teacher fruitful, plausible and intelligible (Posner *et al.,* 1982). Conceptual change may be impeded by learners' attitudes to the new conception. Learners' attitudes towards evolution may be influenced by religious and/or cultural background, and by parents' attitudes (Evans, 2001).The role that teachers play in conceptual change and the attitudes (a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour) that learners develop towards the topic evolution will be a factor under investigation i.e. the attitudes towards evolution of the learners, teachers and school community will also be investigated.

1.1.2 Motivation and Rationale

Prior to 1994 and the election of a new government, evolution was not included in the South African school curriculum because it conflicted with the religious beliefs of the government (Dempster and Hugo, 2006). A new National Curriculum Statement for Life

Sciences was released by the Department of Education in 2003. This was the first curriculum to include evolution in South African schools. This particular version of the curriculum did not include aspects of evolution in the grade 10 and 11 Life Science syllabus. Key evolutionary concepts were however introduced in the Natural Science Learning area (even though the word evolution is never mentioned), such as natural selection, variation in species, mass extinction and the fossil record (Department of Education, 2002). There was thus a two year gap where evolution was not addressed in the classroom and grade 12 learners were then bombarded with content of all aspects of evolution in their final year. This may have resulted in additional stress on teachers and increased negative attitudes of learners when approached with the topic in their final year.

The lack of continuity between Grade 9 and Grades 10-12 was addressed by curriculum writers and version 2 (Department of Education, 2008) of the Life Sciences curriculum was released. Version 2 includes various aspects of evolution in the Grade 10 to 11 syllabus, and was implemented in 2009 in grade 10, and grade 11 in 2010 i.e. evolution is currently included in all Life Science classes. Subsequently, the National Curriculum Statement was amended in the form of Curriculum and Assessment Policy Statements for all subjects. CAPS curricula for Grades 10-12 were implemented in Grade 10 January 2012. Amendments made include minor changes to the content. The CAPS curriculum retains a phased approach to evolution, with fossil record in Grade 10, phylogenetic trees and cladograms in Grade 11, and the theory of evolution by natural selection, along with genetics in Grade 12. Data for the present study was collected in 2009 when the first version of the NCS for Life Sciences was being taught in Grade 12. The curriculum was in its second year of implementation, and public opposition to the teaching of evolution was high. Not much research has gone into the effect that NCS Life Sciences Version 1 or Version 2 curriculum has on learners or whether the structure of this syllabus is achieving what curriculum developers had hoped it would.

Evolution in the school curriculum has been met with much debate, concern and conflict and is recognised by many as a controversial topic (Dempster and Hugo, 2006; Dixton, 2009; Miller *et al.,* 2006; Wiles and Branch, 2008). Opinions on the matter range from one

extreme, as stated by Michael Berger (2006) p.102 "To empty modern scientific thought of Darwinian evolution would result in the conceptual collapse of the entire field of Biology and its offshoots", to the other extreme as some American teachers who state that teaching it [evolution] could have grave consequences for them and for their students. Learners themselves bring a variety of ideas, beliefs and knowledge to the class which ultimately affect their attitudes towards and acceptance of evolution. The biggest conflict that needs to be managed in the classroom is that between religion and evolution. This conflict between religion and evolution can result in deep internal personal conflicts when teachers' own beliefs are at odds with the curriculum (Griffith and Brem, 2004). A Biology teachers' acceptance or rejection of evolutionary theory as a scientifically valid explanation is potentially important because it can influence how teachers teach and ultimately will influence the level of importance that evolution takes in the curriculum.

Teachers are faced not only with internal, but external pressures as well concerning the teaching of evolution. External pressures are those from outside sources and include learners, parents or administrators (Griffith and Brem, 2004). Teachers may stop teaching effectively because these external pressures force teachers to adopt coping methods which ultimately affect the classroom environment negatively (Berkman *et al.,* 2008; Griffith and Brem, 2004; Wiles and Branch, 2008). Some of the coping strategies teachers adopt include omitting certain information that should be included in the curriculum e.g. human evolution, avoiding evolution altogether and disallowing class discussion (Griffith and Brem, 2004).

It is not only external pressures that influence teachers' teaching strategies when teaching evolution. Rutledge and Mitchell (2002) state that a teachers' conception and knowledge structure of evolution also impacts learner understanding of evolution. Most learners come to class with some ideas about the origin of life. Evans (2001) suggests that these ideas are influenced by previous class experience, parents' beliefs, activities encouraged by the parents' and community, and religious ideas encouraged by the community. Evans, (2001) and Mathews, (2001) further suggest that these initial ideas affect how the learners experience evolution in the classroom.

A learner's belief system, cultural norms and conceptual understandings overlap and co-exist. One system influences the other and results in particular attitudes and values towards various subjects. The conceptual change that occurs in the classroom can disrupt belief systems and cultural norms. This interaction is important when considering teaching and lesson planning around topics such as evolution. Differing conceptual structures can co-exist, but seem to force learners to make a choice between evolution and religion (Cavallo and McCall, 2008), which can have a negative effect on any one of the conceptual structures ultimately affecting conceptual change in the classroom. A study carried out by Lawson and Warsnop (1992) found that learners' beliefs did not shift during an evolution unit, but learners' understanding of the concepts of evolutionary biology did increase, indicating that learners may understand science concepts taught in class regardless of whether they believe in the subject matter. It can thus be concluded that the attitudes and beliefs of the learners and teachers will affect the type and quality of learning and teaching that occurs in the classroom.

When I started this investigation I was a full time teacher and I found myself in just such a situation: teaching evolution in a religious community where learners' brought strong Christian beliefs coupled with particular ideas concerning evolution, to class. The teaching environment was not made any easier by my own personal religious beliefs. Many learners attended scripture classes before school, where the topic of evolution was addressed. These learners were often uncomfortable and resistant during lessons and showed their distress by: refusing to write tests or essays concerning the topic and by starting confrontational discussions/debates during class, these often directed at me, their teacher. I have many personal questions and issues concerning this topic that I feel this investigation will answer: why is this topic so controversial especially in Christian communities? Will teaching the topic have any negative effects (such as doubting religious teachings) on learners' religious beliefs as many communities feel it will have? How can this topic be approached more effectively in classrooms without the controversy and possible negative effects? Many teachers face external and internal pressures, concerning evolution which forces them to adopt a 'coping' method that ultimately affects their effectiveness as teachers in the classroom. I feel that I

am merely asking the questions that many are too afraid to come forward and ask themselves.

1.2 REVIEW OF RELATED LITERATURE

Through the study of Life Sciences, learners are expected to develop an understanding of the nature of science, the influence of ethics and biases, and the interrelationship of science, technology, indigenous knowledge, environment and society (Department of Education, 2003). This is one of the main purposes of the Life Science curriculum in South Africa. The inclusion of evolution in curricula is said to achieve this purpose (Cavallo and McCall, 2008). Evolution can be used across all grade levels to guide instruction and align the curriculum (Haury, 1996). Many scientists agree that evolutionary theory is the central and unifying theme of biology (Cavallo and McCall, 2008; Dempster and Hugo, 2006; Haury, 1996; Rutledge and Mitchell, 2002; Mathews, 2001; Moore and Kraemer, 2005) and is critical to understanding modern biology (Jensen and Finley, 1995). Dobzhansky (1973) explained that: 'Nothing in biology makes sense except in the light of evolution'. It is thus understandable why evolution is included in many school curricula across the world.

The inclusion of evolution in school curricula has, however, been met with conflict, especially in American schools (Meadows *et al.,* 2000; Wiles and Branch, 2008). This conflict and controversy is especially rife between creationists and evolutionists (Bergman, 1999; Berkman *et al.,* 2008; Scott and Branch, 2003; Wiles and Branch, 2008). It is not only Christians that have a creationist view, but Jewish creationists as well as Muslims and Hindus have a creation event as part of their belief system. The question of the origin of humans is the source of most conflict and emotional issues (Bergman, 1999; Blackwell *et al.,* 2003). Most Western countries, other than the United States of America, however rarely experience the evolution-creation controversy (Dempster and Hugo, 2006).

The USA has been the focal point of attention concerning the issue of teaching evolution in schools. Robelen and Cavanaugh (2008) reported that a new law signed in on June 26 2008 in Louisiana, allows school districts to use additional material in class that helps learners

"analyse, critique and review" scientific theories such as evolution, the origins of life, global warming and human cloning. Teachers are still, however, expected to teach material presented in standard textbooks supplied by their school systems but they may include other material that may be examined. This allows teachers to incorporate religious viewpoints into classrooms. Some scientists feel that religious based ideas should not be included in the classroom whether in the form of creation science or intelligent design (ID) (Berkman *et al.,* 2008; Scott and Branch, 2003), and feel that it will promote religious doctrine or belief (Robelen and Cavanagh, 2008).

Time spent on teaching evolution depends on teachers' attitudes and beliefs concerning the topic. This has resulted in differences in classroom time allocated by teachers to the topic. In Minnesota, science education standards and professional teachers' organisations support the teaching of evolution and reject the teaching of creationism. A study conducted by Moore and Kraemer (2005) in Minnesota, found that over an 8 year period the percentage of biology teachers who include evolution in their courses increased from 69% to 88%. The study also found that biology teachers who include evolution in their courses now spend more time on evolution than they had done previously. All textbooks included evolution and none included creationism. The teachers also reported that they believe that most scientists believe that the modern theory of evolution is scientifically valid. The study also found the following: The percentage of biology teachers in public schools who teach creationism also increased from 16 to 20% and these teachers also spent more time on creationism than previously. The percentage of biology teachers who reported pressure to teach evolution increased from 5% to 17% and the percentage of teachers who reported pressure to avoid evolution increased from 19% to 48%. This pressure comes from parents, administrators and the school community (Berkman *et al.,* 2008; Griffith and Brem, 2004; Moore and Kraemer, 2005). Almost a quarter of biology teachers believe that creationism has a valid scientific foundation (Moore and Kraemer, 2005), but the study of Scott and Branch (2003) states that teaching creationism in classrooms robs students of an understanding of evolution.

Intelligent design (which suggests that evolution occurs under guidance of an intelligent being) has been included in some curricula and textbooks as an alternative theory explaining the origin of life. This inclusion has also been contested and debated by evolutionists and creationists alike. Covaleskie (2008) argued that educators are making a mistake by not including intelligent design (ID) as a counter example that includes some elements of scientific explanation. A similar study conducted by Mathews (2001) provides evidence that including creation stories in the curriculum facilitates the acceptance of scientific views because learners are encouraged to reflect about their ideas and are better equipped to compare old ideas with new ones and progress through the sequence of rejection, assimilation or accommodation. This is in agreement with Covaleskie (2008) who stated that including ID might improve and enhance teaching because learners would understand that science and religion answer different kinds of question; and that schools are good places to help children understand the difference between deductive scientific reasoning and different, although perfectly valid inductive forms of reasoning. Including ID is an attempt to reconcile faith and science (Covaleskie, 2008).

The clash between religion and science found in the U.S.A has also crept into the South African context. Tucker (2012) investigated education and evolution in South African schools from a Christian perspective by examining the problems and opportunities provided by the introduction of evolution in South African schools. Tucker (2012, pp219) explains a Christian point of view as follows: "Darwinian evolution presents the church and society with new dangers and opportunities. The dangers involve a potential loss of faith in the Judeo-Christian revelation, the resultant moral consequences for society of this, and offending the consciences of educators and learners who reject the theory of evolution for religious reasons." Tucker (2012) also recognises that these dangers cannot be avoided by the banning of the teaching of evolution since there are compelling reasons for the teaching of evolution. Instead, how evolution is included in the curriculum and how teachers teach evolution, should be taken into account when attempting to avoid possible problems and barriers between religion and science in South African schools (Tucker, 2012).

The study done by Abrie (2010) also gives an indication of the views of some religious teachers. The study investigated South African student teachers, and results showed that the majority of the participants rejected the theory of evolution and also indicated that they were religious. These student teachers experienced conflict between different accounts of the origin of life, and 84% experienced conflict between religion and science in general. Results also showed that the majority of the life science students agreed that it was important for teachers to understand the theory of evolution, but did not, however, support the idea that evolution be taught in schools. Stears (2011) found similar results when investigating the attitudes that final year student teachers had towards evolution and how these attitudes might influence their teaching of evolution. Prior to being taught a module on evolution the majority of the student teachers felt evolution was against religion. Student teachers also showed a poor understanding of fundamental concepts e.g. some student teachers viewed evolution in terms of human evolution only, or thought that it was unimportant because it was 'just a theory'. Interviews conducted after a module on evolution was taught to the student teachers showed that improvement in content knowledge was limited but their understanding of the nature of science improved and they had altered their views of the conflict between science and religion.

Teaching evolution in South African Schools is fairly new and little information exists on evolution concerning teaching and how teachers and learners perceive this (Yalvac, 2011). Even less information exists the teaching and learning of evolution in South African Muslim schools and Yalvac (2011) attempts to address this by investigating what barriers exist in the teaching and learning of evolutionary biology in Muslim Life science classrooms, as well as looking at skills that Muslim teachers have to teach evolution and deal with any barriers to learning that arise. The study showed that Muslim school teachers have doubts about evolution being a scientific theory, and even though they showed sufficient theoretical knowledge of evolution, they discredited the theory in their teaching. Yalvac (2011) recognises that the most important factor in evolution teaching is the "barriers" to evolution teaching. Yalvac (2011) lists the following as possible barriers that need to be considered: Lack of pedagogical content knowledge, religious objections and controversial conceptual change i.e. teaching and learning evolution asks for radical conceptual change

for those who have not encountered it before, and evolution is in direct conflict with some religious beliefs.

Learners would have likely been exposed to some opinions about evolution from parents, religious leaders and the media before entering the classroom which contributes to learners' pre-conceptions (Cavallo and McCall, 2008). Learners' pre-conceptions as well as scientific and religious orientations, view of the biological world and acceptance of evolutionary theory contribute to a learners' conceptual ecology, and this conceptual ecology varies amongst individuals (Demastes *et al.,* 1995). Teachers need to consider learners' pre-conceptions and understandings when designing instruction (Cavallo and McCall, 2008; Mathews, 2001; Sinatra *et al.,* 2008; Smith, 1994). Teachers should consider how instruction should address concerns linked to learners' preconceptions (such as conflicts between religion and evolution), and if learner preconceptions are ignored then it is done with the risk of limiting the understanding teachers might help learners develop (Smith, 1994). Helping learners understand evolution is not simply a matter of adding to their existing knowledge, instead, learners need to be taught how to see the world in different ways (Sinatra *et al.,* 2008).

Teachers face many challenges in teaching for conceptual change in evolution. Considering students' existing ideas is important for conceptual change to occur (Jensen and Finley, 1995; Mathews, 2001). In a study conducted by Lawson and Worsnop (1992) two important questions were addressed when considering teaching evolution: What factors influence learners' ability to learn science concepts, and what factors influence learners' ability to reject prior non-scientific beliefs. The study's main focus was learners' strength of religious commitment, reflective reasoning skill and prior knowledge of evolution and how these influence learning about evolution and rejecting religious beliefs. The study found that instruction produced no overall shift towards a belief in evolution, and the strength of religious commitment was negatively correlated with initial belief in evolution and with a change in belief toward evolution post-instruction. Thus, existing knowledge affects the probability that change will occur. If the learners' existing conception is coherent and deeply inter connected with other ideas they hold, the likelihood of change decreases (Sinatra *et*

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al., 2008). Bishop and Anderson (1990) found similar results that indicated that a better understanding of evolutionary biology did not necessarily lead to a general acceptance of evolution as a historical fact. Blackwell *et al.,* (2003) investigated just this question: Why the presentation of evolution in class often does not result in acceptance of evolutionary theory. The investigation found that a level of acceptance of evolution could develop over time in the minds of most learners and that 'acceptance' can exist at different levels or in different degrees. Only 9.4% and 6.3% in the two classes of the study indicated that they could never believe in evolution, and 34.4% and 35.4% respectively considered evolution compatible with belief systems. Another aspect that needs to be taken into account are the perceived consequences of evolution. Brem *et al.,* (2003) investigated how college-educated adults from diverse ethnic and religious backgrounds perceive the impact that evolutionary theory has on individuals and society. All groups, creationists and evolutionists, perceived the impact of evolutionary theory to be negative. They felt that it results in increased selfishness and racism, decreased spirituality, and decreased sense of purpose and self determination.

The debate on the issue of creationism has been low key in the UK and much of Europe, and this may be due to the inclusion of religious education as a separate subject in all state schooling (Williams, 2007). The inclusion of religion as a separate curriculum or in the teaching of evolution is seen as a means to correct a serious problem with education that is strictly secular (Cavaleskie, 2008; Williams, 2007). Not only has the UK government rejected creationism and ID and any call for their inclusion of either in the school science curriculum, but the Church of England's highest authority, the Archbishop of Cantebury, also rejects the teaching of creationism in school science because it may be more harmful than helpful for learners (Williams, 2007). A Gallup poll (conducted in 2009) in the U.S.A, showed that 30% of those surveyed would be upset if evolution was taught, but not creationism; in contrast to 18% that said they would be upset if creationism was taught, but not evolution. The same poll found that 48% believed more in creationism and only 28% believed more in evolution, and only 8% believed ID to be true. Another survey done by Berkman *et al.,* (2008) found similar results in that 48% of the general public believed in young earth creationism and 30% of the public and 47% of high school teachers believed humans developed over millions

of years but God guided the process. A study done by Miller *et al.,* (2006) found similar results for the U.S.A where a third of American adults indicated that evolution is "absolutely false", but found that significantly more adults in Japan and 32 European countries accepted the concept of evolution than did American adults. Evolutionists oppose the teaching of creationism (Bergman, 1999; Scott and Branch, 2003) even though the vast majority of individuals in the USA (90%) wanted creation and evolution to be taught in public schools (Bergman, 1999).

There are many influences that affect how a teacher approaches the teaching of evolution. For example, Berkam *et al.,* (2008) found that even though the majority of teachers see evolution as central and essential to high school biology, the amount of time that teachers devote to teaching evolutionary biology varies substantially. Such variances are a result of pressures, as mentioned previously, as well as teacher's academic background, years of teaching experience, size of school enrolment, teachers' understanding of statements concerned with evolution (Shankar and Skoog, 1993) and teachers' personal beliefs. The survey conducted by Berkman *et al.,*(2008) suggests that between 12 and 16% of American biology teachers are creationist in orientation, and about 1 in 8 reported that they teach creation or ID in a positive light. Shankar and Skoog (1993) found that 86% of teachers in Texas agreed that evolution should be taught in high school biology and only 8% of the teachers indicated that evolution conflicted with the Bible. Some teachers even find an overlap between their religious beliefs and evolution and that one supports the other (Cavillo and McCall, 2008).

Asghar *et al.,* (2007) conducted a study that explored pre-service elementary school teachers understandings of evolutionary science and their feelings and concerns about teaching evolution in Canadian schools. Even though the majority of teachers accepted the theory of evolution and indicated that they would teach the topic at a grade specific level, results unveiled that a number of sensitivities that these teachers considered when contemplating teaching evolution. These sensitivities include: parent religion and opposition to evolution, conflict between creationism and evolution, type of school where they would be employed (public vs. .private, secular vs. Religious), lack of understanding of evolution,

prospective teachers own beliefs about religion and evolution, inadequate knowledge of of pedagogical techniques to teach evolution, and imposing their scientific ideas on students holding contradictory beliefs about evolution.

Not only learner beliefs and knowledge play a role in the classroom, teachers' beliefs and values influence teaching and ultimately affect the learning environment. Teacher academic background and personal religious beliefs may be a contributing factor to teacher acceptance of evolution as well as how teachers approach the teaching of evolution (Rutledge and Mitchell, 2002). Teachers from various religious and philosophical backgrounds face conflicts between their beliefs and biological evolution (Meadows *et al.,* 2000). Internal and external conflict experienced by teachers results in unevenness and variation of how evolutionary biology is taught. Some of this conflict can be managed by improving and increasing teacher knowledge and confidence in subject content (Berkman *et al.,* 2008). Shankar and Skoog (1993) found that there is a significant and positive correlation between the academic background of the teachers and their understanding of evolution. Teacher understanding and acceptance of evolutionary theory was a key factor in determining the amount of time teachers allocated to teaching evolution.

The South African situation is similar. The challenges and opportunities that can arise teaching evolution in South African schools is well researched and documented by Holtman (2010). The study done by Holtman (2010) shows that even though learning outcomes and assessment standards are made clear in the policy document, teachers find the content challenging to teach, design and implement teaching programmes. Teachers reported a general lack of support and training and thus felt that they were inadequately prepared to implement new topics such as evolution. Teachers did not have a deep understanding of evolutionary biology due to poor training and preparation resulting in teachers 'buying' into common misconceptions. Lack of training also added pressures on the teachers with regard to teaching alternative theories (faith based and indigenous knowledge) due to the multicultural classes with different faiths and indigenous knowledge systems of learners in South African schools. Data from surveys obtained by Holtman (2010) also indicated that the majority of science teachers lacked the most fundamental knowledge in the new

learning areas. Interviews done by Holtman (2010) revealed that teachers avoided teaching evolution and that some teachers regarded teaching evolution in schools a personal attack on their religious beliefs.

The study done by Sanders (2009) found similar results as those by Holtman (2012). The aim of the investigation done by Sanders (2009) was to identify the concerns teachers faced when teaching evolution, so that developers of support materials and providers of professional development programmes can develop appropriate ways to support teachers who are required to teach evolution, Sanders (2009) began by identifying problems which make teaching evolution difficult all over the world: Firstly, evolution contradicts many religious beliefs, and the consequences of this controversy is that a number of teachers omit teaching evolution, or do not teach it properly; and secondly, teachers lack the necessary content knowledge about evolution or have misconceptions. These two contextual problems are not unique to South Africa as highlighted by Rutledge and Mitchell (2002) and Asghar *et al.,*(2007). Asghar *et al.,* (2007) found that there is a need for developing a better understanding of the basic concepts of evolution and fostering a positive attitude towards evolutionary science in Canadian teachers as well.

Sanders (2009) then focused on South African teachers. Results of the study showed that the most common concern amongst the teachers was related to inadequate knowledge and what teaching approaches to use. Another concern expressed by the teachers was the controversial nature of the topic. The study indicated that the main source of this conflict was linked to misconceptions about religious beliefs and that teachers did not realise that many major religious groups do not necessarily see evolutionary theory as conflicting with their beliefs. Of great concern is the idea that both Holtman (2010) and Sanders (2009) showed that in-service courses provided by the department to help teachers implement the new curriculum was criticised by the teachers as being unhelpful leaving teachers frustrated and ill-equipped to cope with the task of teaching evolution.

Teachers need to be more comfortable and confident in their profession because this is crucial to how effective they will be in the future (Grifith and Brem, 2004). Smith (1994)

makes valuable recommendations for the successful teaching of evolution that respects individual learners' backgrounds and beliefs but is also scientifically appropriate: It is important to a) know our students (their cultures, personal histories, cognitive abilities, religious beliefs, scientific misconceptions), b) to take the opportunity (of teaching evolution) to teach about the nature of science and its distinctions from non-science, c) to address directly the likely cultural or religious concerns with evolution and to do so early on so as to break down barriers. The goal of teaching evolution should not be to change one's personal beliefs. Cavallo and McCall (2008) suggest that how teachers teach and learners' experiences in class can affect them much later in their lives and teachers need to be aware of such consequences. Teachers must maintain their professionalism and provide a balance in the learning environment that they create.

All of the factors mentioned influence how learners experience evolution in the classroom and ultimately have an effect on how they learn evolution. It is only when we understand how learners learn evolution, and how religious and cultural aspects play a role in learning, that we can improve how teachers teach evolution.

1.3 KEY RESEARCH QUESTIONS

1. What are some of the contributing factors to South African learners' conceptual ecologies and pre-conceptions towards evolution?

2. What are the attitudes of South African learners and teachers towards evolution?

3. What conceptual changes occur when learners are taught evolution?

4. What factors influence this conceptual change?

Chapter 2

CONCEPTUAL / THEORETICAL FRAMEWORK

The conceptual change model is used by many science teachers interested in understanding the process of learning (Demastes *et al.,* 1995; Hewson, 1981; Posner *et al.,* 1982). To understand how learners learn, learning needs to be viewed as a constructive process that involves actively generating and testing alternative conceptions, where learners then recognise what they know to understand the world (Demastes *et al.,* 1996; Tyson *et al.,* 1997). It can thus be said that learning is the result of the interaction between what the learner is taught and his current concepts (Posner *et al.,* 1982). This is further explained by Demastes *et al., (*1995) in that learning is characterised as a series of cognitive restructurings in which a learner's conceptual framework undergoes structural modifications or revisions based upon new experiences, information or concepts the learner encounters i.e. learning is seen as a change in a pre-existing conceptual framework.

Essentially, as stated by Sinatra *et al.,* (2008), conceptual change is necessary for some learners to understand evolution. Conceptual change in learners can be understood by looking at two different patterns of learning: Firstly, Assimilation; which occurs when learners use existing concepts to deal with new phenomenon (Posner *et al.,* 1982). New information is added to existing knowledge structures and is an additive process (Sinatra *et al.,* 2008). Secondly, Accommodation; in which learners' current concepts are inadequate to allow them to understand the new phenomenon successfully or the idea is in direct conflict with what they already know and the learner must then replace or reorganize existing knowledge structures to incorporate new information (Posner *et al.,* 1982; Sinatra *et al.,* 2008). The process of accommodation has been closely linked to learning evolution (Posner *et al.,* 1982; Tyson *et al.,* 1997).

The conceptual change model, developed by Hewson (1981) and Posner *et al., (*1982), can be used to describe and follow the conceptual change process. This conceptual change

model highlights the importance of learners' conceptual ecologies and the role they play in conceptual change. Hewson and Hewson (1992) explain that a person's conceptual ecology provides the context in which conceptual change occurs, influences this change as well as gives it meaning. The conceptual ecology for evolution, as described by Demastes *et al.,* (1995), has six facets that can be influential in the process of learning evolution: 1) The prior conceptions related to evolution, 2) the learner's scientific orientation, 3) the learner's scientific epistemology, 4) the learner's view of the biological world 5) the learners religious and cultural orientation, and 6) the learner's acceptance of evolutionary theory.

The conceptual change model as described by Hewson (1981) and Posner *et al.,* (1982) implies that it is necessary that four conditions be satisfied before accommodation is likely to occur:

1) There must be dissatisfaction with existing concepts.

2) The new concept must be intelligible.

3) The new conception must be initially plausible.

4) The new conception must be fruitful (should have the potential to be extended).

Tyson *et al.,* (1997) have reviewed and done further research concerning the theory and conceptual change model. Their study highlights the importance of studying changes in learners' conceptual knowledge but that a multidimensional interpretive framework be used to analyze conceptual change. This framework suggests that the way learners view a concept in terms of its status, or the motivational and contextual factors necessary for conceptual change to occur, should also be considered, i.e. the epistemological, ontological and social/affective influences on conceptual change should be considered to establish a more holistic and meaningful picture of conceptual change. The status of a persons' conception is determined according to how the conception meets the four conditions of the conceptual change model (listed above); and the more conditions that a conception meets, the higher its status (Hewson and Hewson, 1992). Hewson and Hewson (1992) explain that in order for conceptual change to occur, the status of a person's conception must rise or if the two conceptions (new and old) are in conflict with each other i.e. the learner has reason

to be dissatisfied with the new conception, then the status of the existing conception must be lowered.

The conceptual change model can easily be used to follow accommodation for major organizing concepts, but the study by Demastes *et al.,* (1996) and Tyson *et al.,* (1997) show that conceptual change is not a simple pattern to follow. Demastes *et al.,* (1996) showed that conceptual change can occur following a variety of patterns, these include (a) cascades of changes (the change in one conception allows a sequence of conceptual change to occur), (b) wholesale changes, (c) incremental changes and (d) dual constructions.

Özdemir and Clark (2007) have extended research done on conceptual change theories and have reviewed some important ideas and issues concerning conceptual change. They analyzed competing theoretical perspectives regarding knowledge structure coherence. These perspectives (knowledge-as-elements and knowledge-as-theory) need to be considered when addressing conceptual change, and depending on which scientific domain under investigation, and the age of the learner, will determine which theory might be more useful in describing and analyzing conceptual change. Scientists are still unsure which perspective is best suited to which domain, and it is for this reason that neither will be considered in this study.

Conceptual change theory provides a basis framework for this study, as it addresses certain challenges faced with biological evolution rooted in learners' prior conceptions and conceptual ecologies. Evolution is a controversial and counter-intuitive topic in schools and because of this complex, controversial intersection that evolution can be considered an excellent content area in which to study the influence of learners' conceptual ecologies (Demastes *et al.,* 1995). It is, however, due to the controversial nature of the topic that conceptual change cannot be considered in isolation in this study. Cognitive conflicts arise from cultural and religious differences between the learner's life-world and what they are taught at school, and it is because of this conflict that another framework needs to be considered to understand how learners deal with this conflict and learn school science.

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Collateral learning provides an alternative to the conceptual change model as a way of describing learning (Herbert, 2008). Aikenhead and Jegede (1999) describe it as a new intellectual tool with which to understand learning. The model of collateral learning was put forward by Jegede (1995), and defines collateral learning as an accommodative mechanism for the conceptual resolution of potentially conflicting tenets within a person's cognitive structures.

Collateral learning was initially used to understand how non-Western learners learn in a Western science classroom. Jegede (1995) recognized that African learners come to science classrooms with their traditional world view. These learners are faced with a Western world view and it is the interaction between the two world views (traditional and western) that complicates cognitive processes. The culture of the learner has a central role in learning science and the relationship between prior knowledge and the sociocultural environment of the learner is recognised as central to memory and learning. Jegede (1995) explains that collateral learning represents the process whereby a learner in a non-Western classroom constructs, side by side with minimal interference and interaction, Western meanings of a simple concept i.e. it is possible to hold a scientific as well as a traditional view of the world. This is in contrast with the conceptual change framework where learners would have to replace their prior concepts with currently accepted Western science concepts. Collateral learning honours learners prior knowledge and at the same time allows learners to access western science (Herbert, 2008).

In this study instead of learners being of non-Western origin, some learners are religious and the topic evolution can be counter intuitive for these learners and can act as a serious learning barrier, just like indigenous knowledge would for non-Western learners. The transition from learner's life-world into a science classroom can thus be a cross-cultural experience for many learners (Aikenhead and Jegede, 1999).

Collateral learning generally involves two or more conflicting schemata held simultaneously in long term memory (Jegede and Aikenhead, 1999; Aikenhead and Jegede, 1999). Jegede (1995) and Aikenhead and Jegede (1999) describe different types of collateral learning

according to the degree to which conflicting ideas interact with each other and the degree to which conflicts are resolved. The different types are not distinct from each other but can be viewed as a continuum depicting degrees of interaction and resolution.

Parallel Collateral Learning: The learner acquires and maintains in the long-term memory opposing schema about an idea or concept and when learning new science concepts (Jegede, 1995). The conflicting schemata do not interact at all and learners' access one schema or the other depending upon the context (Aikenhead and Jegede, 1999).

Simultaneous Collateral Learning: A unique situation can occur in which learning a concept in one domain of knowledge or culture can facilitate the learning of a similar or related concept (Aikenhead and Jegede, 1999).

Dependent Collateral Learning: This occurs when a schema from one worldview or domain of knowledge challenges another schema from a different worldview or domain of knowledge, to an extent that permits the learner to modify an existing schema without radically restructuring the existing worldview or domain of knowledge (Aikenhead and Jegede, 1999).

Secured Collateral Learning: The learner evaluates seemingly conflicting world views or explanatory frameworks and draws from them a convergence towards commonality. This strengthens the learning process and secures 'new conception' in the long-term memory (Jegede, 1995).

The work done by Herbert (2008) shows that learner's explanations will reflect their understanding and that at the end of a unit of work learner's explanations often include their prior conceptions. Herbert (2008) also found learners engage in dependent or parallel collateral learning when their prior knowledge is challenged by new concepts when learning conventional western school science. Aikenhead and Jegede (1999) propose that collateral learning can successfully probe what occurs in the hearts and minds of learners and provides a cognitive explanation for a cultural phenomenon.

Chapter 3

RESEARCH PARADIGM AND METHODOLOGY

A researcher's philosophical ideas about the world, and in particular, research; are important factors that need to be considered when planning and conducting research. It is necessary to identify such ideas because they influence the practice of research (Creswell, 2009). Such ideas and views are referred to as paradigms. Without nominating a paradigm as the first step in planning research, there is no basis for subsequent choices regarding methodology, methods, literature or research.

Many definitions for a paradigm and 'what a paradigm is' exist. The broadest version treats paradigms as a worldview or all-encompassing way of experiencing and thinking about the world, including beliefs about morals, values and aesthetics (Morgan, 2007). Creswell (2009) defines worldviews/paradigms as a general orientation about the world and the nature of research that a researcher holds. Morgan (2007) explains that in the science studies a paradigm refers to the consensual set of beliefs and practices that guide a field. Morgan (2007) goes further to define his version of a paradigm as being a system of beliefs and practices that influence how researchers select both the questions they study and methods that they use to study them.

The paradigm identified for this study is the Pragmatic paradigm. Pragmatism is not committed to any one system of philosophy or reality (Creswell, 2009; Mackenzie and Knipe, 2006). The pragmatic paradigm places the research question central, and data collection and analysis methods are chosen as those most likely to provide insight into the question and understanding the problem (Creswell, 2009; Mackenzie and Knipe, 2006) i.e. pragmatist researchers focus on the 'what and 'how' of the research question (Creswell, 2009).

Pragmatism is seen as the philosophical partner for mixed methods research (Johnson and Onwuegbuzie, 2004). Tashakkori and Teddlie (1998) define mixed method/model studies as studies that are products of the pragmatist paradigm and that combine the qualitative and

quantitative approaches within different phases of the research process. Creswell (2009) suggests that the pragmatic paradigm implies that the overall approach to research is that of mixing data collection methods and data analysis procedures within the research process. Creswell (2009) explains that the pragmatic paradigm applies to mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions when they engage in their research. Onwuegbuzie and Leech, (2009) state that mixed methods research represents research that involves collecting, analyzing and interpreting quantitative and qualitative data in a single study or in a series of studies that investigate the same underlying phenomenon. Research is often multi-purpose and a 'what works' tactic allows the researcher to address questions that do not sit comfortably within wholly a qualitative or quantitative approach to design and methodology (Armitage, 2007). Pragmatic investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem (Creswell, 2009) i.e. research approaches should be mixed in ways that offer the best opportunities for answering important questions (Johnson and Onwuegbuzie, 2004).

The mixed methods approach is associated with the pragmatic paradigm (Armitage, 2007) and is thus the chosen methodology for this study. Both qualitative and quantitative research, associated with the constructivist and positivist/post-positivist paradigm respectively, have advantages and disadvantages as pure research approaches. The strengths and weaknesses are well documented by Amaratungo *et al.,* (2002) and Johnson and Onwuegbuzie, 2004). The combination of methodologies can, however, focus on their relevant strengths (Amaratunga *et al.,* 2002). Hallie Preskill explains that mixed methods research acknowledges that all methods have inherent biases and weaknesses; that using a mixed method approach increases the likelihood that the sum of the data collected will be richer, more meaningful, and ultimately more useful in answering the research questions i.e. It is used in a single study for purposes of obtaining a fuller picture and deeper understanding of a phenomenon by combining the strengths of qualitative and quantitative research.

Leech (2005) explains that by having a positive attitude towards both techniques, pragmatic researchers are in a better position to use qualitative research to inform the quantitative portion of research studies, and vice versa. For example, the inclusion of quantitative data can help compensate for the fact that qualitative data typically cannot be generalized. Similarly, the inclusion of qualitative data can help explain relationships discovered by quantitative data (Leech, 2005). Alternatively the quantitative and qualitative data can be merged into one large database (Creswell, 2009). Tashakkori and Teddlie (2003) point out that there are 3 areas where a mixed methods approach is more beneficial than using either qualitative or quantitative methods on their own: firstly, mixed methods have the ability to answer confirmatory and exploratory questions simultaneously (answers research questions which other approaches cannot). Secondly it provides deeper and wider answers for complex social phenomenon; and thirdly it provides the possibility for expression of differing viewpoints.

Green *et al.,* (1989) outlined the following five broad purposes of mixed methodological studies:

a) Triangulation – seeking convergence and corroboration for results from different methods studying the same phenomenon.

b) Complementarity – seeks elaboration, enhancement, illustration, clarification of results from one method with the results from another.

c) Development – seeks to use the results from one method to help develop or inform the other method, where development is broadly construed to include sampling and implementation, as well as measurement decisions.

d) Initiation – seeks the discovery of paradox and contradiction, and new perspectives that lead to reframing of the research question.

e) Expansion – seeks to extend the breadth and range of enquiry by using different methods for different inquiry components.

Onwuegbuzie and Leech (2005) state that becoming a pragmatic researcher offers a myriad of advantages for individuals. It enables researchers to be flexible in their investigative

techniques, as they attempt to address a range of research questions; and they are able to delve further into a dataset to understand its meaning and to use one method to verify findings from the other method. Johnson and Onwuegbuzie (2004) describe it as an expansive and creative form of research that is inclusive and complementary. A pragmatic paradigm using a mixed methodology thus best suits this study because it is unlimiting and does not restrict the researcher.

Chapter 4

RESEARCH DESIGN AND METHOD

The design of this investigation was based on methods used by Rutledge and Mitchell (2002) and Mathews (2001). These methods were used because of their simple yet well thought through structure which is based on previous research. The combination of concept mapping (method based on Rutledge and Mitchell, 2002) and a survey (based on Mathews, 2001) acknowledges the existence of multiple intelligences, focusing on visual (drawings) as well as verbal/language intelligences. A mixed methods approach, using qualitative and quantitative data, was used. The strategy pertaining to concurrent mixed methods was followed. This procedure, as explained by Creswell (2009), is one in which the researcher converges and merges quantitative and qualitative in order to provide a comprehensive analysis of the research problem. The investigator simultaneously collects both forms of data and then combines the information in the overall results.

A sample school from the KwaZulu-Natal midlands area, that is well resourced, multicultural and co-educational, was identified and used for this investigation. The grade 12 Life Sciences classes of this school are the focus of the investigation. There were two classes, one with 21 learners and the other with 24 learners. The investigation of learners' ideas was divided into four parts: 1) Concept Mapping, 2) 15 Item Survey , 3) Extra Questions Questionnaire and 4) Interviews. Three school visits were necessary to collect the data from learners. The teachers of each of the Life Sciences classes were also tested using a similar concept mapping task and survey questionnaire as was used with the learners.

Part 1: Concept Mapping

Learners were given a brief period of instruction explaining the process of concept mapping, where an example of a concept map was done on a school chalk board to ensure that all learners were capable of carrying out the task. Learners were then asked to draw a concept

map plotting everything that they knew about the topic evolution, making links between ideas including religious ideas and points of view. Learners were also asked to identify which of the concepts and ideas they believe to be true or plausible. This was done by circling, marking or highlighting the relevant concepts and ideas on concept maps.

A Concept map task was used because it provides an open ended method for learners to communicate their conceptions and knowledge structures about evolution. This eliminated any prompts given by questions or discussions i.e. the individuals' intuitive/naive (uninfluenced) conceptions were mapped. Learners showed great difficulty trying to draw these concept maps. Many learners remained seated with a blank sheet of paper before them. When asked why they were not attempting the task, many replied that it was too difficult or impossible to put their ideas about evolution in a concept map format. The learners were then instructed to use any format that they felt comfortable with instead of using a strict concept map format. All learners then participated and completed the task. Even though learners did not use a concept map format, the task will still be referred to as the concept map task.

The maps were analyzed for trends and used to gain an overall impression of the conceptual framework concerning evolution. In order to further identify patterns and valuable data an organising system of data reduction was used based on that described by McMillan and Schumacher (1993). Each concept map was read and the main concepts of each written down. Concept maps were then re-read and analyzed, and a list of topics was identified on each concept map. The number of times that each topic appeared across the concept maps was recorded and tabulated. From this list it is possible to identify patterns and links between various aspects of the data. Concept maps will provide qualitative data for analysis.

Part 2: 15 Item Survey

A 15 item survey was given to learners concerning specific beliefs and ideas about evolution and whether learner knowledge is based on scientific or non-scientific notions. The survey was scored using a 5-point Likert-type scale with 1= strongly agree, 2= agree, 3= disagree, 4=

strongly disagree and 5= undecided. When scores were analyzed, values of statements were altered in order to score 'undecided' a zero instead of a 5. Score values then worked as follows: 1= strongly agree, 2= agree, 3= disagree, 4= strongly disagree. Scoring 'undecided' a zero best suited this investigation as it better reflected the meaning and value of learner answers. Lower values represent a non scientific view i.e a view that is not commonly accepted by the majority of scientists (in this case, religious views), while higher values represent a scientific view. Scores of questions 2, 4, 10 and 14 were reversed prior to analysis to maintain consistency in direction. These questions initially had a 'reverse' score to eliminate the possibility of learners understanding that a 'high' score for questions shows that they 'understand' the question, and then merely answering with a 'high' scores to give the impression of understanding.

Survey Questions:

1. *Landforms like the Drakensberg mountains were created by God and have not changed ever since.*
2. *Certain types of living things such as dinosaurs that once lived on Earth no longer exist.*
3. *Fossils were intentionally put on Earth to confuse humans.*
4. *All humans originate from Africa from where they populated the rest of the world.*
5. *The creation story is the best account of how the Earth was created and populated with life.*
6. *Humans and apes are as closely related as humans are to dogs.*
7. *Living organisms are different from nonliving things because they possess some kind of special force.*
8. *Human beings are different from other living organisms because they possess a soul.*
9. *All events in nature occur as a predetermined plan.*
10. *You have the same genes as bacteria for essential life processes.*
11. *Living organisms on Earth may have come from an alien life form.*
12. *It seems reasonable that the universe was created by God.*
13. *Aliens sometimes land on Earth.*

14. Evolution should be taught in Biology class.

15. All events in human life occur as part of a predetermined master plan.

The survey included scientific knowledge based questions, religious based questions, supernatural type questions and an opinion question which served to probe learner's sense of the importance of evolution. A survey was used because it provided data that could be statistically analyzed and provide quantitative data. The survey used was short which encouraged learners to remain focused and interested in the task. Such a survey eliminates judgement or bias of the researcher during data analysis, giving more consistent results increasing the reliability of the investigation.

Parts 1 and 2 were carried out pre and post instruction. The 15 item survey will be referred to as the pre survey (survey done before instruction), and post survey (survey done after instruction). Similarly, concept maps will also be referred to as either pre or post concept maps. The results from the pre and post surveys were plotted on various bar graphs to illustrate changes that learners had made, in particular whether they moved towards a more scientific understanding. A paired sample t-test was done to determine significant differences between the mean pre and post survey scores, whilst the one way analysis of variance (ANOVA) was used to test for a difference between the mean scores of the scientific knowledge, religious/cultural, opinion and supernatural explanation question groups. Since we are dealing with the mean scores, the use of the above mentioned parametric tests are qualified, owing to the fact that the mean or sample mean as it is sometimes known follows a normal distribution.

A paired sample t-test is used for data from only one group of participants. In other words an individual obtains two scores under different levels of the independent variable. Data that are collected from the same group of participants are also referred to as within-subjects. Studies, as is the current one, which employs a pre survey-post survey design, are commonly analyzed using the paired sample t-test.

The basic procedure of ANOVA is to derive two different estimates of population variance from the data, then calculate a statistic from the ratio of these two estimates. One of these estimates (between groups variance) is a measure of the effect of the independent variable combined with error variance. The other estimate (within group's variance) is of error variance itself. The F-ratio is the ratio of the between groups variance to within groups variance. A significant F-value tells us that the population means are not equal.

A multiple comparison, least square difference, was then done to assess exactly where the change was that emerged in the ANOVA. A Pearson correlation was done to identify potential relationships between the questions in the pre and post survey. This data derived from the above mentioned tests will then be used to examine possible shifts in learners' beliefs, attitudes and their scientific understanding of evolution. Concept maps provide further evidence and detail concerning such changes.

The data quality needs to have the following characteristics: validity and reliability. The Cronbach's Alpha was calculated for the test questions that have the same scales. A value of 0.7 or higher is deemed to conclude a good internal consistency and reliability amongst test questions.

Part 3: Extra Questions Questionnaire

An extra questions questionnaire was given to learners post instruction (questions included below). The purpose of the questionnaire was to probe learner acceptance of evolution directly with regards to macro and micro evolution and natural selection. The extra questions questionnaire also provided learners with the opportunity to express their opinions and concerns about evolution; this entailed learners listing and explaining concepts that they found easy to understand or difficult to deal with. Questions also asked learners to explain if they felt evolution was compatible or incompatible with their religious beliefs and whether or not they thought evolution should be included in the school curriculum. The

question concerning evolution in the school curriculum appears in all questionnaire tasks, this was done to determine if learners answered consistently for the duration of the study. Questions included in the Extra Q Questionnaire:

Circle the underlined word in each question below that best completes the sentence and then give an explanation as to why you said so.

a) I <u>reject</u> / <u>accept</u> the theory of macroevolution because...
b) I <u>believe</u> / <u>don't believe</u> Natural selection to be true because...
c) During the section on evolution I found the following concept difficult to deal with because....
   (state the concept and then explain why)
d) During the section on evolution I found the following concepts interesting and easy to understand because...
   (State the concept(s) and explain why)
e) I find evolution <u>compatible</u> / <u>incompatible</u> with religious beliefs because...
f) Evolution <u>should</u> / <u>shouldn't</u> be included in the Life Science curriculum because...

The extra questions were analyzed for general trends that emerged for individual learners as well as groups of learners. A simple data reduction technique was applied to the questionnaire and the results tabulated. This task provided qualitative as well as quantitative data for analysis.

Part 4: Interviews

The purpose of the interviews in this study was to gain in depth and more detailed data from learners that could not be otherwise achieved from a questionnaire or concept map. Six learners were randomly selected and interviewed. The interview schedule consisted of 10 questions, one open ended semi structured question (question 1), and 9 structured questions. The questions are outlined in the results section. The first question addressed learner concept maps. Learners were given the opportunity to fully explain both concept maps, their format, information included and changes made between their pre and post concept maps. Questions 2 to 7 investigated certain external factors that might influence conceptual change and learner attitude, and question 8 and 9 investigated learner

understanding of natural selection and knowledge application. Question 10 was an open ended question allowing learners to express any last concerns or bits of information they felt needed to be heard.

Interviews were kept short and further prompt questions were only used where necessary to keep learner answers focused on relevant information and to ensure they fully understood the initial question asked. This limited interviews generating large amounts of textual data, instead data remained focused and clear and thus easier to analyze. Interviews were recorded onto a tape and transcribed. Data was then analyzed for general trends as well as identification of data that could support or explain trends noticed in parts 1-3 of the study.

Implementation and Procedure of Parts 1-4

The school was visited on three different days. Each visit was allocated a 1 hour lesson by the school for the study. The first school visit was done before learners had experienced any instruction in evolution in Life Sciences. Learners completed the pre concept map and the pre survey on this day. The second school visit was done post instruction i.e. after they were taught the section on evolution, where learners completed the post concept map and post survey. The third school visit was done after learners had written a Life Sciences exam which included evolution. A teacher from the school monitored learners while they completed the extra questions questionnaire. It was during this 1 hour session that individual learners were removed from the class to be interviewed.

Categorisation Scheme and Learner Groups

Once the analysis of Parts 1-4 was complete, learners' were classified in order to assess learner's positions with regard to their cultural backgrounds, scientific knowledge structure and religious standings, learners were categorised and divided into 5 groups using results of

learner test scores, concept maps and the extra questions questionnaire. The categorisation scheme and learner groups identified in this study was based on the original work done by Costa (1995) on patterns of categorisation, later revised by Jegede and Aikenhead (1999) and Aikenhead (2001). Learners are categorised according to the ease with which they succeed in school science; which in turn is related to how different learner life-worlds align with school science (Aikenhead, 2001). Jegede and Aikenhead (1999) and Aikenhead (2001) closely link this categorisation scheme to understanding the process of collateral learning and cultural border crossing making this an appropriate scheme to apply to this investigation.

Criteria used to group learners have been designed to fit this investigation (concerned with learning evolution) specifically. Final group categories are based on those described by Aikenhead (2001), excluding the group referred to as 'Inside outsiders', as this group has no relevance to the school context used in this investigation. For the sake of consistency group names (Potential Scientists, Other Smart Kids, I don't know, Outsiders, I want to know) have been kept the same as those initially described by Costa (1995) and Jegede and Aikenhead (1999) and do not indicate level of intelligence, instead, how learners see the world(worldview). Before the analysis of results, further criteria were established and narrowed to suit this study based on the design of the surveys and tasks to be given to learners (Grouping criteria is based on predicting learner response on tasks and surveys).

Group 1 – '*Potential Scientists*'

Description: Transitions are smooth because the cultures of family and science are congruent (Jegede & Aikenhead, 1999).

Smooth border crossing that lead to an in-depth understanding of science.

Their self-image and lifestyle resonate with the world of western science (Aikenhead, 2001)

Learners in this group accept evolution in its entirety.

Criteria:

- Learner obtains a positive score change from pre to post survey.

- Learner scores 35 or more in the post surevy.

- Accepts macroevolution on the extra questions questionnaire.

- Believes natural selection to be true.

- Included 4 or more scientific concepts in the post concept map.

- Learners defined or explained concepts in the post concept map.

- Learner indicates that evolution should be included in the school curriculum.

- Shows good understanding of natural selection.

Group 2 – *'Other Smart Kids'*

Description: Transitions are manageable because the two cultures are somewhat different (Jegede & Aikenhead, 1999).

Easily managed border crossing but with no personal interest in pursuing science (Aikenhead, 2001).

Accepts evolution. Has difficulty with some aspects only.

Criteria:

- Learner obtains a score change of 0 or a positive change from pre to post survey.

- If the learner is religious, then there must be evidence that religious views overlap with scientific views.

- Learner indicates that evolution should be included in the school curriculum.

- Indicates that evolution is compatible with religious beliefs on the extra questionnaire.

- Included 3 or more scientific concepts in the post concept map.

- Shows a fair understanding of natural selection.

Group 3 – *'I don't know'*

Description: Transitions tend to be hazardous when the two cultures are diverse (Jegede & Aikenhead, 1999).

Hazardous border crossing into superficial understanding of science (Aikenhead, 2001).

These learners seem undecided about their decision in accepting evolution. They are uninterested and lack enthusiasm.

Criteria:

- Learner obtains a negative score change from pre to post survey (up to -5).

  or a positive score change (up to 5)

  or score a 0

- Learner answers inconsistently across the various tasks.
- Shows a poor understanding of natural selection.

Group 4 – '*Outsiders*'

Description: Transitions are virtually impossible because the cultures are highly discordant (Jegede & Aikenhead, 1999).

Impossible border crossing that lead to dropping out, physically or intellectually (Aikenhead, 2001).

These are strongly religious learners. Learners reject evolution completely.

Criteria:

- Learner obtains a negative score change, or a positive score change (up to 2), or a 0 score from pre to post survey.
- Learner obtains a score of 35 or less in the post survey.
- Rejects macroevolution on the extra questions questionnaire.
- Indicates that evolution is incompatible with religious beliefs on the extra questionnaire.
- Learner indicates that evolution should not be included in the school curriculum.
- States personal beliefs in concept mapping and questionnaire tasks.

Group 5 – '*I want to know*'

Description: Adventurous border crossing that leads to a modest yet effective understanding of science (there are hazards but learners want to know) (Aikenhead, 2001).

Accept parts of evolution only. Science and religious views overlap.

Criteria:

- Learner obtains a negative or positive score change between -5 and 10 from pre to post survey.
- Learner indicates that evolution should be included in the school curriculum.
- Indicates that evolution is compatible or incompatible with religious beliefs on the extra questionnaire.
- Believes natural selection to be true.
- Few scientific concepts included in concept maps.
- Hesitant but curious.
- Maintains religious beliefs.

Part 5:Teacher Tasks

The two grade 12 Life science teachers of this school were given a similar concept mapping task and 15 item survey. Instructions for these two tasks were the same as for the learners. The tasks were, however, only given to the teachers once as a pre and post comparison was not necessary. Teachers were also given a separate teacher specific extra questions questionnaire. Questions included in this questionnaire were set as multiple choice questions with the option of explaining or elaborating on answers given. Questions included in the questionnaire are listed:

1. *Have you had a specific course in evolution?*
   A. *Yes*
   B. *No*

2. *How much time in the school year do you devote to the topic of evolution?*
   A. *5 - 10 days*
   B. *10 - 15 days*
   C. *15 - 20 days*
   D. *More than 4 school weeks*

3. *Which expression best characterises your teaching of evolutionary theory?*
   A. *Avoidance*
   B. *Briefly mentioned*
   C. *Studied in depth as a distinct content area*
   D. *The unifying theme for the content of the course*

4. *Do you accept evolutionary theory as a scientifically valid explanation of the state of living organisms of the present and past?*
   A. *Yes*
   B. *No*

5. *Have you experienced any difficulties teaching the topic?*
   A. *Yes*
   B. *No*

Questions included served the purpose of determining the level of teacher training in evolution, the level of importance they placed on evolution in the curriculum, teacher acceptance of evolution and ultimately whether there is a link between any of these factors. Teachers were given the tasks to complete in their own time as it was unpractical and inappropriate for either teacher to take time at school to complete the tasks. The tasks provided qualitative data.

Limitations

The design of the investigation is complex, limiting this investigation to only one school. Only using one school limited the sample size. Only 45 learners and 2 teachers participated in this study. Introducing another school would increase this number and would allow for

different school cultures to be compared; but including more schools would introduce variables that would be difficult to account for because different schools have different influences, possibly reducing the reliability of this investigation based on its current design.

Due to the fact that learners were divided into groups, prior to the statistical analysis, resulted in data being less reliable for group statistics because there were only a small number of learners in each group, and groups varied in size. The topic evolution in itself is a limiting factor due its controversial nature. Learner attitudes were severely influenced by the topic of the study and created a negative environment on the first school visit.

Chapter 5

RESULTS

5.1 QUANTITATIVE RESULTS

5.1.1 Pre and Post Survey Results

The Cronbach's Alpha was calculated for the survey to determine the reliability and internal consistency of the questions. A Cronbach's Alpha value of 0.751 was calculated for pre survey, and 0.785 for post survey questions. These alpha values are considered good values and indicate good internal consistency i.e. the same results will be obtained if the survey is carried out with a larger group of learners. Thus the survey results can be used with confidence for this study.

After scanning the data, it was obvious that learners would be easily allocated to the 5 groups identified in the methods section. The 45 learners were grouped according to the criteria they met. The learner was placed into the group from which they met all or most of the criteria. Table 1 shows the number of learners grouped in each group, group 2 having the highest numbers of learner (13), and Group 1 the lowest with 6 learners. Teacher B and Teacher A had learners from each group in their classes.

Levene's test for equality of variance was performed to determine homogeneity of the data. Results showed that data was homogenous and did not need to be transformed, thus a t–test could be carried out. A t-test was done to determine if there is a difference in the mean scores of the two classes taught by the two different teachers with respect to pre survey scientific knowledge, religious/cultural, opinion and supernatural explanation questions and the mean scores of the post survey scientific knowledge, religious/cultural, opinion and supernatural explanation questions.

Table 1 Number of learners in each group, and the proportion of each group taught by the respective teachers.

| | Number of learners in each group | | | | | |
	Group 1	Group 2	Group 3	Group 4	Group 5	Total
Teacher B	3	4	4	7	3	21
Teacher A	3	9	5	3	4	24
Total Number of Learners	6	13	9	10	7	45
Percentage of Total	13.3	28.9	20	22.2	15.6	100

Table 2:1 Results of the equality of variances test of the equality of variances test on the mean pre and post survey scores of the two classes

	Teacher	N	Mean ± Std. Deviation	t - statistic for comparison	Sig. (2-tailed)
Pre survey scores	B	21	33.66 ± 9.35	0.28	0.78
	A	24	33.00 ± 6.60		
Post survey scores	B	21	34.81 ± 8.19	0.12	0.90
	A	24	34.50 ± 8.79		
Change in score	B	21		-0.18	0.86
	A	24			

Table 2.1 shows that there is no significant difference between the two classes with respect to the scores on the pre or the post survey, or the change in scores between pre and post survey (p>0.05, two-tailed t-test). Hence the teacher effect is non-significant, and the classes can be combined into one sample.

The results of the learner pre and post survey scores are summarised in graphs 1.1-1.5. The questions used in the pre and post survey are listed below. Learners were asked to indicate

the extent to which they agree or disagreed with each statement on a scale of 1-4, with 0 providing the option of "undecided".

Questions

1. *Landforms like the Drakensberg mountains were created by God and have not changed ever since.*
2. *Certain types of living things such as dinosaurs that once lived on Earth no longer exist.*
3. *. Fossils were intentionally put on Earth to confuse humans.*
4. *All humans originate from Africa from where they populated the rest of the world.*
5. *The creation story is the best account of how the Earth was created and populated with life.*
6. *Humans and apes are as closely related as humans are to dogs.*
7. *Living organisms are different from nonliving things because they possess some kind of special force.*
8. *Human beings are different from other living organisms because they possess a soul.*
9. *All events in nature occur as a predetermined plan.*
10. *You have the same genes as bacteria for essential life processes.*
11. *Living organisms on Earth may have come from an alien life form.*
12. *It seems reasonable that the universe was created by God.*
13. *Aliens sometimes land on Earth.*
14. *Evolution should be taught in Biology class.*
15. *All events in human life occur as part of a predetermined master plan.*

For ease of reference and making comparisons, the questions listed above have been grouped based on the content being questioned. These groups are marked on the graphs as follows:

A – Scientific knowledge based questions: Questions 1-4, 6 and 10

B – Religious/Cultural based questions: Questions 5, 7-9, 12 and 15

C – Supernatural explanation type questions: Questions 11 and 13

D – Opinion question: Question 14

Any score change that indicates a learner has moved toward a more scientific understanding of a concept will be referred to as a positive change. Any score change that indicates a learner has moved away from a scientific understanding of a concept will be referred to as a negative change.

Graph 1.1 shows the number of learners with a scientific understanding of the subject addressed by each question in pre and post surveys. A scientific understanding is reflected by a score of 3 or 4 for a question. Most questions, except numbers 4, 5, 7 and 14 show that more learners have a scientific understanding of the concept being questioned in the post survey, than in the pre survey. Question 1 showed the greatest change with 18 learners having a scientific understanding in the pre survey, and 27 learners in the post survey. Question 3, based on knowledge of the origin of fossils, has the greatest number of learners with a scientific understanding pre survey (39 learners) and post survey (43 learners). Question 12, based on religious/cultural understanding, had the least number of learners with a scientific understanding pre and post survey. Less than half of the learners adopted a scientific understanding pre and post survey for all the religious/cultural questions. Question 4, 5, 7 and 14 show that fewer learners have a scientific understanding in the post survey than in the pre survey.

Graph 1.1 only shows the number of learners with a scientific understanding (a score of 3 or 4) in the pre and post survey. All changes made by learners during classroom time need to be considered. Graph 1.2 separates the changes that learners made into 4 broad categories: learners that showed no change (their score remained the same in the pre and post survey), those learners that moved to 'undecided' in the post survey (a score of 0, from a non scientific or scientific understanding), learners that showed a negative change (moved away from a scientific understanding such as from a pre score of 4 to a post survey score of 3), and those learners that showed a positive change (any movement in score towards a 4).
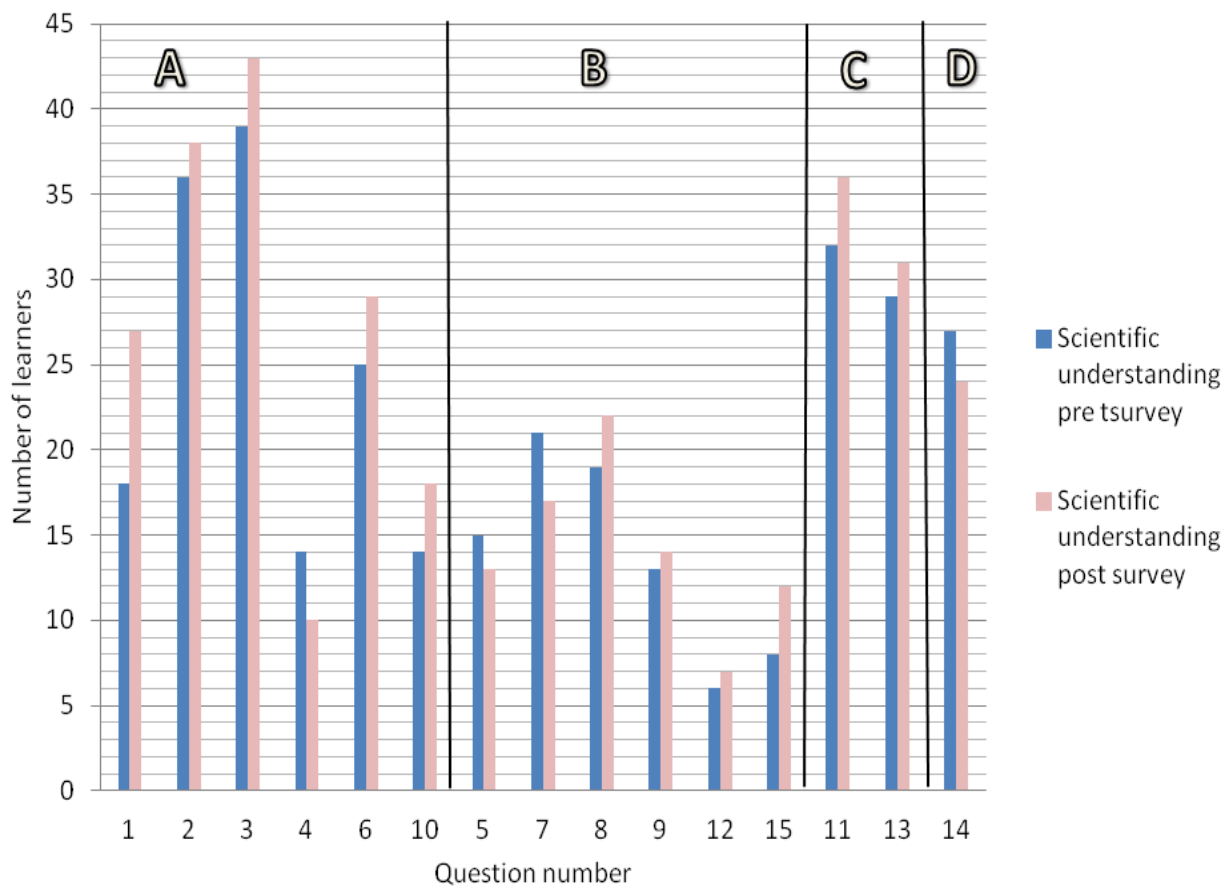
Graph 1.1 Bar graph showing the number of learners with a scientific understanding pre and post survey.

Every question has at least one learner in each of the 4 categories. A large portion of learners show no change for each question, question 5 and question 12 showing the greatest with 30 and 32 learners not changing their ideas from the pre to post survey i.e. they maintain their unscientific, or in this case due to the content of the question, their religious views. Questions 5 and 12 show the largest resistance to change. Both questions mention creation, and imply control by a supernatural being, named as God in Question 12. It was clearly not easy for learners to abandon ideas of external control in these questions, although creation was also mentioned in question 1, where 36% of learners were willing to abandon the idea of constancy of earth forms created by a deity. Less than half the learners show any form of positive change in each question, question 6 having the highest number of positive score changes of 18. This is a content question, where many learners have acquired

a more scientific understanding of the relationships between humans and apes relative to the relationship between humans and dogs. Question 1 also has a large number of learners who showed a positive change towards scientific understanding. This is a question about the changing landscapes, where conceptual change occurred in 16 of the 45 learners. Question 11 has the second highest number of learners that showed a positive change towards a scientific understanding. This particular question makes a link between the origin of life on earth and aliens. The post survey thus shows that fewer learners are satisfied with this explanation and are willing to replace this idea with the theory of evolution as an explanation of how life began.

There are also a large number of learners (especially in the religious/cultural and opinion questions) that show a negative change (they are moving away from a scientific understanding), and every question shows a portion of learners moving in a negative direction. Questions 4, 7 and 9 were interesting because almost as many learners made a positive change as those who made a negative change. Questions 9 and 15 are related, since both refer to the possibility of a master plan for nature and life, but 12 learners moved to a non-scientific position in question 9, while only five did so in question 15. Less than 30% of learners held scientific views on both of these questions in the pre-and post-survey. However, after instruction, more learners moved away from a scientific understanding in question 9 than was the case with question 15. His difference in change is due to the slight difference in the question asked. Question 9 merely refers to a 'predetermined plan for nature' whilst question 15 is more specific and refers to a 'predetermined plan for humans'. Question 9 applies to a wider set of beliefs, religions and cultures and more learners possibly relate to the question, but when learners consider a predetermined master plan for humans, the question becomes more religious in nature and can be interpreted as a link between God and humans (God has a plan for all humans). Thus explaining why more learners agree with question 9 over question 15.
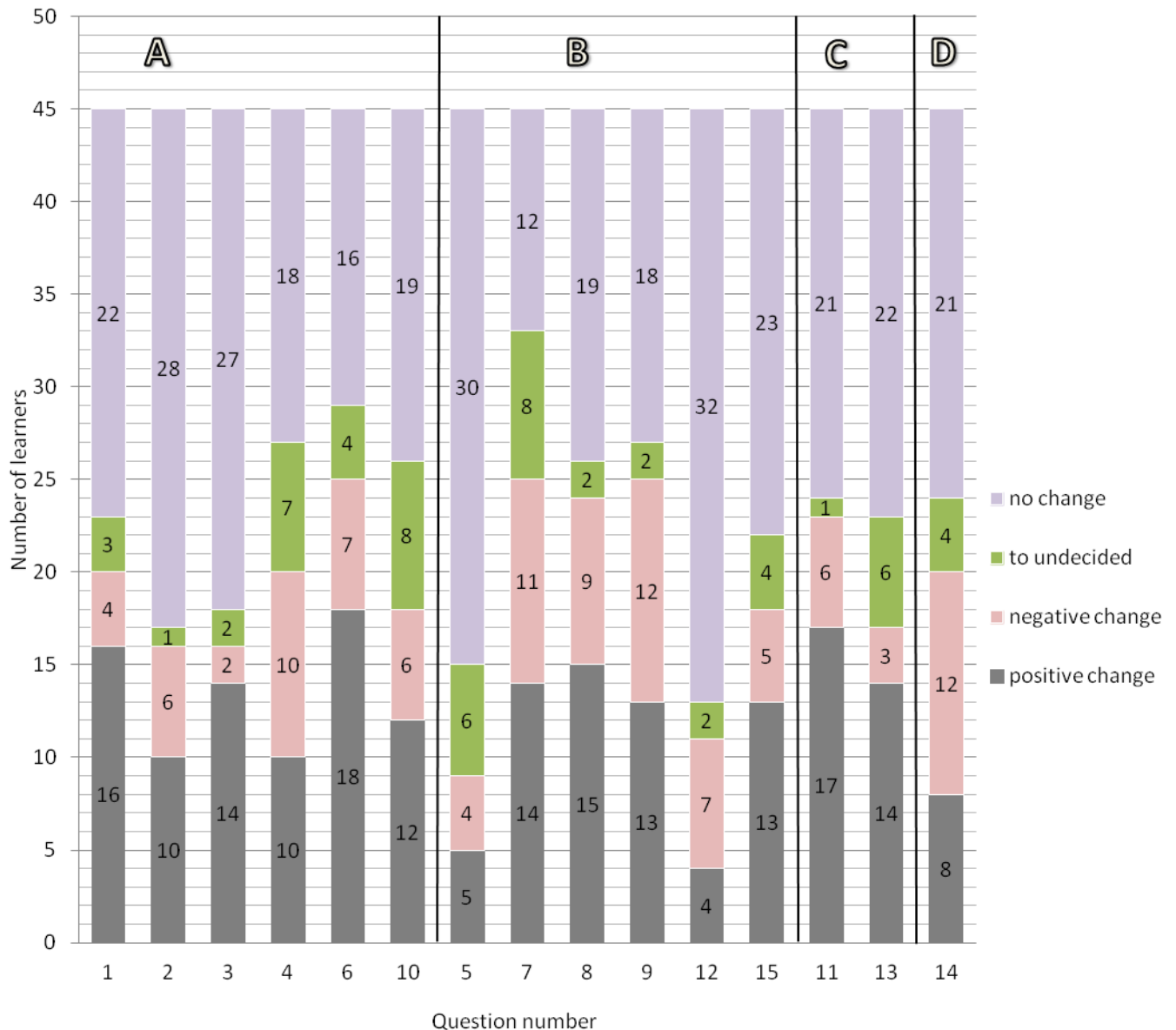
Graph 1.2 Bar graph showing the type of score change made by learners for each survey question.

It is necessary to look at score changes of learners in greater detail and to look into each of the 4 broad categories illustrated in graph 1.2. Graph 1.3 takes the first group of learners that showed 'no change' and analyses it further to show the learners that did not change their ideas (be it scientific or not) through the section taught on Evolution. Graph 1.3 shows 3 different groups of learners that fall into this bracket, namely the learners that remained undecided for each particular question in the pre and post survey (they scored 0 in the pre and post surveys); learners that scored a 1 or 2 in both pre and post survey i.e. they hold a

non scientific view of the concept in question; and those learners that scored a 3 or 4 in the pre and post surveys i.e. they show a scientific understanding of the concept in question.

Results show that only a small number of learners remained undecided from the pre to post survey, except in question 10. It also clearly illustrates that most learners have a scientific understanding through the pre and post survey in questions 1, 2, 3, 11, 13 and 14 (these are the knowledge based, supernatural based and opinion based questions). The religious/cultural based questions show the greatest numbers of learners that maintain their unscientific ideas in the pre and post surveys. Question 5 and 12 show the greatest number of learners unwilling to change their ideas/views from what is considered unscientific to scientific.
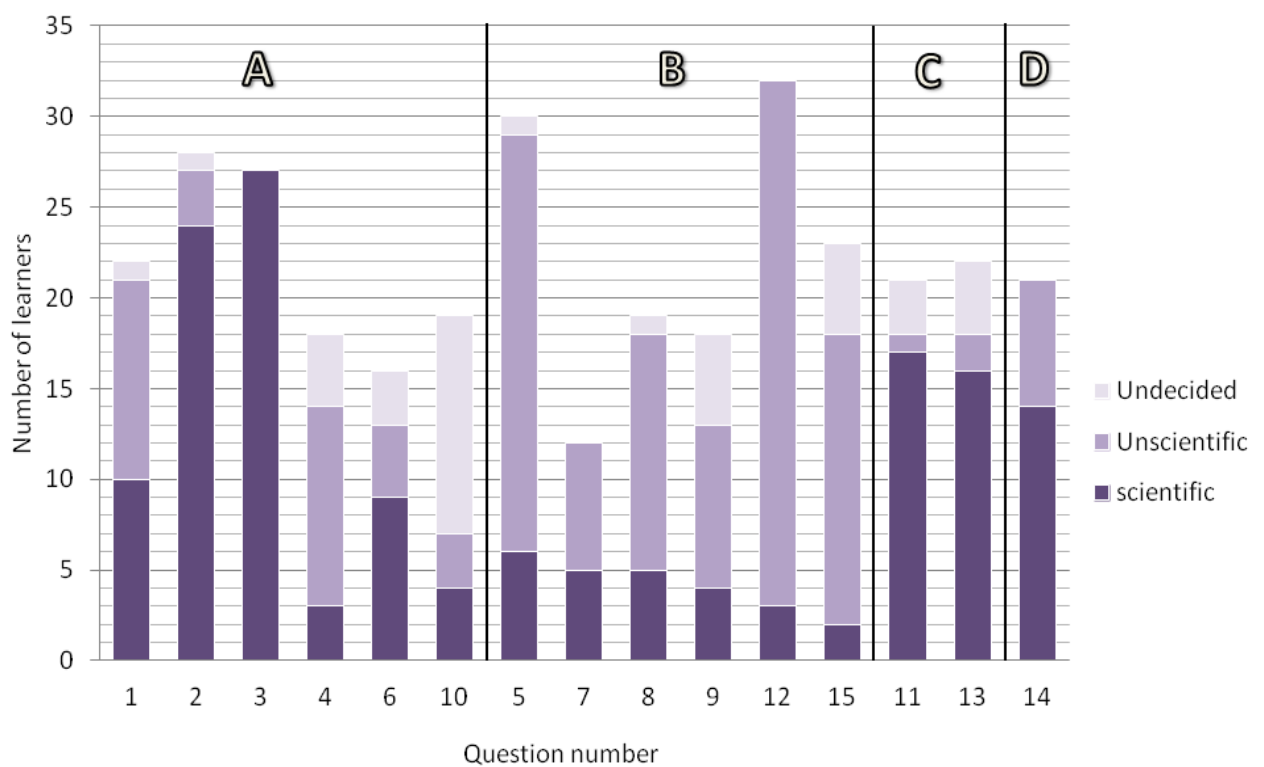
Graph 1.3 Bar graph showing the number of learners that showed no change in score from the pre to post survey.

Graph 1.4 shows the number of learners that moved away from a scientific understanding i.e. a score of 2 in the pre survey is followed by a 1 in the post survey, or a score of 4 in the

pre survey is followed by a 3 in the post survey; and if learners score a 3 or 4 in the pre survey followed by a 1 or 2 in the post survey (this is considered a complete negative change). Question 7, 9, 11, 13 and 14 show the greatest movement away from a scientific understanding, with 18% or more of the learners making a complete negative change. The religious/cultural, supernatural and the opinion based questions have the most learners making a complete negative change.

Graph 1.5 shows the number of learners that moved to a more scientific understanding (positive change). Far more learners made positive changes than those that made negative changes (shown in Graph 1.4). All questions show that at least 4 learners developed a more scientific understanding post survey in comparison to pre survey scores in each question. Most positive change was either a complete positive change (scoring a 1 or 2 in the pre survey and then scoring a 3 or 4 in the post survey), or a change from a score of 3 in the pre survey to a score of 4 in the post survey. In each question less than half the learners make any form of positive change.
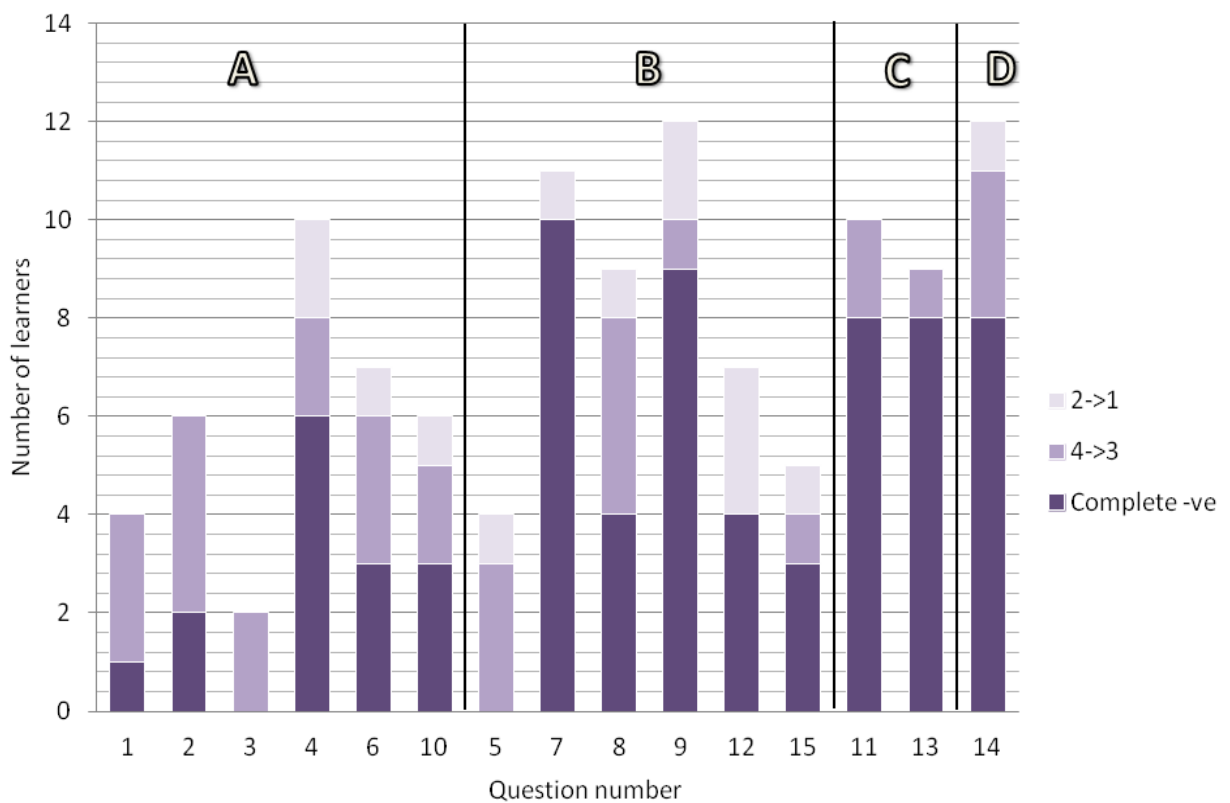
Graph 1.4 Bar graph showing the number of learners that moved away from a scientific understanding from pre to post survey.

45
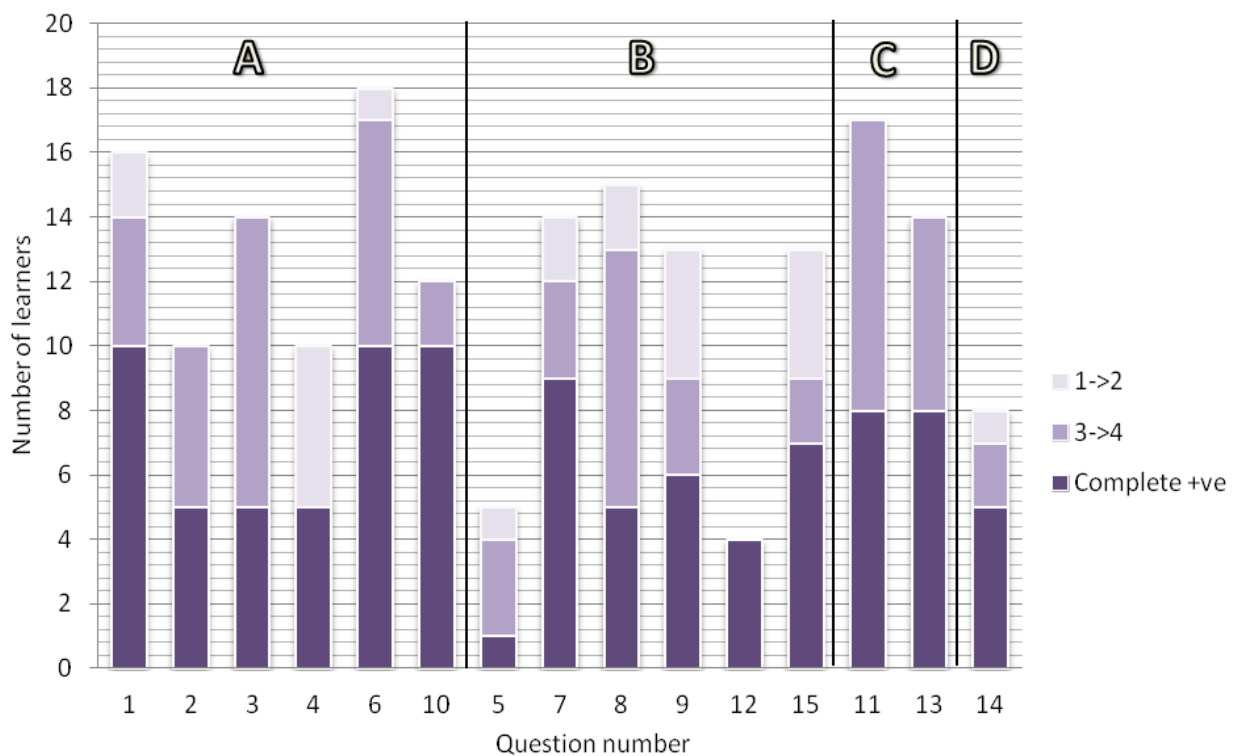
Graph 1.5 Bar graph showing the number of learners that moved to a more scientific understanding from pre to post survey .

Throughout graphs 1.1-1.5 results for question 4 do not follow the trend for the scientific knowledge based questions. Many learners make a negative change, a low number of learners show a scientific understanding in the post survey and there is a large portion of learners that maintain their unscientific understanding from pre to post survey. The results for this question are not what is expected and can be considered an 'outlier'. This is due to the nature of the question. Even though it is a scientific knowledge based question (tests the out of Africa theory), the question content can be closely linked to the religious ideas of Adam and Eve and cultural heritage and lineage of learners. Thus learners react similarly to this question as they do for the other, more obvious, religious questions, and the pattern more closely follows that of the religious based questions than the scientific knowledge based questions.

The graphs 1.1-1.5 show that most learners either make no change or they make a positive change. Question 12 showed the greatest resistance to change (learners maintained their

unscientific views). Question 12 also showed the least number of learners to make any positive change. This means that deeply religious learners do not abandon the fundamentals of their faith (in this question – God created the Universe).

To determine if there is a significant difference between the mean pre and post survey scores; as well as the mean pre scientific knowledge, religious/cultural, supernatural and opinion based question scores and post scientific knowledge, religious/cultural, supernatural and opinion based scores a pair sample t-test was done. The results are summarised in table 2.2 and 2.3.

Table 2.2 Results of Paired sample test for pre and post survey mean scores
(n=45 for every question)

Question	Pre survey Mean	Post survey Mean	t	Sig. (2-tailed)
Question 1	2.22	2.53	-2.319	.025
Question 2	3.29	3.33	-.269	.789
Question 3	3.36	3.56	-1.354	.183
Question 4	1.87	1.56	1.266	.212
Question 5	1.87	1.64	1.431	.160
Question 6	2.33	2.62	-1.114	.271
Question 7	2.13	2.04	.330	.743
Question 8	2.20	2.38	-1.308	.198
Question 9	1.60	1.93	-1.638	.109
Question 10	1.56	1.62	-.232	.817
Question 11	2.76	3.18	-1.928	.060
Question 12	1.56	1.49	.363	.718
Question 13	2.60	2.78	-.658	.514
Question 14	2.53	2.31	.990	.328
Question 15	1.44	1.67	-1.402	.168

Results in table 2.2 show that for question 1 (highlighted in the table), there is a significant difference between the pre survey mean score and the mean post survey score (p<0.05). This question is the most amenable to change. For the rest of the paired pre and post survey questions, since their p-values are all greater than 0.05, it can be concluded that there is no significant difference between pre and post survey scores for these questions, although question 11 was close to significant. Some questions were very resistant to change, as indicated by high significance levels. Questions 10, 2, 7 and 12 were the most resistant to change. Little change occurred in question 2 because learners already had a scientific understanding in the pre survey i.e. they understand the concept of extinction. Question 10, however can be linked to learning the basics of evolution and is one of the scientific knowledge based questions. Resistance in question 10 shows that conceptual change has not occurred and learners do not understand the concept in the question.

Table 2.3 Results of Paired sample test for pre and post survey mean scores of scientific knowledge, religious/cultural, opinion and supernatural based questions. (n=45)

	Pre survey Mean	Post survey Mean	t	Sig. (2-tailed)
Scientific **Questions 1,2,3,4,6,10**	2.44	2.54	-1.13	0.27
Religious / Cultural **Questions 5,7,8,9,12,15**	1.80	1.86	-0.60	0.55
Opinion **Question 14**	2.53	2.31	0.99	0.33
Supernatural **Questions 11,13**	2.68	2.98	-1.47	0.15
Survey totals	33.31	34.64	-1.36	.0.18

Results in table 2.3 indicate there is no significant difference in the mean scores of the pre and post survey scientific knowledge, religion and supernatural questions (p>0.05). This illustrates the resistance of learners' ideas to conceptual change. Learners adopted more scientifically accepted conceptions in the scientific, opinion and supernatural questions than

in the religious/cultural questions. Across the whole survey, in each individual section, and in individual questions, the change from pre- to post-test score was not significant.

A Pearson correlation was carried out to identify any potential relationship between the questions (pre and post survey). Results are summarised in table 3.1 – 3.3.

Table 3.1 Results of the Pearson correlation to identify relationships between pre survey question scores. *Highlighted results indicate a significant relationship.*

	Pre scientific	Pre religious	Pre opinion	Pre supernatural
Pre scientific	1			
Pre religious	0.398[*]	1		
Pre opinion	0.035	0.126	1	
Pre supernatural	0.146	0.111	-0.293	1

Results in table 3.1 show that there is a significant positive relationship between pre religious and pre scientific questions. Since the scores were inverted, learners who obtain low scores on scientific questions also obtain low scores on religious/cultural questions.

Table 3.2 Results of the Pearson correlation to identify relationships between post and pre survey question scores. *Highlighted results indicate a significant relationship.*

	Pre scientific	Pre religious	Pre opinion	Pre supernatural
Post scientific	0.558[**]	0.355	-0.10	0.207
Post religious	0.313[**]	0.683	0.305	0.072
Post opinion	0.050	0.258	0.402	-0.289
Post supernatural	0.163	0.122	-0.185	0.382

Cells on the diagonal in Table 3.2 show the relationship between pre-and post scores in each of the four categories of questions. All these cells show a significantly positive relationship, confirming that learners retain their conceptual positions between pre and post surveys. The strongest positive correlations are between pre and post scientific scores, and pre and

post religious scores. Weaker, but significant positive correlations are found between pre religious questions and post scientific questions, pre scientific and post religious scores, and pre opinion and post religious scores. This confirms that learners who held strong scientific conceptions in the pre scientific questions also obtained high scores in post scientific questions and post religious questions. Similarly, those learners that held weak religious conceptions in the pre survey, held strong scientific conceptions in the post survey. Learners who held the opinion that evolution should be taught in class, also held weak religious conceptions in the post survey, (indicting that non-religious learners are of the opinion that evolution should be taught in class and conversely). The religious conceptions impact on learners' scientific conceptions, opinion about whether evolution should be taught in schools, but not on their acceptance of supernatural explanations.

Table 3.3 Results of the Pearson correlation to identify relationships between post survey question scores.

	Post scientific	Post religious	Post opinion	Post supernatural
Post scientific	1			
Post religious	0.292	1		
Post opinion	-0.004	0.272	1	
Post supernatural	0.240	0.163	-0.045	1

Results in table 3.3 show that there are no significant relationships between post survey scores.

In summary, the correlation tables show that there are significant positive relationships between:
- pre scientific knowledge and pre and post religious, and post scientific knowledge and post religious questions
- pre religious and post scientific knowledge and post religious questions
- pre opinion and post religious and post opinion questions
- pre supernatural and post supernatural questions

This means that learner's preconceptions impact learning, and have an effect on conceptual change and learner attitude towards evolution.

In order to explore further the interaction of the four different categories of questions, a repeated measure analysis of variance (ANOVA) was conducted to determine if there is a difference in the pre and post survey mean scores of the categories of questions. An ANOVA allows one to identify changes in the score on the questionnaire administered to a population (the learners) over time. ANOVA results show that there is a significant difference between the mean scores (F= $p<0.001$) in both pre and post survey. A multiple comparison test, least squares difference (LSD), was done to assess which categories of statements were responsible for the significant F-statistic. LSD results are summarised in tables 4.1 and 4.2.

Table 4.1 Least squared difference test results showing significant differences of pre survey question scores. *X = significant difference at the 5% level*

PRE SURVEY	Scientific knowledge Questions		Religious/Cultural Questions		Opinion Questions		Supernatural Questions
Scientific knowledge Questions							
Religious/Cultural Questions	**X**						
	Mean diff.	Sig.					
	0.638	0.005					
Opinion Questions			**X**				
	Mean diff.	Sig.	Mean diff.	Sig.			
	0.096	0.670	-0.733	0.001			
Supernatural Questions			**X**				
	Mean diff.	Sig.	Mean diff.	Sig.	Mean diff.	Sig.	
	-0.240	0.286	-0.878	0.000	-0.144	0.520	

Table 4.1 shows that there is a significant difference between pre survey scores of religious questions and all other question categories. This means that scores of the religious questions were different from scores obtained for the other categories of questions. Results

in table 4.2 shows that there also a significant difference between scores obtained for post religious questions and all other question categories in the post survey. Table 4.2 identifies a significant difference between the post scientific scores and post religious and supernatural scores. There is also a significant difference between scores obtained for post religious questions and all other question categories. A significant difference also exists between scores of post opinion questions and religious scores as well as between post supernatural scores and post opinion scores. This means learners that hold a religious view post survey do not feel that evolution should be included in the curriculum. Similarly, learners that hold supernatural views about the origins of life on earth post survey do not feel that evolution should be included in the curriculum.

Table 4.2 Least squared difference test results showing significant differences of post survey question scores.   *X = significant difference at the 5% level*

POST SURVEY	Scientific knowledge Questions		Religious/Cultural Questions		Opinion Questions		Supernatural Questions
Scientific knowledge Questions							
Religious/Cultural Questions	**X**						
	Mean diff.	Sig.					
	0.678	0.003					
Opinion Questions			**X**				
	Mean diff.	Sig.	Mean diff.	Sig.			
	0.225	0.310	-0.452	0.042			
Supernatural Questions	**X**		**X**		**X**		
	Mean diff.	Sig.	Mean diff.	Sig.	Mean diff.	Sig.	
	-0.44133	0.047	-1.119	0.00	-0.667	0.003	

Learner groups established as described in the Methods section were then compared in terms of mean scores in pre- and post-surveys. An ANOVA showed that there is a significant difference in the learner group with respect to the post survey scores ($p<0.001$). However, with respect to the mean pre survey scores there is no significant difference between the learner groups ($p>0.05$). A multiple comparison was done to ascertain where the differences lie in the post survey scores within the learner groups. Results are summarised in table 5.

Group 1 (potential scientists) is the 'stand out' group in that it is significantly different from all other groups. Group 1 learners answered differently from all other groups. This group obtained high scores for for most questions, indicating that these learners have a good scientific understanding of the concepts of evolution, and do not hold religious views, and those that do find no clash between science and religion. There is also a significant difference between groups 2 (other smart kids) and 3 (I don't know).

Table 5 Results of a multiple comparisons test showing significant differences in survey scores between groups of learners.   *X = significant difference at the 5% level*

Learner Group	1 Potential scientist		2 Other smart kids		3 I don't know		4 Outsiders		5 I want to know
1 Potential scientist									
2 Other smart kids	**X** Mean diff. 8.10714	Sig. 0.019							
3 I don't know	**X** Mean diff. 15.4127	Sig. 0.000	**X** Mean diff. 7.30556	Sig. 0.022					
4 Outsiders	**X** Mean diff. 13.6571	Sig. 0.000	Mean diff. 5.5500	Sig. 0.070	Mean diff. -1.75556	Sig. 0.586			
5 I want to know	**X** Mean diff. 12.4286	Sig. 0.002	Mean diff. 4.32143	Sig. 0.199	Mean diff. -2.98413	Sig. 0.400	Mean diff. -1.22857	Sig. 0.722	

The average of the pre and post survey total scores indicates that there was an overall increase from pre to post survey of 1.33. The highest pre survey score was 53 by learner 1 in group 1, and the highest post survey score was achieved by learner 3 in group 1 who also scored 53. The lowest pre survey score of 17 was obtained by learner 26 in group 3, and the lowest post survey score of 16 was obtained by learner 22 in group 3. The greatest positive change from pre to post survey was a score of 17 by learner 19 in group 2, and the greatest negative score change was a score of -13 by learner 29 in group 4.

Quantitative data provides a good foundation of information for this study, but does not answer all research questions and is limiting. Further qualitative data investigates and

reveals information which qualitative data does not produce. Thus, this investigation contains a substantial qualitative portion which explores learning with greater depth. The results of this qualitative portion are discussed in the next section.

5.2 QUALITATIVE RESULTS

5.2.1 Concept Map Results

The second part of the school visit consisted of learners drawing concept maps of everything they knew or had heard of (if they believed it to be true or not) concerning the topic evolution. Examples of the variety of formats that emerged from this task are shown below in figures 1-3. Learners wrote paragraphs, while some used flow charts and some included pictures.
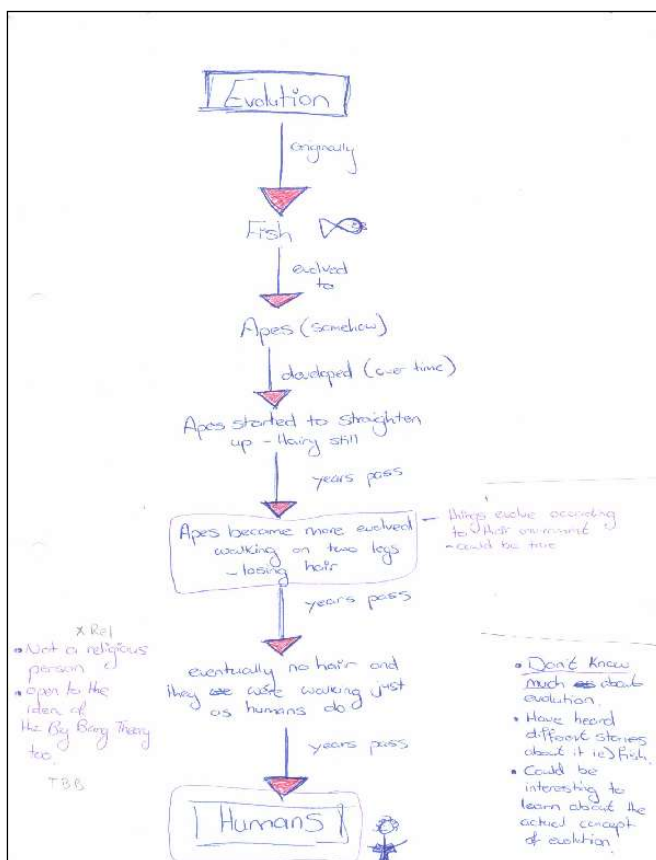
Figure 1
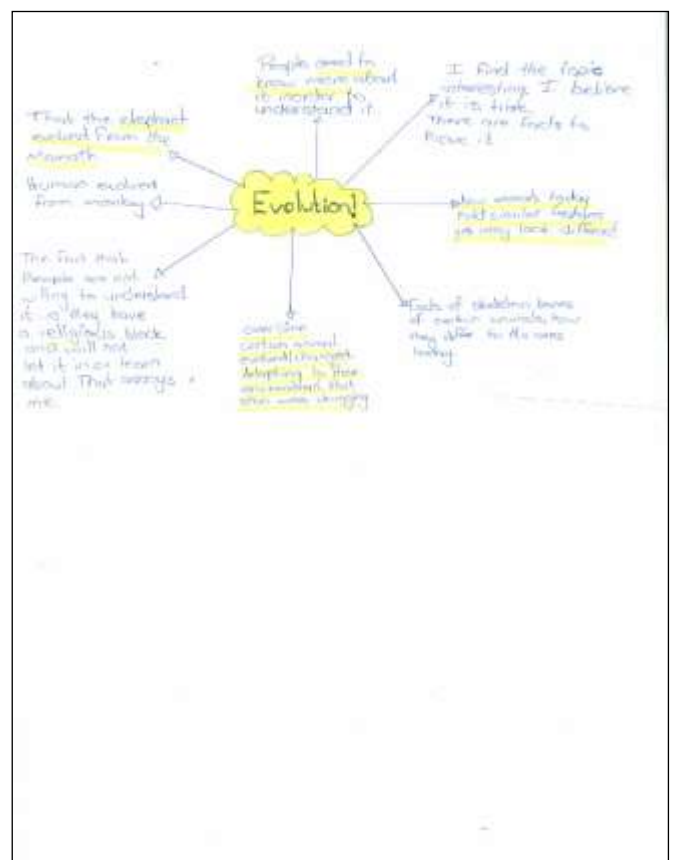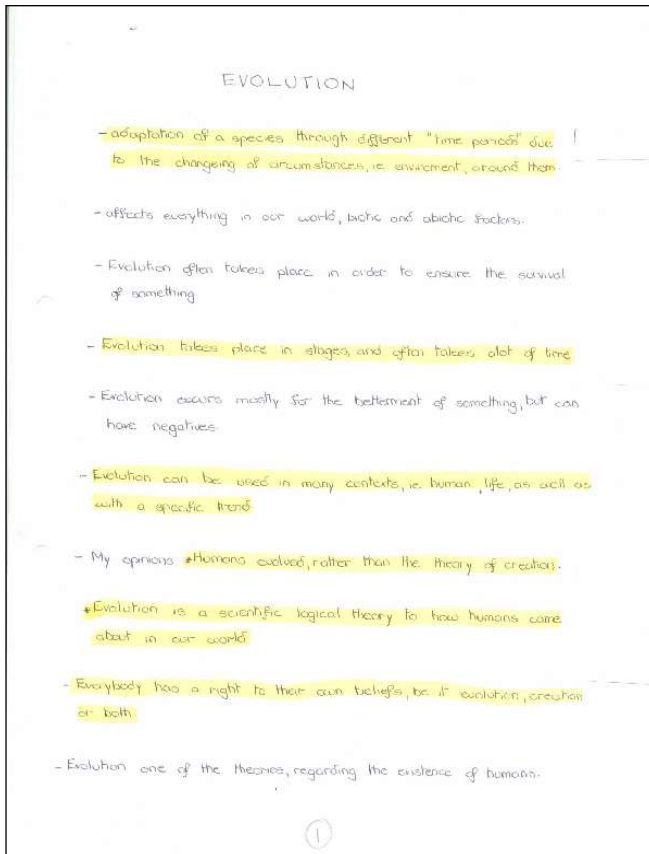
Figure 2

Figure 3

On assessment of the pre concept maps, it became evident that learners had difficulty making links between any facts, ideas or beliefs that they had written down about evolution. This may be why learners found it difficult to use a concept map format in the first place: because they could not see any logical links between concepts they already knew. During the time when learners were completing the task, many showed a negative attitude towards the tasks voicing their opinions about how they felt about being taught evolution at school. However, there were learners that showed interest and enthusiasm during the tasks and tried to motivate their peers to settle with the idea and complete the tasks. As with the pre and post survey questionnaire, learners also did a pre and post concept map. Learners were a lot less hostile and showed more confidence in doing the tasks a second time around.

Due to the fact that learners did not use a concept map format it was difficult to assess concept maps and make comparisons because every learner used a different format. In

order to further identify patterns and valuable data an organising system of data reduction was used. The main concepts that emerged from the data reduction process are outlined in table 6.

Results in table 6 show that in the pre concept map, 71.1% of learners associated the idea of humans evolving from apes with evolution. Most learners included some form of description or basic picture diagram to show that humans evolved from apes/primates. Figure 1 shows the emphasis that some learners placed on human evolution. In general, not a large variety of facts or ideas were included in the pre concept maps.

Table 6 Table of main concepts identified from pre and post survey concept maps.

	Pre Concept Map		**Post** Concept Map	
	Total	%	Total	%
Big Bang Theory	10	22.2	2	4.4
Humans evolve from apes/primates	32	71.1	16	35.6
Believes Christian religious view	18	40	8	17.8
Does not believe evolution to be true	12	26.7	7	15.6
I don't know much	13	28.9	0	0
Emotive language against Evolution / Emotional	9	20	1	2.2
Lamarck's Theory	0	0	28	62.2
Lamarck's Theory Explained	0	0	14	31.1
Darwin's Theory	2	4.4	30	66.7
Fossils	0	0	15	33.3
Mass Extinctions	0	0	12	26.7
Natural Selection	1	2.2	25	55.6
Natural selection explained	2	4.4	17	37.8
Definition of evolution given	5	11.1	13	28.9
Survival of the fittest	1	2.2	14	31.1

Highlighted figures indicate a high percentage

Forty percent of learners included religious views and statements confirming their Christian views over 'believing' evolution in the pre concept map. Of this 40%, 9 learners are from group 4 and 5 from group 5.

Examples of such statements include those made by learner 32 group 4:

"N.B Believe in creation by God."

Learner 31 group 1:

"I, being a Christian, believe that God created us. I don't believe I evolved from a monkey."

26.7% of learners stated that they do not believe evolution to be true, 6 of these learners are from group 4 and 2 learners each from groups 2, 3 and 5.

20% of learners, half of whom belong to group 4, used emotional/emotive language on their concept maps when describing how they felt about evolution.

Learner 36 is an example of such a learner and wrote the following on his pre concept map:

"He [Charles Darwin] came up with all the ideas and lies about evolution. I think it is stupid that we as students that have different beliefs should have to study something that is not true and is just made up for people who are searching for a belief that makes them feel part of something."

Learner 33 group 4 wrote:

"Don't like it. It makes no sense. It makes me angry."

Learner 20 group 3 wrote:

"It [evolution] really irritates me."

In contrast to the pre concept maps, only one learner still included emotive/emotional language against evolution in the post concept map. The pre concept maps revealed that

28.9% of learners admitted that they did not know much about the topic, 5 of these 13 learners belonged to group 3 and 4 to group 2. This figure declined to 0% in the post concept maps i.e. no learner felt they did not know anything about the topic meaning they have learnt something in class.

There is a noticeable difference in the content included between the pre and post concept maps. Sixty-two point two percent and 66.7% of learners included something about Darwin and Lamarck respectively. Fifty five percent included the concept of natural selection and 37.8% included an explanation of natural selection. Sixty percent of learners included either natural selection or survival of the fittest in their post concept map. This is a vast improvement from pre concept map numbers where 0% knew about Lamarck and only 2 learners mentioned Darwin. Also, the importance that learners placed on the idea that humans evolved from apes/primates decreased in the post concept maps. 35.6%, the majority from groups 3, 4 and 5, still included human evolution, but from a more factual and scientific point of view.

There is a clear shift in concepts included in the pre and post concept maps of learners from all groups i.e. there is a shift away from purely religious views and human evolution, to a balance of scientific concepts. Concept maps drawn by learner 42 group 5 are a good example of this and show the shift from religious to scientific. The pre concept map, figure 4 is very heavily weighted on religious aspects and what the learner believes about scientists. Learner 42 also defines evolution as the scientific theory of human development only. To this learner evolution only refers to humans. Learner understanding of human evolution is also very limited and they have misconceptions. The post concept map shows the change the learner has made in their understanding of evolution. The learner has a better understanding of human evolution and how it fits in to evolution as a whole. The learner still includes their religious beliefs but it is a very small part of the concept map and does not over shadow the scientific concepts of evolution.
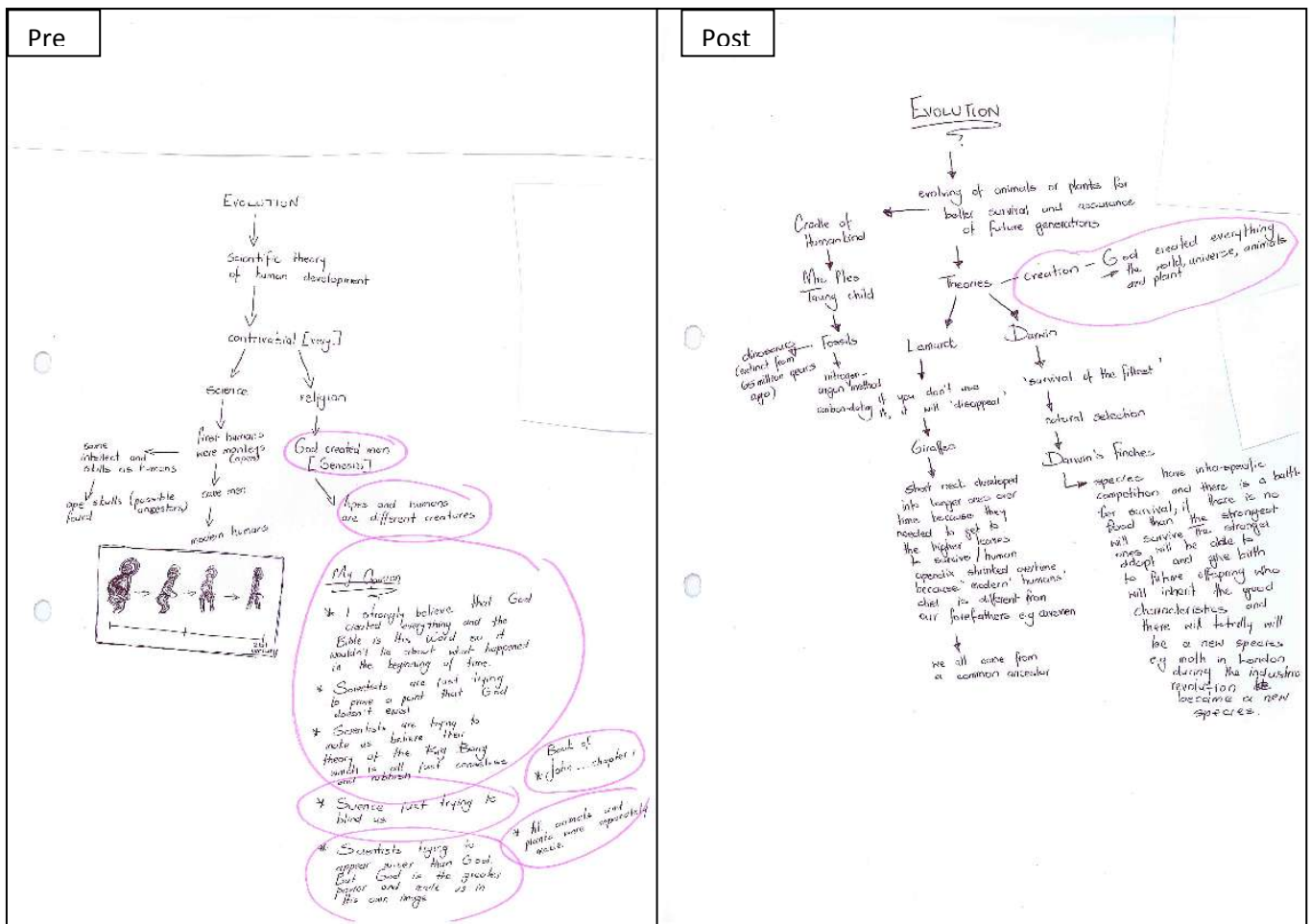
Figure 4 Pre and post concept map done by learner42 group 5.

Learner numbers 1 and 3 of group *1* are good examples of learners that did not include a large variety of concepts, but wrote a paragraph explaining a few of the main concepts only. Learner 1 (shown in figure 5) describes how natural selection works, defines evolution and gives a brief explanation of why he finds evolution a plausible theory. Learner 3 (figure 6) describes how species evolve and how some factors influence the process of evolution over time. The learners demonstrate a clear understanding of these key concepts. In contrast learner 32 group 4 has also included some of the key concepts of evolution in their post concept map and attempted a concept map layout instead of a paragraph. The concept map drawn by this learner, shown in figure 7, does not show a deep understanding of these concepts because the learner did not include many links between concepts and did not include a wide variety of concepts either.

Evolution is the theory that, over millions of years, organisms change their form to better suit their environment. This process occurs due to different environmental factors that best suit certain individuals in a population. These individuals breed well while others, less suited to their environment, die out. Due to this breeding well adapted traits form a large part of the population meaning most individuals of this population possess these well adapted traits. This process, over a long period of time, changes the over all attitude of a species.

evolution

I think that it is the most plausible theory as, unlike religion, which is based on word of mouth, it is based on scientific research. I do not think, however, that it is a fool proof.

Figure 5 Post concept map of learner 1 group

Evolution is the theory that organisms have come from a common ancestor and have changed and variate according to their specific living conditions to form the wide variety of organisms that are in the world today. Variation in organisms occurs when there is either a physical or genetic change, which could either lead to the downfall (or even extinction) of a species or give if a major advantage to enable it to survive and compete better for food and resources in its environments. Changes however do not occur rapidly, like over a few years but in fact take generations of the species and lots of years to completely show. Gradual change will lead to a completely different species (genetic and physical) and can lead to a completely new organism.

All True

Figure 6 Post concept map of learner 3 group 1
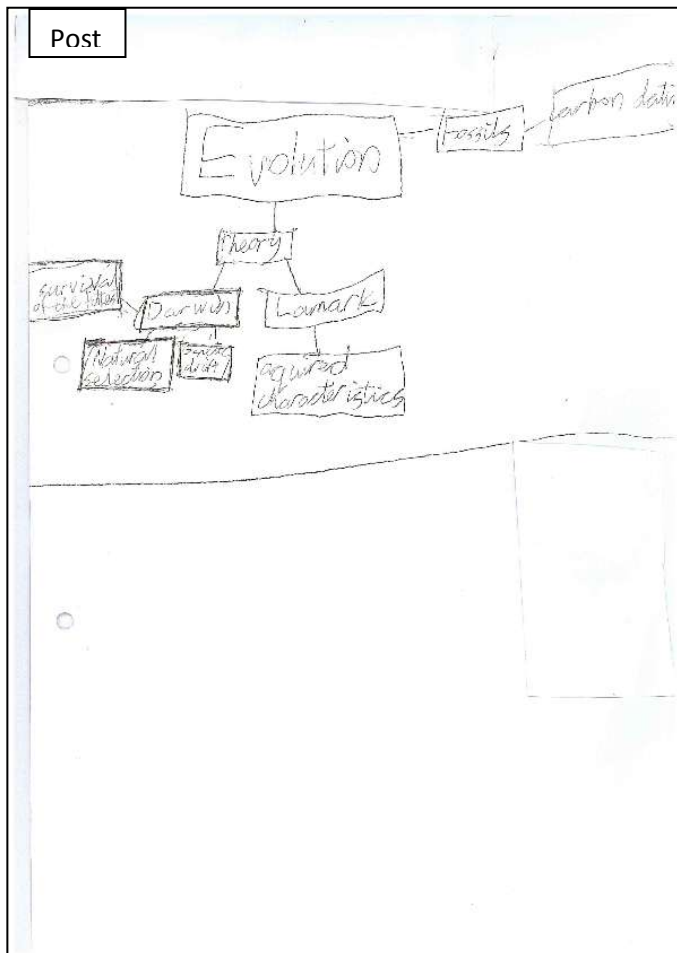
Figure 7

Post concept map of learner 32 group 4

5.2.2 Extra Questions Questionnaire

Part 3 of the school visit consisted of a questionnaire named the extra questions questionnaire (extra Q questionnaire). These questions serve to probe learners' opinions, concerns and understanding of evolution concepts that could not be achieved through the pre and post survey questionnaire and the concept mapping task. The questions included in this questionnaire are as follows:

Circle the underlined word in each question below that best completes the sentence and then give an explanation as to why you said so.

g) *I reject / accept the theory of macroevolution because...*

h) *I believe / don't believe Natural selection to be true because...*

i) *During the section on evolution I found the following concept difficult to deal with because....*
   (state the concept and then explain why)

j) *During the section on evolution I found the following concepts interesting and easy to understand because...*
   (State the concept(s) and explain why)

k) *I find evolution compatible / incompatible with religious beliefs because...*

l) *Evolution should / shouldn't be included in the Life Science curriculum because...*

The extra Q questionnaire was given to learners on the same day as the interviews were done i.e. the 3rd school visit. On the day that the third school visit was made, not all learners were present to complete the extra Q questionnaire as some learners were writing an exam in another subject. The results of the extra Q questionnaire are summarised in table 7.

Table 7 Table showing how learners answered in the Extra questions questionnaire.

	Group 1		Group 2		Group 3		Group 4		Group 5	
	Accept	Reject	Accept	Reject	Accept	Reject	Accept	Reject	Accept	Reject
Macroevolution	3		11		2	2		6		5
Believe natural selection to be true	Believe	Don't	Believe	Don't	Believe	Don't	Believe	Don't	Believe	Don't
	3		11		3	2	1	5	6	
Compatibility with religious Beliefs	Comp.*	Incomp.**	Comp.	Incomp.	Comp.	Incomp.	Comp.	Incomp.	Comp.	Incomp.
		3	4	7	1	4		6	1	5
Inclusion in school curriculum	Should	Shouldn't	Should	Shouldn't	Should	Shouldn't	Should	Shouldn't	Should	Shouldn't
	3		11		2	3	2	4	4	1

*Comp. = compatible   ** Incomp. = Incompatible

The squares highlighted in table 7 indicate the larger number of learners that answered a particular way for that question in each group. There are distinct patterns of answering that emerge. This way of answering/thinking coincides with the outlines and criteria used to group learners. Learners are easily grouped by analysing the manner in which they answered questions in the extra Q questionnaire. All learners in group 1 accept macroevolution, believe natural selection to be true and find most of evolution to be incompatible with religious beliefs. Group 2 answered similarly except for the question concerning compatibility with religious beliefs. Four learners answered that evolution was compatible with religious beliefs and seven answered that it was incompatible. Reasons that the learners in group 2 gave for answering either compatible or incompatible varied greatly:

Learner 11 answered 'compatible' and gave the following reason:

"Just because animals and plants do evolve over time, this does not mean that there is not a higher power watching over us and that God created us in the first place. It does not contradict religion.

Learner 17 answered 'compatible' and gave the following reason:

"I have no religion."

Learner 14 answered 'incompatible' and gave the following reason:

"Some theories contradict the basic principles of religion and values."

No distinct answering pattern emerged from group 3, and this in itself separates group 3 learners from all the other groups. Learners from group 3 lacked enthusiasm and interest in the topic and thus very different reasons emerged from their answers given in the extra Q questionnaire. Learner 21 answered 'reject' for the question concerning macroevolution and the following reason was given:

"It won't do me any good, what happened in the past should stay there. What's the point knowing evolution."

This answer shows that the learner has not given the concepts of evolution much thought, the learner does not base his reasoning on religion or that he finds faults in the content learnt in class (as some learners do from other groups). This learner did not engage in the content taught in class and thus finds no value in the concept.

Learner 23 answered that he does not believe evolution with the following reason:

"There are 2 theories that contradict each other (Darwin and Lamarck). Natural selection seems to be some sort of fantasy."

This reasoning shows a poor understanding of Lamarck and Darwin's theory, and of natural selection.

Group 4 shows a distinct answering pattern i.e. Learners from group 4 reject macroevolution, don't believe natural selection to be true, find evolution incompatible with religious beliefs and feel that evolution should not be included in the school curriculum. Reasons given by learners for answering in this particular way are based on their own religious beliefs. Group 5 also shows a clear pattern of answering. The difference between group 4 and 5 is that group 5 believes natural selection to be true and that it should be

included in the school curriculum, even though they find it incompatible with their religious beliefs. This difference in answering between the two groups shows that group 5 (a mostly religious group like group 4) is more open minded about new ideas than group 4. Group 5 learners are willing to learn about concepts that they don't necessarily agree with. The examples below show the difference in thinking between learners from group 4 and 5 and their approach to learning about evolution.

Learner 43 group 5 answered that evolution is compatible with religious beliefs and explained their answer as follows:

"There are plausible ideas regarding evolution such as adaptations and acquired characteristics although these theories do not change my beliefs in God."

Learner 44, another religious learner from group 5, answered that evolution should be included in the school curriculum. The following explanation was given:

"Everyone is entitled to their own opinion and we need to know about various theories that exist."

Learner 31 group 4 answered that evolution is incompatible with religious beliefs and gave the following reason:

"I believe that God created everything on earth the way he wanted things to be.

Learner 31 also answered that evolution should be in the school curriculum and gave the following reasoning:

"Interesting to learn about different ideas and opinions, helps people to understand their beliefs more.

Learner 32 group 4 answered 'incompatible' and gave the following reason:

"The creation states that God created Adam and Eve, not some monkey that evolved into Adam and Eve."

Learner 32 answered that evolution shouldn't be included in the curriculum and explained as follows:

"It is complete theory. There are no facts only opinions regarding the field of evolution. Adaptation is reasonable, but not evolution."

Two questions on the questionnaire asked learners: a) what concepts of evolution they found difficult to deal with and why, and b) what concepts of evolution they found interesting and why. Table 8 summarises how the learners answered these two questions.

Table 8 Table showing the answers given by learners from different groups about which concepts they found difficult to deal with/learn in class and which concepts they found interesting.

Concepts difficult to deal with

Concept	Total	Group 1	Group 2	Group 3	Group 4	Group 5
Whole Concept	4		1		1	2
Origins of Humans	8		1	2	1	4
Deep time	1		1			
Types of selection	1		1			
Darwin's Theory	1		1			
Fossilisation	1		1			
That it clashes with religion	3		1		2	
Graphs	2	1		1		
Idea that it might be plausible	2				1	1
Mental block from being taught against it	1					1
Fossil dating	1			1		
Variation	1			1		
Evidence for Evolution	1			1		

Interesting Concepts

Concept	Total	Group 1	Group 2	Group 3	Group 4	Group 5
Variation	1		1			
Natural Selection	11	1	5	3	1	1
Darwins Theory	5	2	2			1
Mass extinction	1		1			
Geographic isolation	1		1			
Evidence for Evolution	2	1		1		
Fossils	5	1			2	2
Macroevolution	1	1				
Microevolution	2	1				1
No concept was interesting	3			1	1	1
Thought and concepts of others about the topic	1				1	
Different theories (Darwin & Lamarck)	4			3		1

Eight learners wrote that the 'origins of humans' was a difficult concept to deal with. The reasons given by learners for this varied between the learner groups.

For example learner 44 from group 5 wrote:

"I believe in the creation theory and I believe that God created man."

Learner 21 from group 3 wrote:

"I have no interest to know there are different kinds of primates that lived millions of years ago, and we are similar to them. It's too much."

Four learners found the entire concept of evolution difficult to deal with. Most learners listed natural selection as a concept that they found interesting, as well as Darwin's theory and fossils. Learners explained that they found natural selection interesting because it was an easy concept to understand. Two learners (learner 8 and 9 from group 2 each gave the following reasons:

"It was so simple and easy to understand."
"It was a logical series of concepts."

Learner 6 from group 1 wrote:

"It gave me a logical explanation of evolution."

Three learners wrote that they didn't find any concept of evolution interesting. One of the learners from group 4 (learner 29) that answered like this wrote:

"The concept of evolution was not clear and was very difficult because I've got my view points on Christian beliefs. And I refuse to understand evolution."

5.2.3 Interviews

The fourth part of the school visit consisted of the learner interviews. Interviews were conducted on the same day as the extra Q questionnaire. A sample of 6 learners were randomly selected and interviewed. Question 1 of the interview was an unstructured question where learners were asked to explain the concept maps that they had drawn and their thinking behind their layout. Learners had difficulty explaining their concept maps and why they had made the changes that they had from pre to post concept maps. Learners explained that the difference between concept maps was because in the pre concept map they didn't know much, and in the post concept map they included what they had learnt in class. Learner 36 group 4 gave the following response:

"Well, basically I believe that God created the Earth and even though that things change and do adapt, it's not, I don't fully believe in the theory of evolution. I feel that scientists have made another belief; it's quite hard you asking just to explain. I have really learnt much about evolution. You are asking about evolution so I've told you what I thought about evolution."

The main focus of question 1 thus became investigating why some learners did not use concept map layouts. Learner 20 group 3's pre and post concept maps are shown in figure 8. When this learner was asked this question she responded as follows:

"I don't know. I don't really ever work with concept maps; that's why I laid it out this way, but before, because this is before we actually started evolution so I don't know about any of this. I really didn't believe it at all before we started and I think I didn't fully understand it either."
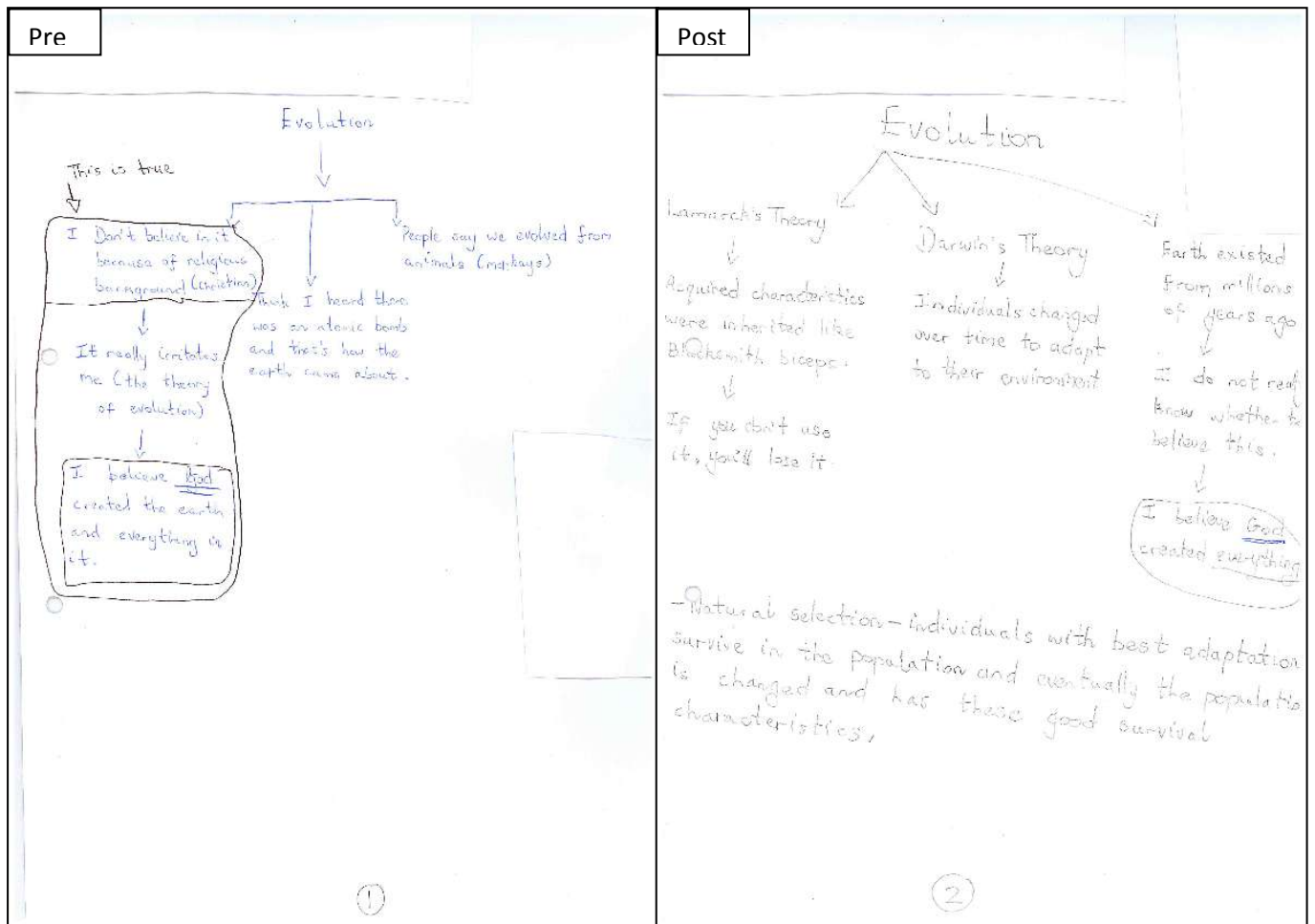
Figure 8 Pre and Post concept maps by learner 20 group 3

Learner 20 did not include much in the pre concept map. The learner was then asked if she had ever heard of evolution before:

"Yes, people always put it down and stuff. I'd always get irritated because I didn't know."

To determine if learner 20's attitude towards evolution had changed she was asked what she thought about natural selection:

I believe in it, I don't know if I fully understand it. I think individuals can change, but because they need to adapt to their environment, but I think God allowed for that change to happen. It's not like there's evolution and no God. That's how I see it.

The response given by learner 20 indicates that for this learner scientific concepts and explanations of evolution overlap with her religious beliefs.

Learner 8 group 2 drew a comprehensive set of pre and post concept maps, shown in figure 9. When the learner was asked to explain this she replied:

"...That's what I knew in from general knowledge because I'm quite interested in biology and I've always been interested in evolution."
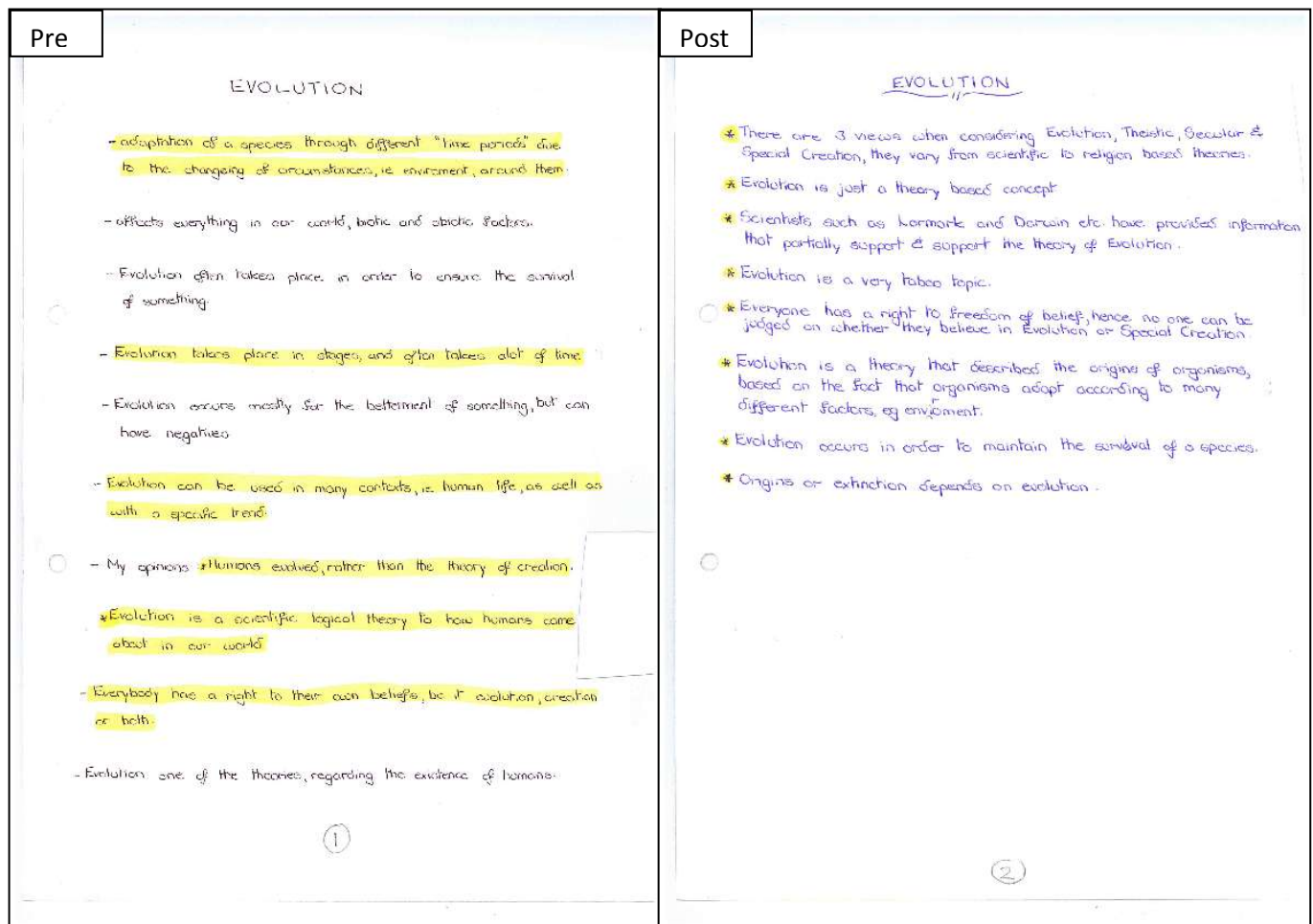
Figure 9 Pre and Post concept map by learner 8 group 2.

Many points that learner 8 included in her pre concept map where repeated in her post concept map. She was asked to explain this:

"Because once I have an opinion, it hardly ever changes."

Learner 8 was also questioned about the layout of her concept maps, and she explained that she prefers a neat and orderly layout.

Learner 11 was also asked about his choice of layout:

"Because I never do flow charts; don't really make sense to me. These look much better."

Learner 7 group 1 explained that a lot of what she had included in her concept maps (figure 10) was based on what she had heard and learnt from T.V programmes, and in the second concept map she just added some of the things she learnt in class like Darwin and Lamarck's theories. She also stated that her beliefs and culture don't interlink with the theory of evolution.
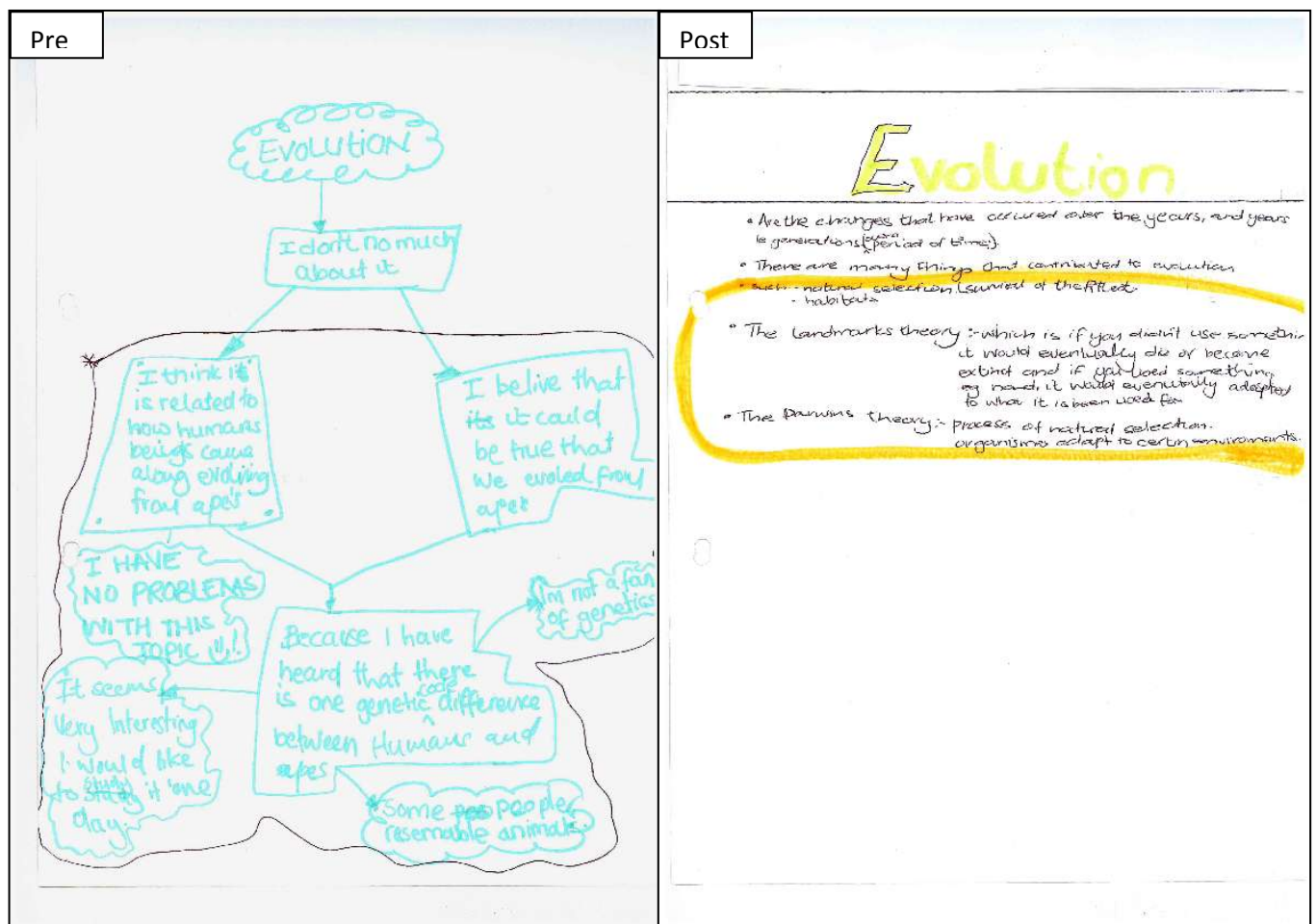
Figure 10 Pre and Post concept map by learner 7 group 1.

Learner 29 included statements about his religious beliefs in the pre and post concept maps and was asked to explain:

"I still feel quite strongly against it. I do allow it, I don't, I don't want to believe it, but I accept the concepts, I accept what people believe. If they want to believe that evolution is real then they can."

Questions 2 through to 10 make up the structured part of the interview. The question schedule was followed and further prompt questions where used only when necessary. Questions 2, 3, 4 and 5 investigate learners' classroom experience. Question's 6 and 7 look at possible external influences and learners opinions about the inclusion of evolution in the school curriculum. Each question and learner responses will now be looked at separately.

Question 2:

Did you find the section on Evolution interesting? Why or why not?

Seven learners answered 'Yes'. Learner 29 gave the following reason:

"Yes, definitely very interesting.
Coming from a background where you believe, you have been taught Christianity and God and all that, to find out what other people believe is quite interesting, how they thought apes,... we came from apes and how creatures evolved into what they are from what they were. That's what I find very interesting and also....um ja... I find that interesting."

Learner 20 group 3 answered that it was 'OK'. Her reason was that she didn't like Life Science and that she wasn't good at it.

Question 3:

Do you feel that your teacher had a role to play in your feelings/attitudes towards evolution?

Learner 29 and 36 group 4 and learner 20 group 3 felt that their teachers played no role in how they felt about evolution. Learner 8 and 11 group 2 and learner 7 group 1 answered 'Yes'.

Question 4:

Are there any particular moments in class that you can connect to why you might feel this way towards evolution?

All learners replied: No. Reasons given by learners do vary and some learners did deviate from the question asked. One reason, given by learner 20, did reflect on the teachers and their approach to teaching evolution:

"No. He would just teach. He would never make like a debate happen or something because he said evolution can happen and God can happen and you can believe in both."

Question 5:

What do you think about the section on Human evolution?

Learners 7, 8 and 11 answered similarly. These three learners thought that learning about human evolution was interesting. Learners 29, 36 and 20 did not feel the same way. Learner 20 group 3 was not even sure what human evolution was. Learners 29 and 36 group 4 both expressed their views against human evolution:

Learner 29:

"Impossible.

I don't really think we came from apes and I really, no, I just don't see how we could come from apes; we could have evolved because if we came from apes then why aren't we still evolving? And why children being born now evolving from apes now grow up into children like we have; that's where I just refuse....... it's impossible."

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Learner 36:

"I don't believe that we evolved from apes. I think it's a load of rubbish. I think we have adapted because obviously we've learnt and we've discovered and have grown our knowledge but I still feel that that's Gods will and nothing to do with our own special force it's everything that's happened is the will of God."

Question 6:

How does your family (mom and dad) feel about the idea of you being taught evolution at school?

Learners 7, 8 and 11's parents/family did not have concerns about evolution being taught in class. Learner 8 said that her parents thought that evolution should be taught at school as well. Learner 20 had not spoken to her parents about it and learner 29 explained that his parents were annoyed that evolution was being taught at school. Learner 36 had an interesting response explaining that his parents thought he should learn about evolution to understand its concepts in order to better explain why he didn't believe it. Learner 36 ended his explanation with the following statement:

"You can't just say: I don't believe in it; and not know much about it."

Question 7:

Do you think it's a good idea to learn about evolution at school?

All learners excepting learner 29 group 4 thought that it was a good idea to learn about evolution. Learner 29 felt that it puts religious learners into a corner and he really doesn't want to be taught something that he feels goes against his beliefs. The answer given by learner 7 group 1 shows the difference in thinking between groups 4 and 1:

"Yes, I think it's a very good idea. I don't feel that it goes against culture, I don't believe that."

Question 8 serves the purpose of investigating learners understanding and acceptance of natural selection. The word 'natural selection' was not used in the question design so that learners could not immediately identify the goal of the questions (testing their understanding of a basic evolution principle). This would allow learners that stated that they did not find natural selection to be true in the extra Q questionnaire due to religious reasons for example, to show, without them knowing, whether they actually did understand the concept and whether they believed it occurred in nature. Question 8 was structured as follows:

Question 8:

Let's talk a little bit about dogs:

Do you agree or disagree with the following statements (question 8.1-8.3):

8.1 There are many different breeds of dog, many dogs look different?

8.2 Some dogs resemble and can still breed with wolves?

8.3 Before the extensive breeding programs that we have today, and we go back several hundred to several thousand years, it is reasonable to say that dogs resembled each other even more than they do today.

8.4 Dogs are known to fight for food and females for breeding purposes. Can you explain what might happen if a number of male dogs are put into a pen with little food and few females?

8.5 Can you explain another situation like the dog scenario that you would expect to find in a natural environment?

All learners, excepting learner 20, showed a fair understanding of natural selection and that it happens in the environment. Learners 20 and 36 also indicated that they did not believe natural selection to be true in the extra Q questionnaire i.e. learner 36 says he does not believe natural selection but still shows that he understands the concept and that it happens in nature.

The purpose of question 9 was to test whether learners had a deeper understanding of natural selection and evolution and if they could apply this understanding.

Question 9

There are so many different plants and animals in South Africa. How did so many different species come to exist?

Learners 7, 8 and 11 could, to some degree, answer this question using their knowledge of evolution. Learner 7 explained continental drift and that species had to adapt due to this. Learner 11 used the concept of common ancestors and that we came to where we are now because we had to evolve because we had different needs and different environments. Learners 29 and 36 tried to explain using concepts they had heard about in class, but their answers show that they did not have a complete understanding of these concepts:

Learner 29:

"Cross pollination, that's for the plants; and species, well, brought over from another country."

Learner 36:

"Through the genetic diversity of cross pollination etcetera."

Interestingly, it was learner 20 (and not learner 29 or 36 as expected), that explained the question using religion:

"I think God created all of them."

Question 10 was an open ended question where learners were asked if they had anything else that they wanted to share about their experience learning about evolution. Learners 20, 29 and 36 answered 'no'. Learner 7 explained that it was exciting but also found it a bit challenging. Learner 8 explained the following:

"Maybe they should teach a bit more human evolution, but I don't know, that's just my personal opinion. That's probably because I like it, it's very interesting. It should be taught because students should know that there isn't just creation, you should be able to expand your knowledge."

5.2.4 Additional Learner Paragraphs

After learners had completed their post survey and concept mapping tasks on the second school visit, there was still time left in the lesson allocated to the school visit tests. Learners where then instructed to use the time and were given the opportunity to write down anything else that they felt still needed to be heard concerning evolution and what they had experienced or felt during the lessons. This was an unstructured and unplanned activity, but important information came to the fore from the learners.

The main trend that emerged from the additional learner paragraphs was that group 3 learners wrote that they found the section on evolution boring. Learners wrote that they learnt too many facts and that they became restless and didn't understand most of it. A number of learners in group 3 admitted to having had to go home and re-read/self-teach the section because they didn't understand what was taught in class. Learner 28 wrote the following:

"Honestly I did not learn anything in class, mainly because I find this section very boring and totally irrelevant to my life right now and my future. I find it stupid and a waste of time. I also hate being compared to apes, why can't people just let life be. I believe there are no answers for everything, let life be. I only passed my exam because I went back home and tried to understand what I find totally stupid, boring and irrelevant!"

Learner 24 also wrote that the section was boring and admitted that she was thinking about the talent show (a school stage production) instead. Learner 24 also wrote that she should never have taken Life Science as a subject. Learner 27 explained that they did not enjoy the section because they only read from the textbook and nothing exciting happened which made it boring. While another learner suggested that they should watch a movie/dvd about evolution to make it less boring and more relevant.

The general trend that emerged from learners in group 1 is that they found the section on evolution interesting. The paragraph written by learner 1 is a good example:

"I think that learning about evolution is a great way of promoting analytical thinking in the youth. Learning about any theory that will challenge ones ways and beliefs is beneficial in my opinion."

Learner 7, however, thought that the way their teacher (teacher A) introduced evolution was boring:

"At first I found evolution very boring as we first learnt about stars and planets. As we got started on the fossils, origins of mankind it became very interesting. When it came to learning about graphs I totally missed the plot because I also felt it boring."

Group 2 learners also thought learning about evolution was interesting, although some learners felt that some sections did become boring and were too long. Learner 9 explained

that it was exciting learning about what happened before her time. Learner 18, however, does not share this view and wrote the following:

when it comes to studying. The teacher does not clearly teach or pin-point the important facts, he is vague. Evolution is easy but from what I have experienced it has been a mission and I know nothing to this day. I'm sorry, but I did not enjoy it and I don't think I ever will. Evolution is not for me."

Learners from group 4 were negative about being taught evolution. Some group 4 learners wrote that they did not want to learn about evolution because it was only a theory, not fact. Learner 29 explained that it was an 'information overload' which added to her dislike of the topic. Learner 30 explains that she was interested to start with, but it turned out being boring because of the way in which it was taught and suggested they watch a dvd. The paragraph written by learner 38 included many of these issues:

"I feel that learning about evolution in class as a selected section is an entire waste of time as everyone has their own opinion for evolution; it would be ok to discuss, but we should not be forced to learn something we disagree entirely about.

I felt this section was unnecessary and could be spent learning something valuable instead of just a theory that cannot be fully proven.

All of evolution is just theory and not fact! Cannot be proven, in fact the person who created this theory, stated he made the biggest mistake of his life and is a lot of.....* yeah."

One learner in the group, learner 37, felt differently and wrote:

"I wasn't uncomfortable learning this section. I respected the theory and was willing to learn although I didn't/don't believe in it and because I need to pass."

Most group 5 learners thought that evolution was interesting even if they did not agree with some aspects. Learner 45 felt that his teacher (teacher B) did not explain properly and made

it boring. Learner 45 suggested that the section would be better if lessons would be more exciting. Learner 40 explained that she was tired and that there was too much information in such a short time; and felt the section was rushed and because of this she won't be able to remember what she learnt in class. Religious learners in group 5 did not show the same negativity and aggression that learners in group 4 showed.

5.2.5 Teacher Results

The teachers of the learners also completed a pre survey and concept map task, as well as a teacher specific extra questionnaire. Teacher B scored 45 in the survey and teacher A scored 38. The lower score of teacher A can be attributed to his religious beliefs thus scoring lower in the religious questions. Teacher A also scored a 1 in question 8 (a scientific knowledge based question). Teacher B's lowest scoring question was question 15 where he scored a 0 (undecided).

The teacher questionnaire revealed that neither teacher had studied a specific course in evolution. Both teachers also allocated more than 4 weeks teaching time to evolution. Teacher B characterised his teaching by selecting the following from a list of expressions: Studied in depth as a distinct content area; and teacher A selected: The unifying theme for the content of the course. Both teachers accepted evolution as a scientifically valid explanation of the state of living organisms of the present and past. The teachers also indicated that neither of them had experienced any difficulties teaching the topic, but teacher B elaborated on his answer:

"No difficulties as such but the topic is sometimes clearly contrary to the persons viewpoints of certain learners – I'm very careful to stress to these learners that I'm merely a facilitator of the THEORY of evolution – and that a theory is just an explanation (the best possible one at that moment in time) based on certain perceived evidence – they can (and often will) change when further evidence becomes available – Also, if you don't know about a certain theory how can one ever argue your particular perspective?"

Both teachers were also asked to draw a concept map, but only teacher B completed this task. The concept map drawn by teacher B is shown below.
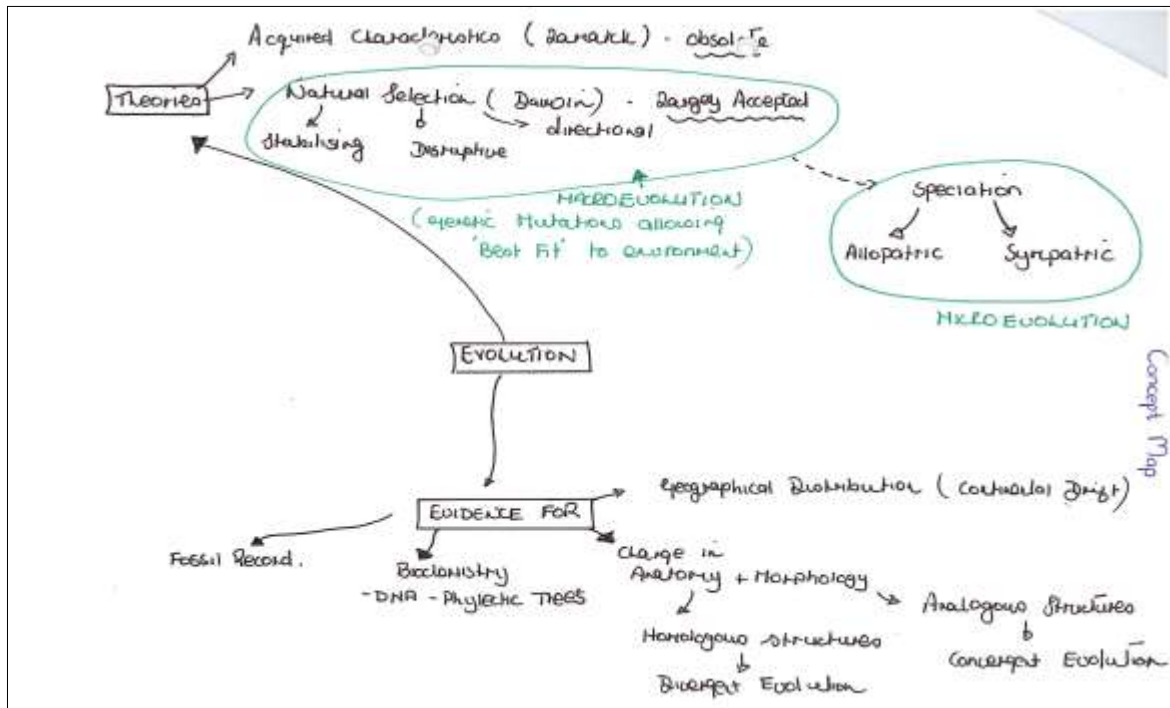
Figure11 Concept Map by Teacher B

Teacher B drew a simplified concept map including the main concepts of evolution. The teachers were asked to circle the concepts on their concept maps that they thought were plausible. It is evident that teacher B finds macro and micro-evolution plausible and believes the theory of evolution to be true. This teacher does not show any negativity or hesitation towards the topic. Religion is not a barrier to this teacher. It is assumed that teacher A did not complete the concept map task due to time constraints with respect to his duties as a senior person in the school i.e. he did not avoid the task due to unwillingness based on religious beliefs.

5.2.6 Examples of Learner Grouping

The following are examples of learners and how they were grouped according to the criteria listed previously. An example is given for each group.

Learner 7

Learner 7 scored 34 in the pre survey and 49 in the post survey, resulting in a positive score change of 15 from the pre to post survey. This learner had 5 scientific answers in the pre survey, and 14 in the post survey. Concept maps drawn by this learner (shown in figure 10) do not reflect this score change. The pre concept map shows that this learner is curious and interested, but does not know much. She has an idea that genetics is a crucial part of evolution but is not sure how it is linked. The post concept map does not include many scientific concepts, Darwin and Lamarck are the main points on her page (she has misspelt Lamarck as Landmark), but the explanation of each is correct. In the extra Q questionnaire she accepts macroevolution, believes natural selection to be true, finds evolution incompatible with religious beliefs and feels evolution should be taught in class. The learner could support each of these answers.

Due to the scores of the pre and post survey and the answering pattern on the extra Q questionnaire this learner was placed in group 1. If her concept maps were looked at in isolation from the other tasks, then this learner would only qualify for group 2, but the learner included enough to set her apart from most other learners substantiating her place in group 1. Even though answers from the interviews were not used to group learners, her answers showed a good understanding of natural selection. The manner in which she answered showed a scientific way of thinking and a deeper understanding of most concepts.

Learner 15

Learner 15 scored 28 in the pre survey and 33 in the post survey resulting in a positive score change of 5. This positive score change meets the criteria for group 2. Learner 15 does not

include scientific concepts in the pre concept map, instead he explains how evolution clashes with the bible and that he does not believe it. The post concept map is more scientific although some concepts are unclear and poorly stated. He does however accept the concept of evolution from a common ancestor. The change from the pre to post concept map reflects the score change from the pre to post survey. In the extra Q questionnaire he accepts macroevolution, believes natural selection to be true, finds evolution compatible with religious beliefs and feels evolution should be included in the curriculum. The learner was able to support each of these answers in a manner that showed a good understanding of scientific concepts learnt, but the leaner also links these concepts to his religious beliefs. Learner 15 states that evolution does not contradict religious beliefs but, instead, explains how God created everything. Answers given by the learner show a cultural overlap, he does not abandon his beliefs but incorporates them into the new scientific knowledge.

Answering in the extra Q questionnaire and survey scores meets the criteria of group 2, thus the learner is placed in group 2. What sets this learners apart from learners in group 5 (because criteria of group 2 and 5 are similar) is that he does not show hesitation and approaches the new information from a scientific view point i.e. his approach to learning and his way of thinking puts him into group 2 and not group 5.

Learner 30

Learner 30 scored a 30 in the pre survey and 18 in the post survey resulting in a negative 12 score from pre to post survey. This is the second greatest negative score change. Some of the score change can be attributed to learner 30 selecting 'undecided' as an answer three more times in the post survey than the pre survey. The learner shows strong religious views in answers chosen. The main focus of the pre concept map is on human evolution and religious beliefs. The main focus of the post concept map is also human evolution and religion, but on this concept map human evolution is addressed in a more scientific manner and includes more scientific concepts. Survey scores do not reflect the change in acquired knowledge that is displayed on the concept maps. In the extra Q questionnaire learner 30

rejects macroevolution, does not believe natural selection to be true, finds evolution incompatible with religious beliefs and feels evolution should not be included in the curriculum. Her reasoning for the last two answers given is that she feels the theories contradict each other and that a person can either believe in evolution or not (no overlap between the two). Her explanations given for answers on the extra Q questionnaire are all based on religious views.

Based on her survey scores, religious statements on concept maps and answering pattern on the extra Q questionnaire; this learner meets all the criteria of group 4 and was thus placed in this group.

Learner 43

Learner 43 scored 35 in the pre survey and 37 in the post survey, a positive score change of 2. Even though the score change was only 2, the learner answered differently for all questions except 13, and only changed her view completely from non scientific to scientific in question 14. Learner 43 did not include much in the pre concept map. She states that she is religious and does not believe in evolution. The post concept map does include more scientific concepts, but also makes the statement that everything was created by God. This learner believes that organisms adapt to survive but does not believe humans evolved from apes. In the extra Q questionnaire the learner rejects macroevolution, believes natural selection to be true, finds evolution compatible with religious beliefs and feels evolution should be included in the curriculum. Learner 43 states that she believes microevolution. Reasoning and explanations given on the questionnaire reveal that this learner finds much of what she has learnt about evolution plausible and that it does not affect her religious beliefs, however she does struggle with the concept of humans evolving because this goes against some of the fundamentals of her religious beliefs. Her answering and reasoning shows an understanding of concepts learnt and can explain why some concepts are/are not compatible with religious beliefs. This is evidence that there is a cultural overlap for this learner. The learner maintains her religious beliefs but is curious about other theories and

concepts and how they 'fit in' with her beliefs. This is an important defining criterion of group 5 learners. This hesitant curiosity coupled with survey scores and answering pattern on the extra Q questionnaire places this learner in group 5.

Learner 23

Learner 23 scored 40 in the pre survey and 38 in the post survey, resulting in a negative score change of 2. The high pre and post survey scores are not, however, reflected in the concept maps. The pre concept map only includes statements about the fact that he has never heard about it and that it (evolution) is weird. Learner 23 drew a basic post concept map which included various concepts, but not much could be derived about his personal view or beliefs. In the extra Q questionnaire learner 23 rejects macroevolution, does not believe natural selection to be true, finds evolution incompatible with religious beliefs and that it should not be included in the curriculum. The learner does not support his answers with concrete beliefs or views; instead he explains that evolution is not interesting or realistic, it doesn't make sense to him. The reason given by learner 23 for answering that evolution should not be included in the curriculum was that he thought it particularly difficult. The learner also showed a poor understanding of basic concepts e.g. he does not believe natural selection to be true because Darwin and Lamarck's theory contradict each other. The learner does not show that he has engaged in the topic and looked at it with interest. Due to this lack of interest and poor understanding of concepts the learner was placed in group 3.

Qualitative data reveals that learning evolution is a more complex process than the quantitative data first suggested. The combination of qualitative and quantitative data provides a rich source of information from which learning and conceptual change can be understood from the unique perspective of learning evolution. This data will be discussed in the next chapter.

Chapter 6

DISCUSSION

6.1 Finding a School

The first step of investigation involved the identification of schools where the research could take place, and then approaching these schools for consent to conduct the research. Finding a school that was willing to participate proved to be an unexpected challenge. Two of the three schools that were approached did not want to be involved in the study due to the nature of the study i.e. evolution. Both the schools referred to evolution as a controversial topic and felt that parents would be upset by the investigation. One of the schools admitted that they spent as little time on the topic as possible and tried to avoid drawing unnecessary attention to it. Both schools also said that if the topic of the study did not involve evolution they would have agreed to the investigation taking place at their schools. The third school did agree to the investigation and was pleased that their learners would be exposed to 'real' research and have the opportunity to be involved. The grade 12 classes of this school included learners from different socioeconomic as well as from different racial and religious groups. This provides a group of learners with diverse backgrounds and cultures.

6.2 The Learner Groups

Grouping learners with similar characteristics made it possible to follow learners' conceptual changes more closely and make meaningful comparisons between individual learners and between groups. The table below summarises the groups that were formed. Grouping also made it easier to identify any patterns and trends that exist within a group concerning conceptual change and the way learners think and approach learning. It is also possible to identify learners that do not follow general patterns and trends, and examine these in isolation from the rest of the group.

Table 9. Table showing a summary of learner group descriptions.

Group	Group Description
Group 1 *Potential Scientists*	Accept evolution in its entirety. No cultural clash with science concepts. Show deep understanding of concepts.
Group 2 *Other Smart Kids*	Accept evolution. Has difficulty with some aspects only. Transition to school science is manageable.
Group 3 *I Don't know*	Uninterested and lack enthusiasm. Superficial understanding of science concepts.
Group 4 *Outsiders*	Strongly religious learners. Learners reject evolution completely. Impossible border crossing because cultures clash severely.
Group 5 *I want to know*	Accept parts of evolution only. Science and religious views overlap. Effective understanding of science concepts.

Table 1, in the results section, shows the learner groups and how many learners were classified into each group. It is important to note that teacher B does not hold any religious views whilst teacher A does. With this in mind, it is interesting that teacher B has a much higher proportion of learners in group 4 than teacher A, while teacher A has a higher proportion of group 2 learners than teacher B. This might be due to chance, or due to the influence of teachers, or peers within the class. This suggests that teachers and the way that they teach have an effect on learner attitude towards what they are taught. This is an important factor raised in a study done by Moore *et al.,* (2011) in which they find that a teachers personal beliefs influences how they teach. Does the teacher influence how and how much learners learn? i.e. do different teachers affect knowledge gained / conceptual change differently? According to the statistics collected in this study, the teacher has no effect on conceptual change and knowledge gained. The notion that teachers might have an influence on learners' attitude towards evolution will, however, still be considered and addressed later in this chapter.

6.3 Survey Shows a Positive Trend

The overall change in score from the pre to post survey indicates that learners gave more scientific responses at the end of the section than at the beginning. This is in accordance with results obtained by Mathews (2001) and Cavallo and McCall (2008).

The results from question 1 reflects what would be expected, or hoped for, by teachers for all the scientific knowledge based questions i.e. that a large proportion of learners make the transition from 'not knowing' to 'knowing'. This is, however, not the case for the other scientific knowledge based questions. Instead, results indicate that many learners did not need to make the transition into 'knowing' because they already knew much or had formulated an opinion about what was being questioned in the questionnaire. Question 2 and 3 tested basic knowledge about fossils and dinosaurs, and more than half the learners already showed a scientific understanding. This might be due to fossils and dinosaurs being well documented in the media in the form of documentaries, movies, children's books and articles in newspapers and magazines. A learner interviewed from group 1 explained that she knew a lot about the content taught in class because she does a lot of background reading. Another learner explained that they had watched documentaries on television about evolution. Results from interviews and the extra Q questionnaire indicated that many learners also showed a greater interest in fossils and dinosaurs as compared with other aspects of evolution. This only explains why some learners already show a scientific understanding for some questions in the pre survey; it does not explain why learners do not make the transition to a scientific understanding for the other questions, or why learners move from a scientific understanding in the pre survey to an unscientific understanding in the post survey as many learners did.

6.4 Conflict for Religious Learners

Religious learners show the greatest cultural conflict and are least likely to change their views which force them to abandon their own religious view for a new scientific one. This is

not only evident from the survey scores that showed that religious learners maintain their religious views from the pre to post survey, but also in other components of the investigation.

All religious learners in group 4, and 5 of 6 learners in group 5 indicated that the theory of evolution is incompatible with religious beliefs. This means that learners who have strong religious beliefs need to find their own beliefs questionable in order to find evolution plausible. Stears (2011) documented that religion and evolution should not be presented to learners as opposing or conflicting systems because learners are then required to make a choice between the two. Strongly religious learners thus feel that in order to "understand" evolution, they need to abandon their own beliefs. A misconception that learners have is that they liken the ideas of evolution to religious beliefs. This is shown by how learners refer to evolution in interviews and questionnaires: learners refer to a 'belief in' evolution, and use sentences that they either 'believe in' or don't 'believe in' evolution. Statements such as 'I don't believe in evolution' imply that evolution, like creationism, is a belief system rather than a scientific theory based on solid evidence' (Moore, 2008 p 82). Learners thus also feel that in order to accept evolution or religious beliefs, the other needs to be abandoned and replaced. This can create a situation of unease and uncertainty and can put religious learners on the defence i.e. protecting their religious beliefs. One learner even suggested that the theory of evolution was merely a belief system created by scientists. If teachers teach evolution as a substitute for religious beliefs it can put a lot of unnecessary negative pressure on religious learners, preventing constructive learning in class for those learners. This is in agreement with Cavallo and McCall (2008) and Blackwell *et al.,* (2003) who found that the goal of teaching evolution should not be to change one's personal beliefs or to make a choice between acceptance of the theory of evolution and their religious beliefs. Stears (2011) also documented that if learners do not view scientific ideas conflicting with their religious beliefs then they are more open minded and willing to learn about the new concepts.

There are two main barriers to learning that are identifiable with regards to religious learners. The first barrier is the concept of human evolution. This was also found to be the

case in a study conducted by Blackwell *et al.,* (2003). Learners in the current study admitted that human evolution was one of the concepts they found challenging and difficult to deal with. The notion that humans evolved, especially from primitive primates, puts the fundamentals of faith in question: God created humans in his own image and humans are placed above all animals and are special and unique. Human evolution which, according to science, took millions of years also puts the idea of a strict 6 day creation in question. The second barrier to learning and accepting evolution for religious learners (especially those that hold a creationist view) is macroevolution. Learners indicated this on their extra Q questionnaires where they wrote that the concept of macroevolution was not plausible as it contradicts the biblical 6 day creation. Macroevolution as a barrier to learning will be explored further later in this chapter.

Lawson and Warsnop (1992) found that religious learners were least likely to change their views to a more scientific one and accept evolution. Their study also found that learners' religious views were negatively correlated with an initial understanding of evolution. This means that strongly religious learners come to class with the least scientific knowledge of evolution and are the least likely to develop an understanding and acceptance of evolution. This resistance to change is also present in this study. Learners' extra paragraphs, survey scores and interviews show that religious learners are wary of learning about evolution and are resistant to changing their religious beliefs especially if it means replacing one by the other. Teachers need to be aware of this conflict and deal with it instead of avoiding it. Moore (2008) recognises that the media, schools and churches often portray a conflict between science and religion suggesting that because of this clash someone cannot have religious beliefs and accept evolution. Moore (2008) suggests that it might be helpful if teachers acknowledge this possible 'relationship' between religious beliefs and evolution and explain that there are scientists who find an overlap between religion and science. Teachers may give examples such as- Dr. Francis Collins (2006), head of the Human Genome Project, who wrote a book titled: *The Language of God: A Scientist Presents Evidence for Belief;* in which he explains his view on how God created humankind through evolutionary processes; and Dr Kenneth Miller (1999), a cell biologist, who wrote a book titled :*Finding Darwin's God: A Scientist's Search for Common Ground Between God and Evolution*; a book

wherein he argues that evolution does not contradict religious faith. Moore (2008) p.84 also suggests that 'a learner's religious faith (or lack thereof) does not mean that they cannot accept evolution or that they confuse science with religion and the supernatural.' Stears (2011) suggest that religious beliefs and scientific understanding can co-exist. Learners are more comfortable learning about evolution if they do not have to compare religious beliefs with scientific concepts (Stears, 2011). Religious learners also experience less conflict if evolution is not taught as an 'alternative' to their religious beliefs because learners then understand that evolution was not 'designed' to oppose religious views. This enables learners to learn how to separate evolution and religion i.e. religious beliefs should not be taught alongside evolution as an alternative explanation (Stears, 2011).

6.5 A Cultural / Religious Overlap & Learners' response to the Main Concepts of Evolutionary Theory

Even though macroevolution, defined as evolution that happens over geologic time at above species level to form new taxonomic groups, contradicts the creationist view of how life began, many learners showed a cultural and religious overlap with regards to the theory of evolution, and in particular, macroevolution. Religious learners from group 5 agreed that even though they believed that God created the Earth, evolution provides a scientific explanation for how this was achieved. This change in attitude by learners is clearly shown in the pre and post survey results. Question 5 and 12 test learners' openness to the idea that evolution might explain how God created the Earth. Question 5 asked if learners thought the creation story was the best account of how the Earth was created and populated; and question 12 asked if learners thought that the universe was created by God. It was expected, and it was also the case, that in the pre survey all religious learners indicated that they agreed with the statement made in question 12. Question 12 does not test/ask learners how the earth was created, question 5 does this. Question 5 targets the creation story and it was expected that all religious learners would, to some degree, agree with the statement made in question 5. Results showed this to be the case. Post survey results show a shift in religious learners' thinking about their own religious beliefs and

evolution. Once again all religious learners, irrespective of their grouping, agreed with the statement of question 12 i.e. they had not changed or lost their faith/religious beliefs; but many answered differently to what they had answered in the pre survey for question 5. Many learners, especially groups 2 and 5, indicated that they thought that the creation story was no longer the best account of how the earth was created.

This change in answering pattern is important because it indicates a cultural/religious overlap. In a study conducted by Moore (2008) results found that 80% of the students in his study believe that evolution has a valid scientific basis and want evolution to be taught in schools. Results from Blackwell *et al.,* (2003) and Moore (2008) indicate that most learners' views are not as restrictive, as one would normally associate with creationism, and have at least a degree of openness to learning and accepting evolution, and that this acceptance can exist at varying degrees. This explains why learners do not need to abandon their personal religious beliefs to understand or accept the theory of evolution. Learners' beliefs do not change when taught evolution even though their understanding of the concepts related to evolution improves, and conceptual changes occur (Demastes *et al.,* 1995; Warsnop, 1992; Cavallo and McCall, 2008). Also, Bishop and Anderson (1990) found that an improved understanding of evolution and its processes do not necessarily lead to a general acceptance of evolution, and that this is due to the social and religious convictions that learners hold. Similarly, the findings by Lawson and Warsnop, (2008) revealed that learners may develop a better understanding of science concepts regardless of whether they believe the subject matter that they are learning'.

The prospect of an overlap between religious beliefs and evolution is not only evident from the survey, but also the extra Q questionnaire. The extra Q questionnaire explored learners' understanding and acceptance of macro and microevolution. Many religious learners indicated that they found microevolution plausible and recognised that there was evidence to show that it occurs, but did not find microevolution true. This shows that even very religious learners are willing to accept parts of evolution. Only four learners from group 4 indicated that they did not find either micro- or macroevolution to be true, but one of these learners indicated that it was purely due to a lack of understanding of either concept.

Blackwell *et al.,* (2003) made similar observations in that acceptance of only part of evolutionary theory is possible, without accepting everything taught in class. Blackwell *et al.,* (2003) also found the question of origins of humans, as was the case in the present study, to be the greatest source of conflict when considering evolution and that learners did not have a problem with accepting and understanding microevolution, but did have a problem when it came to macroevolution. Some non-religious learners in the present study also had difficulty with the concept of macroevolution and indicated on their extra Q questionnaire that they did not find it plausible. Macroevolution and deep time can be a difficult concept to visualise and understand.

When considering microevolution, 77% of all learners that answered the extra Q questionnaire found natural selection to be true; and 60% of all learners included natural selection or survival of the fittest in their concept maps. Many learners, irrespective of grouping, also indicated in the extra paragraphs and the extra Q questionnaire that natural selection was an interesting concept to learn about. Learners explained that it was logical and easy to follow and thus learn. When teaching natural selection, many examples can be worked through to show real life examples. Learners are more easily convinced about a theory if they can observe it and work through examples themselves. This makes the concept less abstract and more understandable. Only 7 learners, 5 from group 4 and 2 from group 3, did not accept natural selection. Some of these learners showed a poor understanding of evolution in the explanations that they included in their concept maps and the extra Q questionnaire. Group 4 learners mainly rejected natural selection for religious reasons, even though learners showed that they fully understood the concept in the interview. The interview did not, however, use the word 'natural selection' i.e. learners were unaware of exactly what the question was testing or exploring: their understanding of natural selection irrespective of their acceptance of it or not. This means that religious learners are denying the plausibility of natural selection if asked directly, even though they agree that it occurs in nature and understand its principles. This could be due to the idea that learners feel that if they find any part of evolution plausible then they are taking plausibility away from their own religious beliefs (a feeling of guilt that they are questioning their faith and what they have learnt at home/church). These learners feel deep conflict

between their religious beliefs and evolution and often adopt a coping strategy such as silence, evasiveness or often become antagonistic and vocal in class. These are group 4 learners. Barner (2011) discovered that it is important to consider learners religious beliefs and cultures for learners to have a positive experience in class, and for meaningful learning to occur.

When learners were asked to do the first concept map, 71% of learners only thought of or linked evolution to the concept of humans evolving, learners thought that evolution referred to how humans evolved i.e. evolution = human evolution. Learners showed a poor understanding of human evolution and either included a drawing of a monkey progressively turning into a human or they stated that humans came from apes/monkeys. This is where much of the resistance to learning about evolution originates for religious as well as non-religious learners. Learners included statements such as: "I don't want to learn about evolution / I don't believe in evolution because I don't believe that we (humans) came from monkeys". The study done be Stears (2011) also found this to be the case, religious learners thought of evolution as human evolution and that this concept suggested there is no God, and thus did not want to 'believe in' evolution. The primitive nature of the understanding shown by the grade 12 learners in the current study is possibly due to a lack of exposure to evolution and its basic concepts. This has, however, already been addressed by the latest curriculum changes that now include various aspects of evolution in grades 10-12. This curriculum change should reduce the hostility of grade 12 learners towards evolution that teachers often experience in the classroom because learners will already understand some of the core concepts and principles of evolutionary theory. Learners can thus approach the more controversial topics such as human evolution with a better foundation of knowledge and a more mature and open way of thinking about evolution.

6.6 Learner Attitude Towards Evolution

The learners as a group at first showed hostility towards / unwillingness to learn about evolution or to participate in the activities linked to this study. Many learners explained their feelings and thoughts against evolution in either the extra paragraph or pre concept

maps. This initial negative attitude can be attributed to a generally negative picture the media and public portray with respect to evolution. Evolution controversies are well documented by the media and discussed in churches. Learners face evolution at school expecting controversial material. Religious learners especially expect to feel uncomfortable.

Group 4 learners showed an overall negative attitude towards evolution which is predominantly due to religious conflict. Group 3 learners, however, showed little or no conflict concerning any aspect of evolution. Group 3 learners showed no interest in what they were learning about and showed no desire to learn or discover. Concept maps showed that many of these learners were neither positive nor negative towards evolution. It is this group in particular that teachers can, and should, most easily target with their teaching methods to move them into another group by merely getting them interested in what they are learning about. Group 3 contained 20% of all learners, more than groups 1 and 5 and thus cannot be ignored. Teachers should aim to have no learners in group 3.

The negative attitude experienced in the first school visit was absent in the second school visit. Having noted this, the majority of learners (60%), religious and non-religious, agreed that evolution should be included in the school curriculum. Only 27% of the learners, most from group 3 and 4, felt evolution should not be included. The varied reasons given by learners to explain this, is an indication that all cultures and backgrounds can find some value in being taught evolution. Learners explained that it promotes analytical and critical thinking, it forces one to keep an open mind and you learn to respect other people's beliefs and opinions.

6.7 Evolution is Boring?

The general trend across the groups indicated that learners did not find all of what they were taught about evolution interesting. Group 3 learners found the entire section on evolution boring and uninteresting. Learners in group 2 thought that many of the sections

became boring although the majority of group 2 thought evolution was interesting. Learners from groups 4 and 5 felt similarly in that they found at least some part of evolution uninteresting. Even a learner from group 1 felt evolution was uninteresting at stages. From the evidence provided by the learners in their extra paragraphs it can be concluded that it was not necessarily the content taught that learners from group 1, 2, 4 and 5 found uninteresting. Instead it was the way in which it was taught that made it uninteresting. Learners indicated that 'nothing interesting' happened in class and that they mostly only read from the textbook.

What seemed to play a role in the method of teaching is that the section was taught just before the exams and was covered in a shorter time period to complete the section for the exam. Rushing through an important section that is controversial can contribute to learner's negative attitudes towards evolution. Blackwell *et al.,* (2003) and Stears (2011) suggest that learners need time to develop an understanding and ultimately a degree of acceptance of evolution i.e. it cannot happen over a short period of time and may take much longer than just the period in which learners are taught evolution at school. This is in accordance with results obtained by Stears (2011) from which the suggestion was made that more time needs to be allocated to allow learners to develop a better and deeper understanding. Teachers often avoid teaching evolution and leave it to the last section to be taught and thus spend the least amount of time on it. This eliminates the possibility of discussions occurring in class because the class is under time pressure to finish the section. Griffith and Brem (2004) indicated that teachers in their study reacted similarly: the teacher explained that discussions are encouraged in all other sections taught, but when it comes to evolution she tolerates no discussions, the format of the class becomes lecture only, she tries to reduce the number of opportunities learners have to disrupt the class i.e. she tries to "sneak it in". This suggests that teachers need to be aware of the time required for an acceptance of evolution to "grow" in learners and that they are playing the role of "seed planters" for this acceptance. What teachers do in class can thus affect learners developing an understanding and acceptance of evolution in years to come. Learners need a strong foundational knowledge of evolutionary theory for this to occur.

Unfortunately teacher questionnaires did not explore methods of teaching, and it is thus unclear as to what activities teachers included in class to facilitate the understanding of evolution and to keep the learners engaged and interested. Watching documentaries, visiting museums and participating in practical's and hands on classroom activities all help guide learners to develop a better understanding of evolution(Stears, 2011). This section of work should not be rushed, instead learners need time to explore their own beliefs and compare and weigh them up against the new information and decide how it fits into their belief structures.

6.8 Learning, Understanding and FATIMA'S rules

Not only did the survey reveal an improvement in scientific understanding of evolution, but the concept maps also showed an improvement in the content included when comparing the pre and post concept maps. Table 6 shows the clear shift between the pre and post concept maps. The table shows the learners' superficial understanding of evolution and the emphasis they placed on human evolution in the pre concept maps. There is a drastic shift away from human evolution as the focal point of the pre concept maps to more comprehensive and holistic post concept maps that include Darwin and Lamarck's theories and natural selection as the focal points and human evolution only being a part of evolution. Not many learners went far beyond these main concepts and failed to include much of what they were taught in class. Many did, however, include explanations of natural selection and showed a good understanding of this concept.

As learners develop a better understanding of evolution they include less emotional and emotive language. This indicates that learners are thinking about evolution in a more scientific and less personal way. The shift in concepts between the pre and post concept maps shows that learning has taken place and that learners have a more positive attitude towards evolution than at the start of the section. Even the religious learners that initially indicated that they hardly found anything plausible about evolution showed a fair understanding of the main concepts of evolution. This goes back to the notion that learners

can have a good understanding of evolution and even apply this understanding without abandoning their religious beliefs.

Fatima's rules need to be considered at this point as an explanation of how some learners approach learning about evolution. Fatima's rules were first documented by Larson (1995) and are 'rules' that learners often follow to be able to pass a test or section of work without understanding it. Fatima's rules apply to those learners that often lack interest in the content being taught i.e. mostly group 3 and 4 learners. Learners in group 2 also showed the use of Fatima's rules. Learners that play Fatima's rules do not show a clear understanding of the main concepts and avoid providing explanations and linking concepts in concept maps. Many of these learners were capable of listing the main concepts associated with evolution but could not correctly group ideas or provide a logical sequence. Fatima's rules rely on rote memorization of key concepts (headings and bold words), tables and graphs and summaries. No meaningful learning occurs. Learners that do this can produce fairly high survey scores and teachers thus assume learners have a good understanding of the content taught. It is because of this that group 2 (considered 'other smart kids') can also include such learners. These learners can easily 'score' highly in the concept maps because they did not have to explain concepts. They can easily give the appearance that they understand. Ultimately, all groups (excepting group 1) contain learners that play Fatima's rules, groups 2 and 3 with the highest proportion of these learners. The reasons for the learners from the different groups playing Fatima's rules vary from the bored and uninterested group 3 learners to the religious learners that 'refuse' to understand. Aikenhead (2000) showed that shallow and superficial learning occurs in class because teachers often teach merely to complete the curriculum set out by government and to make it appear that meaningful learning has taken place, but instead teacher and learner's are playing Fatima's rules.

6.9 Evolution is "Just a Theory"

Many learners referred to evolution as "just a theory" and questioned why it was being taught if it was just a theory and had not been proven yet. This is another misconception

that learners and teachers have. Learners see evolution as a theory that needs to be proven and do not recognise that there is scientific evidence to support the theory or that it is scientifically accepted as 'truth'. This stems from the misunderstanding between the scientific meaning of the word theory and the more common colloquial use of the term. The American heritage dictionary of the English language defines a theory as follows:

A set of statements or principles devised to explain a group of facts or phenomena, especially one that has been repeatedly tested or widely accepted and can be used to make predictions about natural phenomena.

The common use of the term 'theory' outside of the science community implies that a theory is speculative, that it is just a "guess". This is how it seems that most learners view the theory of evolution. Moore (2008) explains that how teachers teach evolution can instigate and worsen this problem. "Evolution is only a theory" is a common statement that teachers also use. This statement suggests that evolution is only a hunch or a guess that is insignificant and easily dismissed because they do not recognise evidence to support evolution, and they do not show learners that a scientific theory explains facts (Moore, 2008). Blackwell *et al., (*2003) state: that to regard evolution as 'just a theory' shows a misunderstanding of the nature of a scientific theory. It also raises issues with evidence for evolution and thus adds doubt when regarding evolution (Dotger *et al.,* 2009).

Teacher B explained that he is only a facilitator of the THEORY of evolution, and that a theory is just an explanation based on perceived evidence. Introducing evolution as 'just a theory' to learners resulted in a barrier to accepting and learners wanting to learn about evolution. Learners felt that because of the controversial nature of evolution and that it is 'only a theory', it should not be included in the curriculum. In an effort to "downplay" the significance of evolution and its obvious clashes with religious beliefs which can antagonise learners, teachers, often intentionally, "play" on the term "theory". This 'playing' with terminology is an indication that teachers do not fully understand misconceptions or are not able to deal with misconceptions associated with evolution. Thus teachers think that if they convince learners that they are only learning an unproven, not-fact-yet theory, that learners

will feel less threatened by the content because it does not go against beliefs or cultures because it is 'only a theory'. According to results, this incorrect use of the term 'theory' has had a negative effect on learner's attitude towards learning about and accepting evolution. This does, however, require more research as not much literature exists which supports or explores this phenomenon, and much of what is speculated in this paragraph is based on personal encounters with a number of different teachers from various schools.

Both the teachers at this school are well educated with University degrees and many years of experience in senior positions at various schools. Their general education and knowledge about the subject they teach would not come into question, but neither teacher has had a specific course in evolution. With their educational backgrounds they would be competent in self-teaching much of the evolutionary concepts. Both teachers show a good understanding of the main concepts. What does come into question is their knowledge about the misconceptions about evolution and if they are aware of all of them i.e. their pedagogic content knowledge. This also questions their ability to deal with and teach evolution to avoid these misconceptions. Teachers that are fully aware of the misconceptions associated with evolution and that have been equipped with the knowledge to teach 'around' these misconceptions would have a class of learners that would experience far less cultural conflict and would learn and accept evolution more easily. A study done by Abrie (2010) on South African student teachers showed that 70% of the student teachers felt that they were adequately prepared to teach evolution with little or no training on the topic of evolution. The same student teachers showed a poor understanding and harboured misconceptions. In another study done on teachers by Brem and Griffith (2004) found that teachers felt that they were not confident in their knowledge of evolution because they had never studied a specific course in evolution. Their lack of confidence was rooted in the unexpected social and personal implications and situations that they felt unequipped to deal with. The teachers in the Brem and Griffith study agreed that refresher courses on up to date material would increase their confidence and ultimately their comfort level in class. Rutledge and Mitchell (2002) as well as Abrie (2010) also suggest that improving teachers' academic backgrounds will improve the quality of teaching in the classroom. Stears (2011) suggests that it is not only teacher understanding of evolutionary

concepts that should be focused on in improving teaching quality, but also improving teachers' ability to deal with conflicts and improving teacher understanding of the nature of science. Rutledge and Mitchell (2002) link an improved academic background with an improved understanding of the nature of science and thus teachers are able to better differentiate between a scientific theory and strongly religious views i.e. the first step in improving learner understanding and acceptance of evolution is to improve the understanding that teachers have of evolutionary biology.

6.10 How Learners Learn Evolution

It has been discussed in earlier sections that learners have gained a better understanding of evolutionary theory through the explicit teaching of evolution. The greatest shift was between learners initially only recognising human evolution as the main concept linked to the theory of evolution, and recognising Darwin's theory and natural selection as main concepts of evolution. This change is significant and indicates that conceptual change has occurred. For conceptual change to occur learners need to find the new concept intelligible, plausible, fruitful and there must be a level of dissatisfaction with existing conceptions (Posner *et al.,* 1982). This form of conceptual change is called accommodation and is an appropriate framework to consider when investigating how learners learn the 'basics' of evolution (i.e. the fundamental concepts such as Darwin's theory of natural selection) because it takes learners' current concepts into consideration (Posner *et al.,* 1982).

The boundaries of the conceptual change model lie in Posner *et al.,* (1982) and Hewson (1981)'s initial explanation of how conceptual change occurs. Learning is considered a logical and rational activity and conceptions undergo a holistic change (Demastes *et al.,* 1996). Hewson (1981) explains that a new concept can either be rejected (an explanation from strongly religious learners in group 4), or incorporated in three possible ways by either memorizing by rote (i.e. Fatima's rules and group 3 learners), by assimilation or accommodation (a possible explanation for group 1 and 2 learners). The limitation of this school of thought, however, is that it can explain the learning that occurs superficially i.e.

learning the 'basics', but it does not take learners' social backgrounds (religious beliefs and cultures), goals, emotions and motivations into account which play a significant role in conceptual change (Demastes *et al.,* 1995). Conceptual change theory focuses on what learning is and not what it depends on (Posner *et al.,* 1982). The present study has shown that learning heavily depends on learners' backgrounds, especially religious learners.

Demastes *et al.,* (1996) recognises conceptual change theory as useful because it takes learners' prior knowledge into consideration, but that it is not sufficient in explaining how all learning takes place because not all conceptual change fits neatly into the conceptual change model. Instead Demastes *er al.,* (1996) suggest that learning a concept can take a variety of pathways. Learning often does not take a logical holistic approach as suggested by conceptual change theory, and this needs to be considered when investigating how learners learn evolution because religious learners' views and beliefs play an important role in the process of conceptual change. As mentioned previously, Demastes *et al.,* (1996) tried to re-look at the conceptual change model and suggested that conceptual change can follow four patterns, two of which do not fit the boundaries set by the conceptual change model, namely: Incremental changes and dual construction. The process of incremental change does not fit the conceptual change model because it suggests that learning is far more gradual than the conceptual change model allows for. Slow change supports how some learners learn evolution because of their initial conflicting ideas. Dual construction suggests that learning does not necessarily rely on wholesale conceptual change, but instead conceptual restructuring occurs far less logically than is expected within the conceptual change model. Dual construction involves two opposing conceptions, and instead of restructuring one to incorporate the other, or exchanging one with the other, two competing conceptions are constructed and applied (Demastes *et al.,* 1996).

Even though dual construction can be considered when looking at how learners learn evolution, Demastes *et al.,* (1996) describes dual construction as a failed conceptual change model path, thus the framework of Collateral learning will be used instead to explain this phenomenon. Collateral learning more accurately explains the pathway of learning that religious learners follow because, as this study shows, religious learners do not abandon or

replace their religious beliefs with evolutionary biology concepts; instead, these learners can construct two meanings (one religious and one scientific) of a concept simultaneously. Collateral learning pays particular attention to cultural conflicts between learners' life-world and what is taught at school (Aikenhead and Jegede, 1999). Unlike conceptual change, collateral learning emphasizes the role that learners' cultural backgrounds have on learning and the capacity learners have themselves to think differently. Aikenhead and Jegede (1999) recognised the conflict between Christian faith and science and identified collateral learning as a tool to understand how such learners learn.

Collateral learning has been closely linked to the idea of cultural border crossing (Aikenhead, 2001; Aikenhead and Jegede, 1999). The learner groups established in this study takes the notion of border crossing into account. The groups categorise the degree of ease with which learners apparently cross cultural borders and negotiate transitions into school science. The table below summarises the categories as described by Costa (1995) and Aikenhead (2001).

Table 10. Table showing the type of border crossing experienced by each group.

Group		Type of Border Crossing
Group 1	*Potential Scientists*	Smooth
Group 2	*Other Smart Kids*	Manageable
Group 3	*I Don't know*	Hazardous
Group 4	*Outsiders*	Impossible
Group 5	*I want to know*	Adventurous

Border crossing is dependent on how different learners see their beliefs in relation to what they are being taught in class, as well as the assistance (how teachers teach) learners receive to make such transitions easier. Cobern and Aikenhead (1998) summarised the cultural aspects of learning science in which they highlighted the importance of recognising learners' life-cultures and the interaction between these cultures and learning. When learners' cultures are at odds with school science, learners are forced to abandon their

views resulting in assimilation (Cobern and Aikenhead, 1998). Forcing a scientific view on learners produces enculturation and learners playing Fatima's rules (Cobern and Aikenhead, 1998; Aikenhead 2000). Achieving successful enculturation is a challenge in the classroom and needs to be a focal point or 'goal' for teachers to teach evolution successfully. Enculturation can, however, only work when learners' life culture harmonises with what is being taught i.e. learners in groups 1 and 2 and possibly 5; learners in group 4 and 3 will react by playing Fatima's rules or rejecting evolution completely. Thus teachers should not teach to enculture all learners. The ideal would be to approach the teaching of evolution to ensure all learners fall into groups 1, 2 and 5 so that enculturation can occur and learners' culture overlaps with scientific culture.

Learners in group 4 are most likely to follow the pattern of parallel collateral learning (which is similar to dual construction), if they do not reject the theory of evolution completely (as some learners did). This way of learning does not require learners to accept concepts linked to evolution, they merely need to memorise, and to some degree, understand what they are taught in class. This type of learning (also followed by group 3 learners) is referred to as shallow learning by Aikenhead (2000). Learners that follow a 'shallow learning' route do not see the need to develop a deeper understanding of what they are taught. This explains how religious learners 'scored' well in the concept maps. They accessed one schema (scientific knowledge) in the context of concept mapping task eliminating conflict with religious beliefs and thus eliminating emotive language used in the post concept maps.

Dependent and secured collateral learning explains how religious learners in groups 5 and 2 learn. These learners find a cultural overlap between scientific concepts and religious beliefs. Group 1 and 2 learners follow what is expected from the conceptual change model. Aikenhead (2000) describes these learners as those that make an in-depth level of meaning for school science and reject Fatima's rules. This is only a small proportion of learners in this study. The chart below shows the unique interaction between conceptual change and collateral learning models and learner groups. The chart attempts to illustrate the possible learning paths that each particular group of learner is most likely to follow. Conceptual change explains how learners learn the 'basics' of evolutionary theory (i.e. material that is

not necessarily controversial in nature, such as natural selection and comparing Darwin and Lamarck), and is followed by learners in all groups. Collateral learning theory then 'takes over' where conceptual change theory fails to appropriately explain the learning process. Collateral learning explains how religious learners learn evolution by addressing how these learners approach and deal with the deeper issues of the theory of evolution that clash with their beliefs and life-world.

Chart 1. Possible learning paths followed by different groups of learners.

```
    Non-religious                          Religious
      Learners                             Learners

Group 1 & 2 & 3 ——— Unit on Evolution ——— Group 4 & 5 & 3

Conceptual Change                          Conceptual Change

                    Group 3    Group 4     Collateral Learning

Understand Evolution    Rejects Evolution         Group 5 & 4    Group 5 & 2

Accept Evolution        Fatima's Rules      Parallel Collateral      Dependent or
                                               learning              Secured
                                                                  Collateral learning

                                          Understand Evolution    Understand Evolution

                                                                  Accept Evolution
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Chart 2, on the other hand, illustrates how learners can move between groups. Learning is not a stagnant process, and learners' beliefs, views and knowledge structures are continuously being challenged in class. It is thus possible for learners, depending on what is being taught and how it is being taught, to move between groups. Chart 2 illustrates the possible movements that learners can make from the different group settings. Starting with group 1 learners, it is possible for these learners to easily move between groups 1 and 2. Group 1 learners have a deep understanding of science concepts and have a natural curiosity in science, but can find some concepts questionable or difficult to understand and can thus move to group 2. Similarly, group 2 learners can also easily move to group 1. Group 2 and 5 learners have the foundational knowledge and understanding necessary to become a potential scientist, and with a little further guidance and instruction can move to a deeper understanding. Group 5 learners can also interchange with group 1, just as group 2, the only difference between group 5 and 2 is that learners in group 5 bring a cultural aspect to learning which they do not need to abandon (which would entail moving to group 2 before group 1), they can move to group 1 with their cultural / religious beliefs because they find a cultural overlap between the science and their beliefs. Group 5 learners can, however, move to group 2 if they choose to abandon their cultural / religious beliefs.

Group 4 learners will not abandon their beliefs and thus must first move to group 5, find a cultural overlap between their beliefs and science, before moving to group 1; or they can move to group 3 where they disengage and become uninterested (a less favourable move). Group 3 should be avoided and should consist of the smallest proportion of learners in the class. Group 3 learners have the potential to move either to group 2, 4 or 5 depending on their backgrounds and how the teacher guides them out of group 3. Group 2, 4 and 5 learners are capable of moving into group 3. This is where teachers' abilities and experience becomes imperative as they need to teach to prevent learners from moving into this group. Having a learner in group 4, rather than group 3, can be considered a better learning route because group 4 learners are engaged in the content being taught and stand a chance to develop a better understanding of evolutionary biology than group 3 learners who will, more than likely, resort to playing Fatima's rules.

Chart 2. Flow chart illustrating possible movement between learner groups.
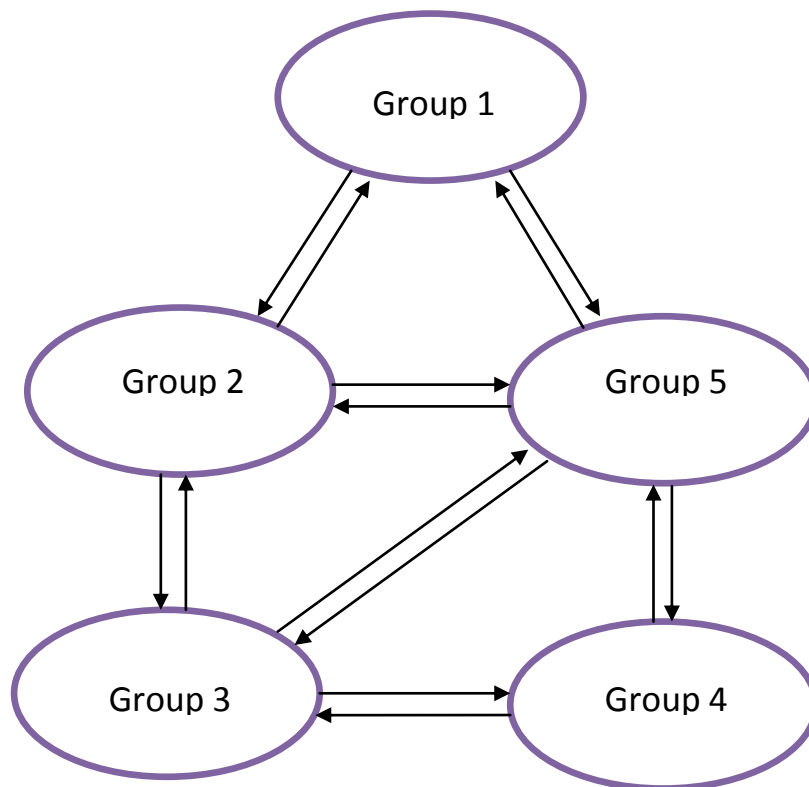
Learning evolution can be considered a much more complex process than learning other, less controversial, concepts in biology. Learner conceptual ecologies play a far greater role in learning than expected and must be considered when teaching this unit of work. This chapter has discussed learner attitudes towards learning evolution as well as contributing factors that affect learner attitudes and learning. The influence that teachers have in the classroom has been looked at and suggestions have been made on how teachers can improve the quality of teaching that occurs in the classroom. Ultimately, this chapter has highlighted the importance of teaching for cultural border crossing and using collateral learning as a framework to understand how learners learn evolution.

Chapter 7

CONCLUSION

This study has investigated and addressed issues that many schools, teachers and learners experience in their everyday classroom lives. Results have provided answers for the initial research questions asked, and will each be revisited:

1. What are some of the contributing factors to South African learners' conceptual ecologies and pre-conceptions towards evolution?

   Religious beliefs proved to be the main contributing factor to learner pre-conceptions and conceptual ecologies. Many Religious learners initially showed conflict when presented with the concept of evolution. These learners were not only faced with the challenge of learning about a new, abstract concept but also had to face the challenge of questioning their beliefs and how this new information would either fit in with existing beliefs or whether they had to replace one with the other. Some learners had a fairly good idea about what evolutionary theory entailed because of documentaries seen on television or because the learners had done extra reading to find out about the topic themselves because it interested them. Other learners brought with them ideas that they had heard from other learners or from what they had heard other people say. The majority of learners had heard about evolution before coming to class but did not necessarily know what it entailed.

2. What are the attitudes of South African learners and teachers towards evolution?

   Schools were nervous to host the study and wanted to avoid attracting attention to the fact that they were teaching evolution. Schools did not want parents to be upset by the content of the investigation, namely evolution. The school where this study was conducted, however, was more positive towards the project and teachers were eager to get the learners involved in research. The school had an overall positive

attitude towards teaching evolution and did not see why it should not be taught, but did recognise the controversial nature of the topic and that it might offend some learners and parents. The learners, however, were more apprehensive when they initially faced the task and displayed an overall negative attitude towards being taught evolution. Religious learners were negative and did not want to be taught evolution because it went against their religion. This overall negative attitude did change towards the end of the unit taught even though some religious learners still felt strongly against the theory and that it is taught in schools. Most learners, religious included, were curious to find out what evolution was all about and whether it was as controversial as they had been led to believe.

3. What conceptual changes occur when learners are taught evolution?

Results indicate that learners made significant conceptual changes. Learners' initially understood evolution to be only human evolution, but by the end of the unit this primitive understanding of the theory of evolution had evolved into learners recognising that evolution included various areas such as Darwin's theory of natural selection, the fossil record and deep time. Even though results did indicate that there was no difference in conceptual change between learners taught by different teachers, results do indicate that teachers have an effect on learner attitude towards evolution.

This study also highlighted the notion that conceptual change theory is not sufficient in explaining how learners learn evolution. Instead, collateral learning needs to be considered because it more accurately explains how religious learners learn evolution. Collateral learning puts emphasis on the importance that learner cultures have in learning.

4. **What factors influence this conceptual change?**

Learners' backgrounds, culture and religious beliefs, are the main factors that influence conceptual change when learning evolution. These factors limit the ease in which learners can cross borders between religious understanding and scientific understanding.

Teachers can influence conceptual change in the way in which they teach and ultimately guide learners from their primitive/religious understanding to a scientific understanding. Teaching evolution as 'just a theory' negatively affects conceptual change and learner attitude towards evolution. Teaching evolution as 'just a theory' places doubt in learners' minds as to the accuracy and acceptance of the theory. Teaching evolution in this manner is an indication that teachers, even though highly qualified, do not necessarily have the pedagogic content knowledge to effectively teach evolution. This is also linked to effectively teaching for cultural border crossing i.e. facilitating those learners who experience conflict, and guide them into a more scientific understanding of the content taught without forcing them to abandon their religious beliefs

Lesson plans and available resources such as textbooks, visual aids etc. can influence conceptual change as well as attitude towards evolution. It is often the case that teachers merely read from the textbooks when they are under time pressure to finish a unit or if they want to avoid class discussions etc. This can become uninteresting for learners, as learners stated in this study, and they disengage from the material being taught. This is also linked to the amount of time spent on the unit. A deeper understanding of evolution develops over time and rushing through this unit negatively effects conceptual change and acceptance of evolution. The more time spent on evolutionary theory the greater the conceptual change and acceptance of the theory learners develop.

A significant amount of information has been brought to light in this investigation. The most important aspects learnt from this study are that teachers need to consider learners' religious beliefs carefully when teaching evolution. Teachers should not teach to change learner's beliefs; learners should not have to abandon their beliefs to accept or understand evolution. Instead, when learners develop a deeper understanding of evolutionary theory they will search and question their beliefs and find overlaps between the two. Learners then experience evolution in a more positive light and are thus more likely to accept the theory. Another important aspect that this study has highlighted is that teacher pedagogic content knowledge plays an important role in conceptual change and developing an understanding of and a level of acceptance of evolution in learners. Teachers need to be equipped with the knowledge and skills to avoid common misconceptions associated with evolution and be able to teach for cultural border crossing. Finally, this study has also identified that conceptual change does not explain how all learners learn evolution. Instead, learners that experience cultural conflict follow various other learning paths explained by collateral learning.

Evolution will remain a controversial issue related to education as long as schools, parents, learners and school communities recognise the two worlds of science and religion as opposing views. The controversial nature of evolution can be appropriately dealt with by schools in the manner in which they teach and approach evolution. It is thus schools that can change the overall attitude of society as a whole by influencing learners in the classroom, because it is those learners in those classrooms that will become the scientists and religious leaders of tomorrow and it is these learners that will determine the level of controversy that this topic will hold in the future.

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Appendix 1

Sample letters used.

1. Consent letter - School.

2. Consent letter - Teachers.

3. Consent letter - Learners.

Dear Principal

Re: Consent Documents Concerning Masters Research

My name is Debra Schroder and I am a MEd student registered at the University of KwaZulu-Natal in Pietermaritzburg.
My research is focused around the teaching of evolution in schools. In particular, I am investigating the conceptual change of learners ideas when taught evolution and the influences that affect this conceptual change. The attitudes towards evolution of learners and teachers will also be investigated. Your school has been identified for this investigation as it suits the requirements: a well resourced school in the KwaZulu-Natal midlands region.
Two lessons would be required with the grade 12 class. One lesson before they are taught the section on evolution and one after. The pre-test will determine their knowledge structure and pre-conceptions.

The sessions with the learners will be broken into 2 parts:
Part 1: (20-30minutes) Learners will be asked to draw up a concept map jotting down all
         they know and believe concerning the topic.
Part 2: (10-15minutes) This will be a multiple choice type questionnaire.
         This will rank learners pre-conceptions to determine how 'scientific' their knowledge is.

This process of questioning (Part 1 and 2) will then need to be carried out after the section has been taught. This is done to follow any conceptual change that occurs during the teaching of this particular section.

A similar questionnaire will be given to the Life Science teachers. This is done to establish the knowledge base and attitudes teachers have concerning this topic. The questionnaire should also shed light on any link between teacher attitudes/values and learners conceptual change.

Some of the questions I hope to answer with my research include the following:
1) What are some of the contributing factors to learners' conceptual ecologies?
2) What are the attitudes of learners and teachers towards evolution?
3) What conceptual changes occur in learners when taught evolution?
4) What factors influence this conceptual change?

All data gathered will be stored at the University of KwaZulu-Natal for a period of 5 years after use, and then destroyed. Your name, the name of the school as well as the name of the learners and teachers will not appear in my thesis or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibility for the school, and you may withdraw from the study at any stage for any reason.

My research project is being supervised by Dr Edith Dempster from the School of Education and development at the University of KwaZulu-Natal in Pietermaritzburg. Her contact number is 033-2605723.

Please do not hesitate to contact me or my supervisor if you have any further questions or concerns! If you agree for your school to participate in my research, please complete the attached consent form which I will collect at a time convenient for you.

Thank you for your time,

Debra Schroder

Contact details:
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July 2009

Dear Teacher

Re: Consent Documents Concerning Masters Research

My name is Debra Schroder and I am a MEd student registered at the University of KwaZulu-Natal in Pietermaritzburg.

My research is focused around the teaching of evolution in schools. In particular, I am investigating the conceptual change of learners ideas when taught evolution and the influences that affect this conceptual change. The attitudes towards evolution of learners and teachers will also be investigated. Your school has been identified for this investigation as it suits the requirements: a well resourced school in the KwaZulu-Natal midlands region.

Two lessons would be required with the grade 12 class. One lesson before they are taught the section on evolution and one after. The pre-test will determine their knowledge structure and pre-conceptions.

The sessions with the learners will be broken into 2 parts:
Part 1: (20-30minutes) Learners will be asked to draw up a concept map jotting down all
       they know and believe concerning the topic.
Part 2: (10-15minutes) This will be a multiple choice type questionnaire.
       This will rank learners pre-conceptions to determine how 'scientific' their knowledge is.

This process of questioning (Part 1 and 2) will then need to be carried out after the section has been taught. This is done to follow any conceptual change that occurs during the teaching of this particular section.

A similar questionnaire will be given to the Life Science teachers. This is done to establish the knowledge base and attitudes teachers have concerning this topic. The questionnaire should also shed light on any link between teacher attitudes/values and learners conceptual change.

Some of the questions I hope to answer with my research include the following:
1) What are some of the contributing factors to learners' conceptual ecologies?
2) What are the attitudes of learners and teachers towards evolution?
3) What conceptual changes occur in learners when taught evolution?
4) What factors influence this conceptual change?

All data gathered will be stored at the University of KwaZulu-Natal for a period of 5 years after use, and then destroyed. Your name, the name of the school as well as the name of the learners and principal will not appear in my thesis or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibility for you or for the school, and you may withdraw from the study at any stage for any reason.

My research project is being supervised by Dr Edith Dempster from the School of Education and development at the University of KwaZulu-Natal in Pietermaritzburg. Her contact number is 033-2605723.

Please do not hesitate to contact me or my supervisor if you have any further questions or concerns! If you agree for your school to participate in my research, please complete the attached consent form which I will collect at a time convenient for you.

Thank you for your time,

Debra Schroder

Contact details:
O33 5070159
082 7456 211
debras@lantic.net

Dear Learner

Re: Consent Documents Concerning Masters Research

My name is Debra Schroder and I am a MEd student registered at the University of KwaZulu-Natal in Pietermaritzburg.

My research is focused around the teaching of evolution in schools. In particular, I am investigating the conceptual change of learners ideas when taught evolution and the influences that affect this conceptual change. The attitudes towards evolution of learners and teachers will also be investigated. Your school has been identified for this investigation as it suits the requirements: a well resourced school in the KwaZulu-Natal midlands region.

You will be asked to do a Concept map and a Questionnaire before you are taught the section about evolution and again after. This information will be used to determine how much you know about the topic before and after you are taught and how some of your ideas might change when you are taught the section.

All data gathered will be stored at the University of KwaZulu-Natal for a period of 5 years after use, and then destroyed. Your name, the name of the school as well as the name of the learners and principal will not appear in my thesis or in any other papers or presentations prepared by me regarding the study. There is no cost or additional responsibility for you or for the school, and you may withdraw from the study at any stage for any reason.

My research project is being supervised by Dr Edith Dempster from the School of Education and development at the University of KwaZulu-Natal in Pietermaritzburg. Her contact number is 033-2605723.

Please do not hesitate to contact me or my supervisor if you have any further questions or concerns! If you agree to participate in my research, please complete the attached consent form which I will collect at a time convenient to the school.

Thank you for your time,

Debra Schroder

Contact details:
O33 5070159

Appendix 2

1. Pre/Post Survey for Learners

2. Extra Q Questionnaire

3. Teacher Survey and Questionnaire

Evolution Questionnaire Learners

The following questionnaire will be used to determine your current knowledge structure concerning the topic evolution. Your responses will remain anonymous and confidential.
Answer questions as honestly as you can.

Please indicate, by ticking the appropriate number, for each question below whether you:
 Strongly agree (1), Agree (2), Disagree (3), Strongly Disagree (4), or are undecided (5).

Example:
Eating spinach everyday will make you strong.   [1] [2] [3] [4] [5]

<u>Questions</u>

1. Landforms like the Drakensberg mountains
    were created by God and have not changed ever since.   [1] [2] [3] [4] [5]

2. Certain types of living things such as dinosaurs that
    once lived on Earth no longer exist.   [1] [2] [3] [4] [5]

3. Fossils were intentionally put on Earth to confuse
    humans.   [1] [2] [3] [4] [5]

4. All humans originate from Africa from where they
    populated the rest of the world.   [1] [2] [3] [4] [5]

5. The creation story is the best account of how the Earth
    Was created and populated with life.   [1] [2] [3] [4] [5]

6. Humans and apes are as closely related as humans
    are to dogs.   [1] [2] [3] [4] [5]

7. Living organisms are different from nonliving things
    because they possess some kind of special force.   [1] [2] [3] [4] [5]

8. Human beings are different from other living organisms
    because they possess a soul.   [1] [2] [3] [4] [5]

9. All events in nature occur as a predetermined plan.   [1] [2] [3] [4] [5]

10. You have the same genes as bacteria for essential
    life processes.   [1] [2] [3] [4] [5]

11. Living organisms on Earth may have come from an alien
    life form.   [1] [2] [3] [4] [5]

12. It seems reasonable that the universe was created by God.   [1] [2] [3] [4] [5]

13. Aliens sometimes land on Earth.   [1] [2] [3] [4] [5]

14. Evolution should be taught in Biology class.   [1] [2] [3] [4] [5]

15. All events in human life occur as part of a predetermined
    master plan.   [1] [2] [3] [4] [5]

☺ *Thank you for your time and effort* ☺

Extra Questions

Circle the underlined word in each question below that best completes the sentence and then give an explanation as to why you said so.

a)   I reject / accept the theory of macroevolution because...

_____
_____
_____
_____

b)   I believe / don't believe Natural selection to be true because...

_____
_____
_____
_____

c)   During the section on evolution I found the following concept difficult to deal with because....
      (state the concept and then explain why)

_____
_____
_____
_____
_____

d)   During the section on evolution I found the following concepts interesting and easy to understand because...
      (State the concept(s) and explain why)

_____
_____
_____
_____
_____

e)   I find evolution compatible / incompatible with religious beliefs because...

_____
_____
_____
_____

f)   Evolution should / shouldn't be included in the Life Science curriculum because...

_____
_____
_____
_____

Evolution Questionnaire Teachers

The following questionnaire will be used to determine your current knowledge structure concerning the topic evolution. Your responses will remain anonymous and confidential.
Answer questions as honestly as you can.

Approx. Time: 10 min

Please indicate, by ticking the appropriate number, for each question below whether you:
Strongly agree (1), Agree (2), Disagree (3), Strongly Disagree (4), or are undecided (5).

Example:
Eating spinach everyday will make you strong.   [1] [2] [3] [4] [5]

Questions Part 1

1. Landforms like the Drakensberg mountains
   were created by God and have not changed ever since.   [1] [2] [3] [4] [5]

2. Certain types of living things such as dinosaurs that
   once lived on Earth no longer exist.   [1] [2] [3] [4] [5]

3. Fossils were intentionally put on Earth to confuse
   humans.   [1] [2] [3] [4] [5]

4. All humans originate from Africa from where they
   populated the rest of the world.   [1] [2] [3] [4] [5]

5. The creation story is the best account of how the Earth
   Was created and populated with life.   [1] [2] [3] [4] [5]

6. Humans and apes are as closely related as humans
   are to dogs.   [1] [2] [3] [4] [5]

7. Living organisms are different from nonliving things
   because they possess some kind of special force.   [1] [2] [3] [4] [5]

8. Human beings are different from other living organisms
   because they possess a soul.   [1] [2] [3] [4] [5]

9. All events in nature occur as a predetermined plan.   [1] [2] [3] [4] [5]

10. You have the same genes as bacteria for essential
    life processes.   [1] [2] [3] [4] [5]

11. Living organisms on Earth may have come from an alien
    life form.   [1] [2] [3] [4] [5]

12. It seems reasonable that the universe was created by God.   [1] [2] [3] [4] [5]

13. Aliens sometimes land on Earth.   [1] [2] [3] [4] [5]

14. Evolution should be taught in Biology class.   [1] [2] [3] [4] [5]

15. All events in human life occur as part of a predetermined
    master plan.   [1] [2] [3] [4] [5]

6. Have you had a specific course in evolution?
    C. Yes [ ]
    D. No [ ]
        If yes, please elaborate and list:

    _____
    _____
    _____

7. How much time in the school year do you devote to the topic of evolution?
    E. 5 - 10 days   [ ]
    F. 10 - 15 days   [ ]
    G. 15 - 20 days   [ ]
    H. More than 4 school weeks   [ ]

8. Which expression best characterises your teaching of evolutionary theory?
    E. Avoidance   [ ]
    F. Briefly mentioned   [ ]
    G. Studied in depth as a distinct content area   [ ]
    H. The unifying theme for the content of the course [ ]

9. Do you accept evolutionary theory as a scientifically valid explanation of the state of living organisms of the present and past?
    C. Yes [ ]
    D. No [ ]

10. Have you experienced any difficulties teaching the topic?
    C. Yes [ ]
    D. No [ ]
        If yes, please explain these:

    _____
    _____
    _____
    _____
    _____

11. If you have any further comments or would like to elaborate on answers given above, please add them below:

    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____
    _____

☺ Thank you for your time and effort ☺

Appendix 3

Abstract Submitted for the College of Humanities Postgraduate Conference 2012:

"Surveying the Humanities Research Landscape: What's under the postgraduate lens?"

University of Kwazulu-Natal

Presented on the 3-4 October 2012

Factors influencing conceptual change when South African learners encounter evolution.

Evolution has been met with much debate, concern and conflict in its inclusion in the school curriculum. The aim of this investigation was to determine what conceptual change occurs when learners are taught evolution and what factors influence this change looking in particular at learners' conceptual ecologies and the role that religious beliefs play. Conceptual change refers to a way of learning. It involves the change of learners existing understanding to the development of new concepts. A mixed methods approach was used because it obtains a fuller picture and provides a deeper understanding of a phenomenon by combining the strengths of qualitative and quantitative research. Learners were given a pre- and post-instruction survey and concept mapping task, and a sample of learners were interviewed post instruction. Results showed that learners made significant conceptual changes and that religious beliefs are the main contributing factor to learners' conceptual ecologies and the conceptual changes that occurred. An overall negative attitude was initially experienced from learners, but this developed into curiosity and interest. This study also highlights the notion that conceptual change theory is not sufficient in explaining how all learners learn evolution. Learners that experience cultural conflict follow various other learning paths explained by collateral learning. Collateral learning puts emphasis on the importance that learner cultures have in learning and highlights the importance of teaching for cultural border crossing

Submitted by: Debra Schroder 201298026
Supervisor: Dr Edith Dempster

Appendix 4

Figure 1. Pre concept map by learner 17 group 2.

Figure 2. Pre concept map by learner 40 group 5.

Figure 3. Pre concept map by learner 8 group 2.

Figure 4. Pre and post concept map done by learner42 group 5.

Figure 5. Post concept map of learner 1 group.

Figure 6.Post concept map of learner 3 group 1.

Figure 7 Post concept map of learner 32 group 4.

Figure 8. Pre and Post concept maps by learner 20 group 3.

Figure 9. Pre and Post concept map by learner 8 group 2.

Figure 10. Pre and Post concept map by learner 7 group 1.

Figure11. Concept Map by Teacher B.

Evolution

originally → Fish 🐟

evolved to → Apes (somehow)

developed (over time) → Apes started to straighten up - hairy still

years pass → Apes became more evolved walking on two legs - losing hair — things evolve according to their environment — could be true

years pass → eventually no hair and they were were walking just as humans do

years pass → Humans

x Rel
• Not a religious person
• open to the idea of the Big Bang Theory too.

TBB

• Don't know much about evolution.
• Have heard different stories about it ie) Fish.
• Could be interesting to learn about the actual concept of evolution.

Figure 1. Pre concept map by learner 17 group 2

That the elephant evolved from the Mamoth

Human evolved from monkey.

The fact that People are not willing to understand it is they have a religious block and will not let it in or learn about. That annoys me.

People need to know more about it inorder to understand it.

I find the topic interesting. I believe it is true. There are facts to Prove it.

Evolution!

how animals today hold similar features yet may look different!

over time certain animal evolved/changed. Adapting to their environment that also was changing

Facts of skeleton bones of certain animals, how they differ to the ones today.

Figure 2. Pre concept map by learner 40 group 5

EVOLUTION

- adaptation of a species through different "time periods" due to the changeing of circumstances, ie environment, around them.

- affects everything in our world, biotic and abiotic factors.

- Evolution often takes place in order to ensure the survival of something

- Evolution takes place in stages, and often takes alot of time

- Evolution occurs mostly for the betterment of something, but can have negatives.

- Evolution can be used in many contexts, ie human, life, as well as with a specific trend

- My opinions *Humans evolved, rather than the theory of creation.

  *Evolution is a scientific logical theory to how humans came about in our world

- Everybody has a right to their own beliefs, be it evolution, creation or both

- Evolution one of the theories, regarding the existence of humans.

①

Figure 3. Pre concept map by learner 8 group 2

EVOLUTION

↓

Scientific theory
of human development

↓

controversial [very]

↓ (Science) ↓ (religion)

Science

first humans
were monkeys
(apes)

same
intellect and
skulls as humans

ape skulls (possible
ancestors)
found

cave men

modern humans

religion

God created man
[Genesis]

Apes and humans
are different creatures

My Opinion

* I strongly believe that God
created everything and the
Bible is His word so it
wouldn't lie about what happened
in the beginning of time.

* Scientists are just trying
to prove a point that God
doesn't exist

* Scientists are trying to
make us believe their
theory of the Big Bang
which is all just nonsense
and rubbish

* Science just trying to
blind us

* Scientists trying to
appear wiser than God.
But God is the greatest
power and made us in
His own image

Book of
* John ...chapter 1

* All animals and
plants were separately
made.

Figure 4. Pre concept map done by learner42 group 5

EVOLUTION
?

evolving of animals or plants for better survival and assurance of future generations

Cradle of Humankind

Mrs Ples Taung child

Theories

creation – God created everything the world, universe, animals and plant

dinosaurs (extinct from 65 million years ago)

Fossils

nitrogen – argon method

carbon-dating if you don't use it, it will 'disappear'

Lamarck

Darwin

'survival of the fittest'

natural selection

Giraffes

Short neck developed into longer ones over time because they needed to get to the higher leaves to survive / human appendix shrinked overtime, because 'modern' humans diet is different from our forefathers e.g omomen

we all came from a common ancestor

Darwin's finches

species have intra-specific competition and there is a battle for survival, if there is no food than the strongest the strongest will survive the ones will be able to adapt and give birth to future offspring who will inherit the good characteristics and there will totally will be a new species. e.g moth in London during the industrial revolution became a new species.
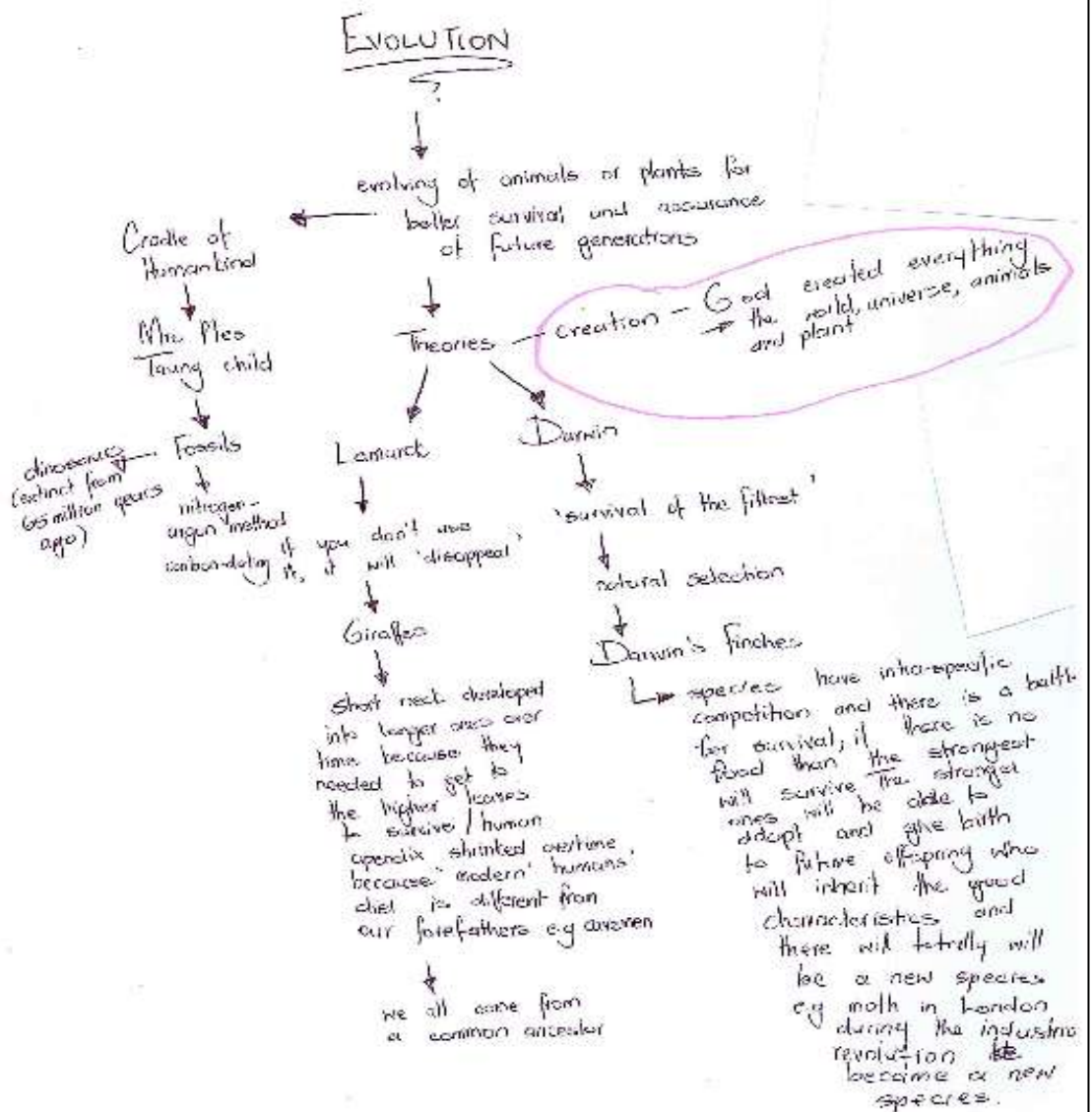
Figure 4. Post concept map done by learner42 group 5

Evolution is the theory that, over millions of years, organisms change their form to better suit their environment. This process occurs due to different environmental factors that best suit certain individuals in a population. These individuals breed well while others, less suited to their environment, die out. Due to this breeding well adapted traits form a large part of the population meaning most individuals of the population possess this well adapted traits. This process, over a long period of time, changes the over all attidude of a species.

I think that evolution is the most plausable theory as, unlike religion, which is based on myth and word of mouth, it is based on scientific research. I do not think that, however, that it is a foolproof.

②

Figure 5. Post concept map of learner 1 group

Evolution is ~~the~~ the theory that organisms have come from a common ancestor and have changed and variate according to their specific living conditions to form the wide variety of organisms that are in the world today. Variation in organisms occurs when there is either a physical or genetic change, which could either lead to the downfall (or even extinction of a spieces or give if a major advantage to enable it to survive and compete better for food ~~its~~ and resources in its environments. Changes however do not occur rapidly, ~~or~~ (like over a few years but in fact take generations of the spiees ~~~~ and lots of years to completely show. ~~Characteristics~~ Gradual change will lead to a completely different spieces (genetic and physical) and ~~will lead~~ can lead to a completely ~~so~~ new organism.
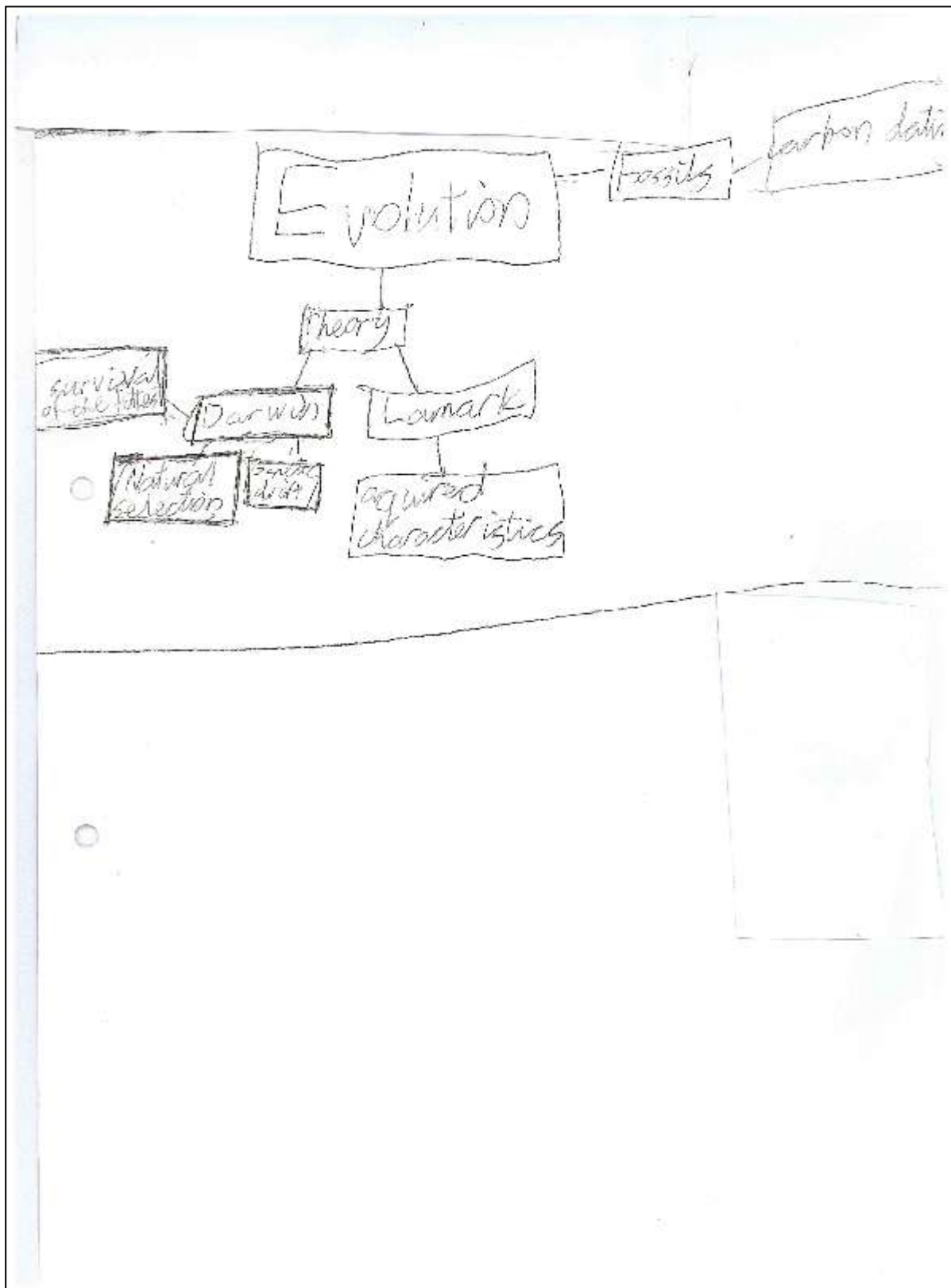
(All True)

Figure 6.Post concept map of learner 3 group 1

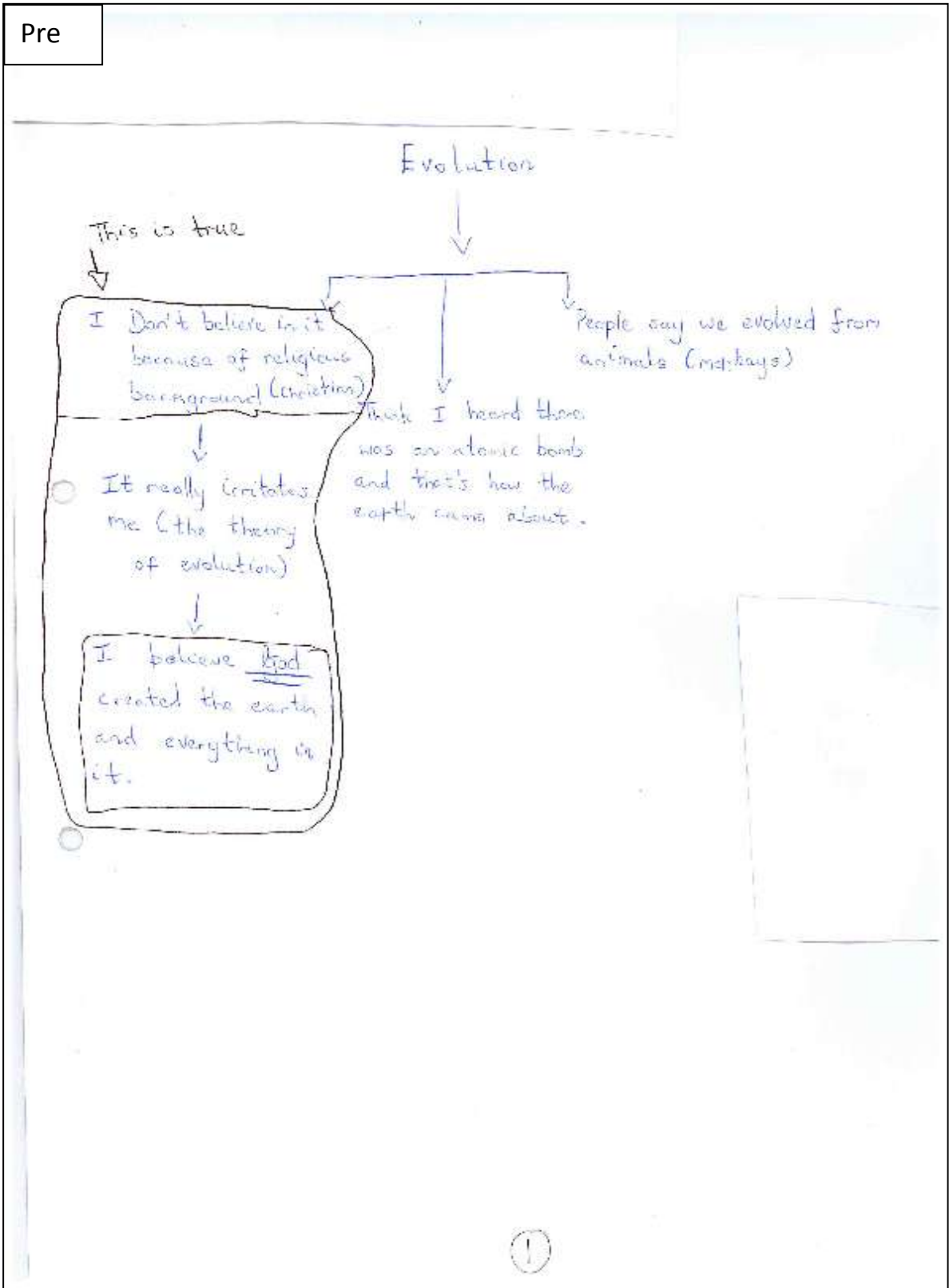Figure 7 Post concept map of learner 32 group 4

Pre

Evolution

This is true

I Don't believe in it because of religious background (christian)

People say we evolved from animals (monkeys)

Think I heard there was an atomic bomb and that's how the earth came about.

It really irritates me (the theory of evolution)

I believe God created the earth and everything in it.

Figure 8. Pre concept maps by learner 20 group 3

Post

Evolution

Lamarck's Theory
↓
Acquired characteristics
were inherited like
Blacksmith biceps.
↓
If you don't use
it, you'll lose it.

Darwin's Theory
↓
Individuals changed
over time to adapt
to their environment

Earth existed
from millions
of years ago
↓
I do not really
know whether to
believe this.
↓
(I believe God
created everything)

—Natural selection—individuals with best adaptation
survive in the population and eventually the population
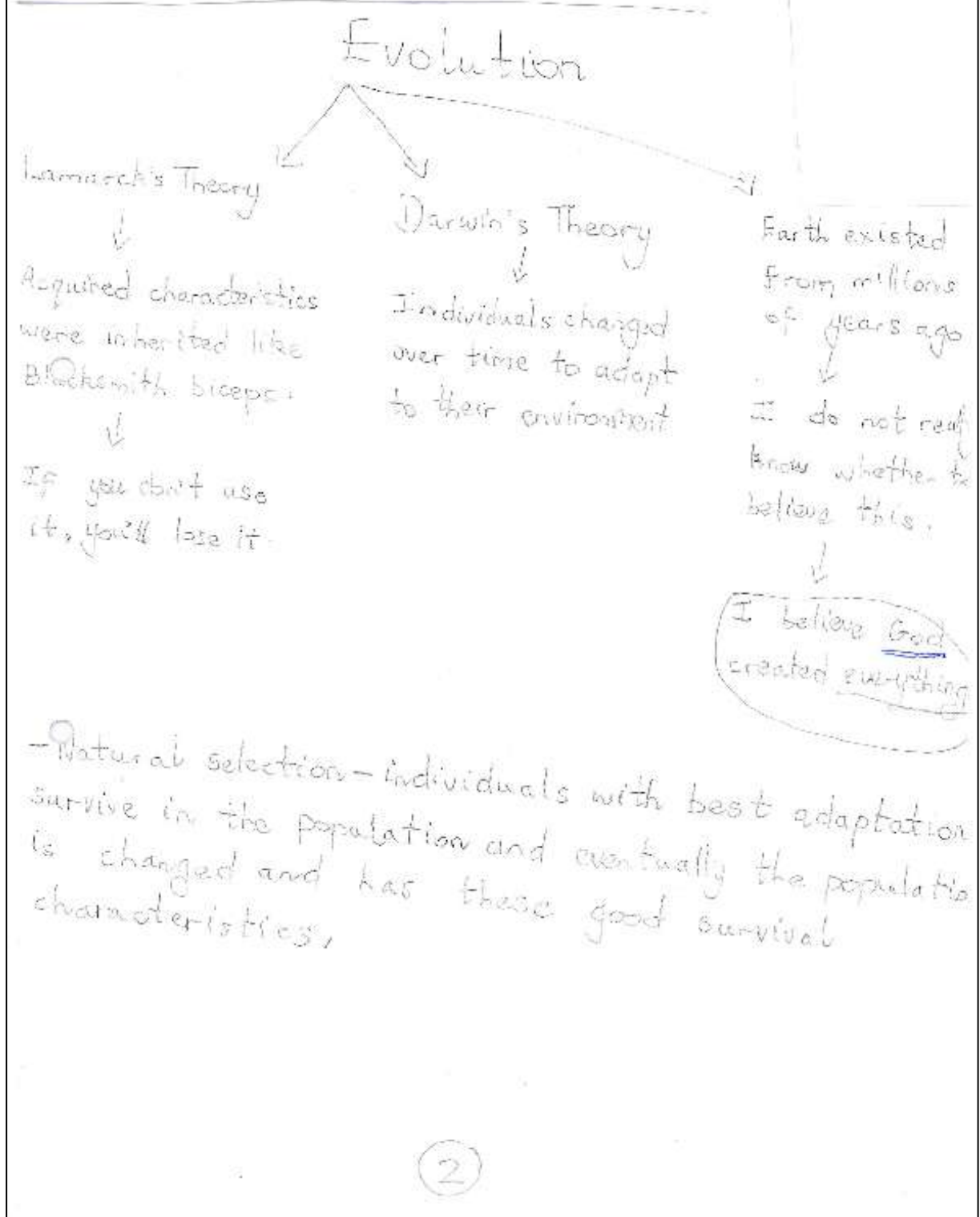is changed and has these good survival
characteristics,

②

Figure 8. Post concept maps by learner 20 group 3

EVOLUTION

- adaptation of a species through different "time periods" due to the changeing of circumstances, ie enviroment, around them.

- affects everything in our world, biotic and abiotic factors.

- Evolution often takes place in order to ensure the survival of something.

- Evolution takes place in stages, and often takes alot of time

- Evolution occurs mostly for the betterment of something, but can have negatives

- Evolution can be used in many contexts, ie human life, as well as with a specific trend.

- My opinions *Humans evolved, rather than the theory of creation.

*Evolution is a scientific, logical theory to how humans come about in our world

- Everybody has a right to their own beliefs, be it evolution, creation or both.

- Evolution one of the theories, regarding the existence of humans.

(1)

Figure 9. Pre concept map by learner 8 group 2

EVOLUTION

* There are 3 views when considering Evolution, Theistic, Secular & Special Creation, they vary from scientific to religion based theories.

* Evolution is just a theory based concept

* Scientists such as Lormark and Darwin etc. have provided information that partially support & support the theory of Evolution.

* Evolution is a very taboo topic.

* Everyone has a right to freedom of belief, hence no one can be judged on whether they believe in Evolution or Special Creation

* Evolution is a theory that described the origins of organisms, based on the fact that organisms adapt according to many different factors, eg enviroment.

* Evolution occurs in order to maintain the survival of a species.

* Origins or extinction depends on evolution.

②

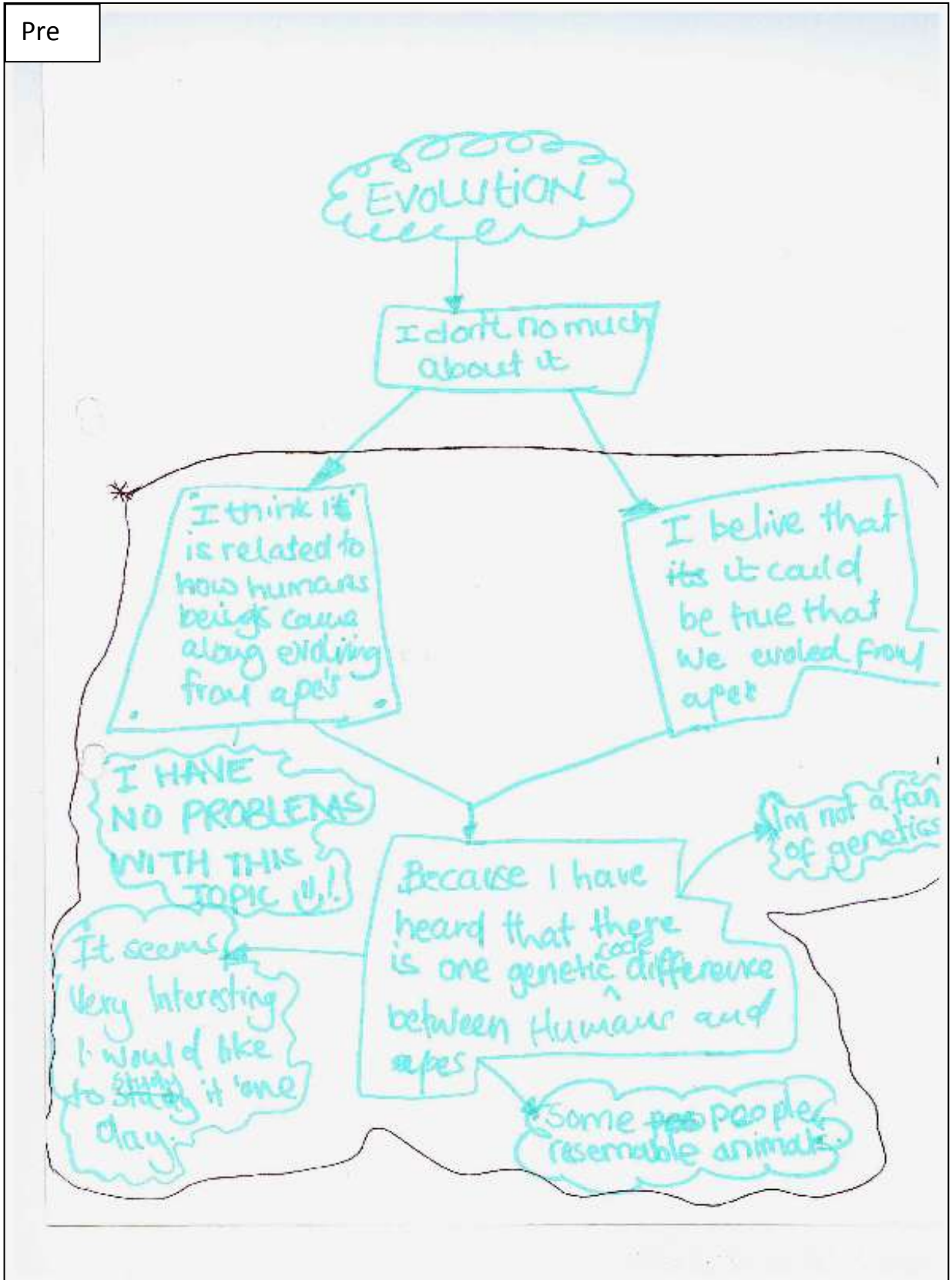Figure 9. Post concept map by learner 8 group 2

Figure 10. Pre concept map by learner 7 group 1

Evolution

- Are the changes that have occurred over the years, and years le generations (period of time).
- There are many things that contributed to evolution
- such - natural selection (survival of the fittest)
  - habitats
- The Landmarks theory :- which is if you didn't use something it would eventually die or become extinct and if you used something eg hand, it would eventually adapted to what it is been used for
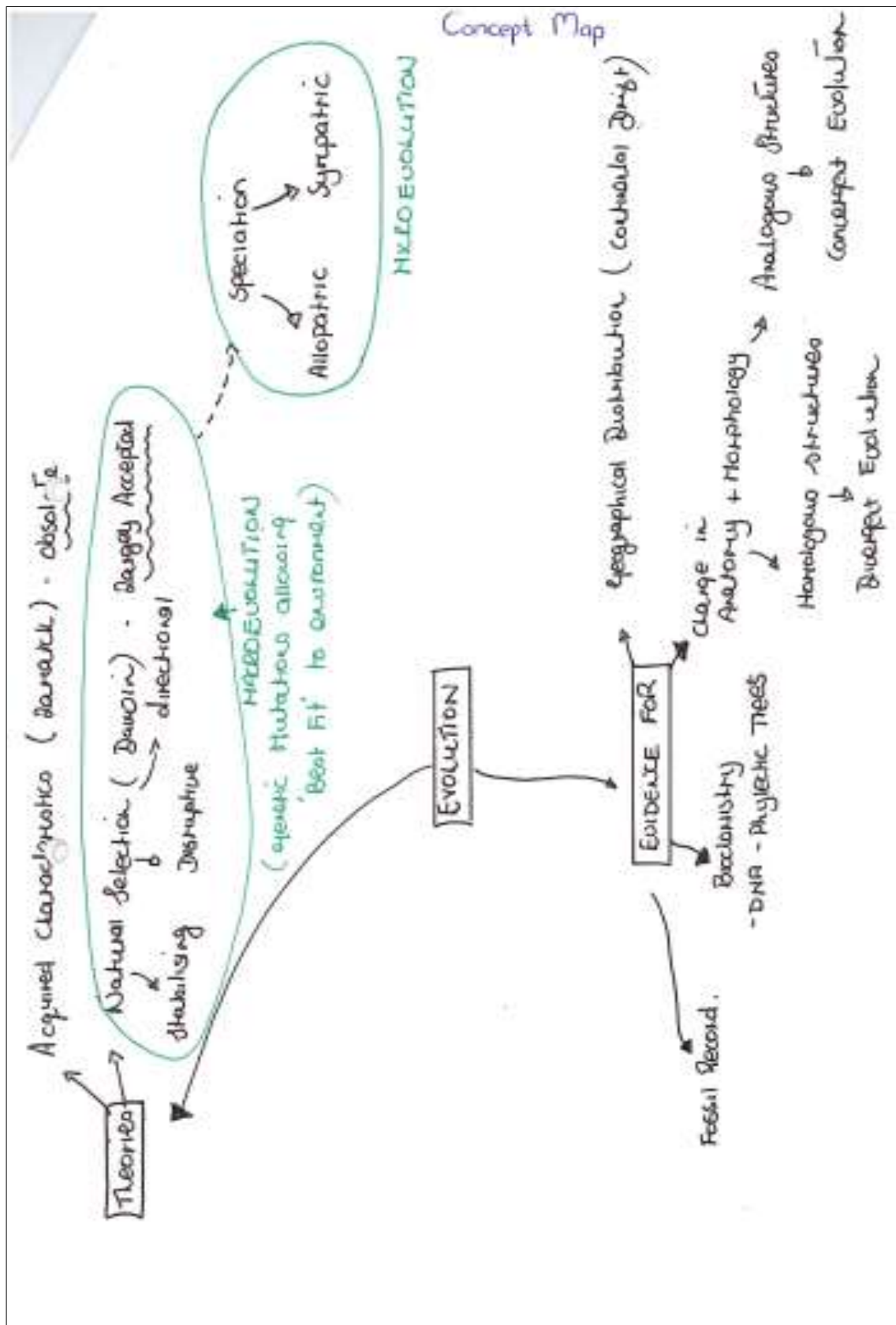- The Darwins theory :- process of natural selection. organisms adapt to certn environments.

Figure 10. Post concept map by learner 7 group 1

Figure11. Concept Map by Teacher B