EFFECTS OF A DIALOGICAL ARGUMENTATION INSTRUCTIONAL MODEL ON GRADE 10 LEARNERS' CONCEPTIONS OF LIGHTNING

A full thesis submitted in fulfilment of the requirement for the degree Masters in Science Education

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DECLARATION

I declare that this thesis, **"Effects of a dialogical argumentation instructional model on grade 10 learners' conceptions of lightning"** is my own work; that it has not been submitted before for any examinations or degree purposes, in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

NOLUTHANDO HLAZO

SIGNED: …………………………………. **DATE: SEPTEMBER, 2014**

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DEDICATION

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ABSTRACT

In many rural areas in South Africa lightning deaths are perceived to result from witchcraft. Many people are being killed and victimized in villages and farms as they were accused of witchcraft. In such communities people believe that lightning can be sent through the practice of witchcraft to kill an enemy (Mahapa, 2002). This study examined two groups from different schools (28 in each) of grade 10 learners' conceptual understanding of lightning using a Dialogical Argumentation Instructional Method (DAIM) as well as the traditional lecture method (TLM). Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT) formed the theoretical framework of the study.

The study employed a quasi-experimental design to determine the effect of DAIM on learners' conceptions of lightning. The experimental group was taught using DAIM while the control group was taught the same content using TLM. Data was collected using the Science Attitude Questionnaire (SAQ), Beliefs about Lightning Questionnaire (BALQ), Conceptions of Lightning Questionnaire (COLQ) and Science Achievement Test on Lightning (SATOL) which was used to determine learners' overall performance on the topic of electrostatics. The data was analysed using both qualitative and quantitative methods.

The findings of the study revealed that prior to the intervention (DAIM); the two groups of learners had both the scientific and the indigenous knowledge about lightning. A majority of the learners believed that lightning is caused by witches and traditional doctors. After being exposed to the DAIM most of the learners in the experimental group were found to have changed to the more scientific explanation of cause of lightning and protective measures against lightning. Few learners in the control were classified as possessing an equipollent worldview in terms of the CAT after the post tests. Some learners' conceptions about lightning wavered between the scientific and traditional worldviews.

The Science Attitude Questionnaire showed that both groups of learners had a positive attitude towards science. The findings also suggested that the inclusion of indigenous knowledge in science lessons promoted active participation from the learners, reinforced the learning of science because it promoted conceptual development and scientific literacy. The learners in the study also supported the

integration of the scientific and the traditional worldviews about lightning. After the instruction, the learners in both groups seemed to still hold indigenous beliefs in relation to lightning. The post-test results showed that the DAIM group seemed to have been able to link the concept of lightning with electrostatics when they related lightning storms to electric discharge. The experimental group was found to be more elaborate in their explanations of the scientific nature of lightning than the control group which was not exposed to DAIM.

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ABBREVIATIONS USED IN THE STUDY

BALQ	Beliefs about Lightning Questionnaire
CAPS	Curriculum and Assessment Policy Statement
CAT	Contiguity Argumentation Theory
COLQ	Conceptions of Lightning Questionnaire
DAIM	Dialogical Argumentation Instructional Model
DoE	Department of Education
DoBE	Department of Basic Education
IKS	Indigenous Knowledge Systems
LO	Learning Outcome
NCS	National Curriculum Statement
NSC	National Senior Certificate
NSLA	National Strategy for Learner Attainment
SATOL	Science Achievement Test on Lightning
SAWS	South African Weather Service
SIKSP	Science and Indigenous Knowledge Systems Project
SW	Science Worldview
TAP	Toulmin's Argumentation Pattern
WCED	Western Cape Education Department

OPERATIONAL DEFINITIONS

Dialogical argumentation- Dialogical argumentation involves one making a claim, and using evidence to logically back one's position. It also involves people proposing alternative views, challenging the claims made by others, and finally coming to a consensus through convincing evidence.

Language of Instruction - The language in which teaching and the learning materials is presented in the classroom.

Indigenous Knowledge Systems (IKS) – A system of thought peculiar to people of a local geographic location or socio-cultural environment (Ogunniyi, 2008: 6)

Conception – A mental idea or one's perception about the nature of a given subject matter.

Science/IKS curriculum – This term refers to an inclusive curriculum which emphasises the integration science and indigenous knowledge. An example of this is the new South African school science curriculum especially Outcome-based curriculum whose third aim calls on teachers to integrate IKS with school science school science.

Nature of Science (NOS) – This deals with the products (e.g. facts, concepts, laws and theories) and the processes or methods of scientific inquiry including the ethical conventions and all the explicit or implicit assumptions underpinning the epistemology of science (Ogunniyi, 2007a).

School science- The science that is taught and learnt at school using standard texts derived from European or Western science.

Lightning- A flash of electrical discharge often accompanied by thunder and rain.

KEY TERMS

Toulmin's argumentation pattern

Contiguity argumentation theory

Border Crossing

Socio-cultural Constructivism

Dialogical argumentation

Dialogical argumentation instructional model

Conceptual change

Indigenous beliefs

Quasi experimental design

Conceptions about lightning

Chapter 1

Introduction

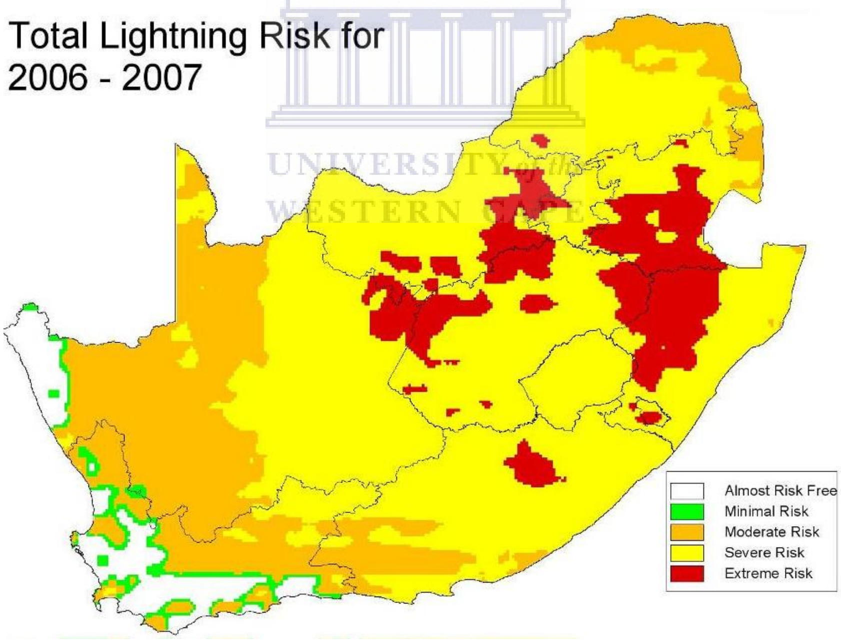
1.1 Introduction

Electricity is a physics concept that relates to one of the most feared natural phenomena namely lightning. Lightning is a concept on which learners have rival explanations from their cultural beliefs; it is a common natural phenomenon. Although lightning strikes are not common in the Western Cape, the learners involved in the study were originally from the Eastern Cape where lightning strikes are more frequent. The interest of this study was to find out the beliefs of the learners about lightning. When I shared this piece of writing with my mother, I was shocked by her response, she revealed to me for the first time that my late twin brothers died from lightning. They were both struck by lightning and they died instantly while I was still a toddler. The realization that lightning was the cause of the death of my late brothers further strengthened my interest in this phenomenon in a significant and personal way. It is therefore of great interest me to find out the beliefs of the learners about lightning.

There are about 2000 people around the world that die each year as a direct result of lightning and according to Geerts and Linacre (1999), this is a global annual average of approximately 0.4 deaths per million of the population. In South Africa, an average of 6.3 per million of the population have been confirmed to have lightning related deaths (Blumenthal, 2005). That means South Africa has an average that is 15 times more than the global average. Blumenthal (2005) reckons this is as an under-report of the number of lightning death victims, as the pathology of lightning damage to the human body is still poorly understood in most rural areas of the country. The South African economic sector also suffers a great deal as a result of lightning strikes. Besides loss of life, lightning causes an extensive financial loss each year. According to Evert and Schulze (2005), insurance companies lose more than R500 million per year as a result of claims due to loss of electronic equipment or from fires initiated by lightning strikes.

In the United States of America, the number of lightning-related deaths over the last century has decreased. This is due to the urbanisation that has happened (Lopez and Holle, 1998). In South Africa, that has not been the case, even though rapid urbanization took place in the last few decades, many people still inhabit the rural areas or in poorly constructed dwellings in the urban areas. There is still poor education about lightning safety as people living in rural areas are still ignorant of how to protect themselves during lightning storms. Hence the country is still experiencing a high death rate from lightning while attributing the deaths to witches who send lightning to others. The above mentioned reasons and the fact that South Africa is a lightning-prone country (Evert and Schulze, 2005), are the primary reasons for the elevated lightning-related death rates.

For many years, attempts have been made to gauge the distribution of lightning and its associated risk factors all over South Africa (Malan, 1963; Anderson, van Niekerk, Kroninger, and Meal, 1984; Proctor, 1993)as could been seen in Fig 1.1.



In the early 1990s, South Africa's major power utility, ESKOM, operated a network of Lightning Position and Tracking System (LPATS)and lightning detection sensors (Evert and Schulze, 2005), but the network has since become disused. Preceding this, the Council for Scientific and Industrial Research (CSIR) operated a network of lightning flash counters across the country (Proctor, 1993). Recent research into rainfall trends in South Africa (Kruger, 2006) indicates that in parts of the country with mostly summer rainfall, the rainfall measures are becoming more intense producing excessive rainfall values. These high rainfalls are mostly associated with lightning. It can be concluded therefore that there is a need for the South African Weather Service (SAWS) to issue lightning warnings, forecasts and services for the protection of life and property, in fulfilment of its legal mandate.

This study looked at the role of using indigenous knowledge and argumentation in learning school science and how learners deal with the possible conflicts that occur during the learning process. The focal point was on the beliefs and conceptions that learners have about lightning. Dialogical argumentation was chosen as an instructional method for the study as it gives learners the chance to freely share their views (Ogunniyi & Hewson, 2008).

The study adopted the Dialogical Argumentation Instructional Model (DAIM) developed by the Science and Indigenous Knowledge Project (SIKSP) located in a South African University (Ogunniyi, 2007a & B). The thrust of DAIM is to create a discursive classroom environment where teachers and learners argue, discuss, dialogue and learn together with the ultimate aim of reaching consensus on various issues at stake. DAIM has been found in earlier studies to enhance learners' conceptual understanding, awareness about certain subject matters, participation in class and to show increased interest in the topic being discussed (Diwu & Ogunniyi, 2012; Ogunniyi, 2007a & b; Hlazo, Ogunniyi & Langenhoven, 2012; Angaama 2013).

In a DAIM-driven classroom, argumentation takes place at the individual, small-group and large-group settings or what Ogunniyi (2007a, 2011) calls intra-, inter- and trans-argumentation. In such a lesson, learners are given ample opportunities to argue, make claims/counter claims supported with evidence to maintain their stances or even pose rebuttals to nullify such claims/counterclaims. In this regard, the teacher's role is that of a facilitator rather than serving as a purveyor of knowledge. At the end of the lesson, the class comes up with a conclusion about the topic under consideration e.g. lightning. In the process learners are able to express their views freely without feeling intimidated, externalize their thoughts, clear their doubts and even change their minds if deemed necessary and consequently their critical thinking becomes challenged and developed (Erduran, Simon & Osborne, 2004; Ogunniyi, 2004,2000a & b; Simon & Johnson, 2008).

1.2 Rationale

The reasons why lightning was chosen as a focus for this study are:

- Static electricity and to a large extent current electricity forms a major component of the physical science curriculum in the FET phase.
- Learner performance in the electricity section of the NSC examinations has not been encouraging. Table 1 below shows the Western Cape's grade 12 results from 2003 to 2009.

Table 1.1: Western Cape Grade 12 Results 2003-2009

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Pass percentage	73.3%	70.7%	68.3%	66.5%	65.2%	62.7%	60.6%

(Adapted from WCED website 2010)

The drop in the pass rate continues a trend that confirms that there is a deep crisis in South African education especially in Physical Sciences.

Table 2 shows, the number of learners who passed Physical Sciences in the Western Cape dropped drastically from 71% to 52%.

Table 1.2: Western Cape Physical Sciences Grade 12 Results 2008 – 2009

Year	**2008**	**2009**
Number wrote	13 611	13 349
Number passed	9 690	7 064
Pass Percentage	71.2%	52.92%

Source: WCED 2010

The poor performance in the NSC examinations as indicated in the tables above has been a concern to the government and this has forced it to come out with remedial measures to rescue the situation. In this regard large sums of money have been budgeted for science as a means of providing solutions to science education in the country and to also promote the quality of education in South Africa.

The other remedial measure was the identification of poorly performing schools to be made Maths and Science focus schools. These schools receive additional support in order for them to produce quality results (Christie, 2008). Even though all these attempts have been made to improve the situation, nothing has changed; the examination results kept on dropping each year.

Teachers tend to focus too much on the content prescribed by the Department of Education forgetting that science is a human explanation of nature (Ogunniyi, 2007). Nature is around us; therefore science is everywhere and not just confined to textbooks or the classrooms. Learners are often regarded as “empty bowls” waiting to be filled up by teachers who are transmitters of knowledge (Lew, 2001). Learners come into science classrooms with prior knowledge upon which they will build new knowledge (Bybee and Fuchs, 2006).

Social constructivist theory posits that learners learn concepts or construct meanings through their interactions with things around them. Therefore, teaching approaches that do not give learners a platform to connect what they learn in the classroom to their prior knowledge result in learning by rote than with deeper understanding of what may be involved. It is therefore crucial to include in lessons; related events in their community, society, or the world around them via extended activities. When learners come into a science classroom, they have existing ideas about diverse natural phenomena. Learning involves construction of knowledge through experience. Science can therefore be taught more effectively if learners’ prior knowledge is taken into consideration. According to Kilpatrick (cited by Rossow and Smith, 1999), learners acquire knowledge when they can incorporate new experiences into existing mental structures. When these structures are reorganised, they can be used by the learner to solve more problematic experiences.

Waldrip and Taylor (1999) took note of the realisation that, western explanation of natural phenomena could be very different from traditional explanation or indigenous ways of interpreting the same phenomena. As teachers, we always tend to enforce the school science view, we fail to recognise that learners' are developing two different sets of values. In order to enhance effective learning of science among our learners, it is imperative to incorporate western and indigenous knowledge. To a great extent, indigenous knowledge has scientific explanations that can enhance learning in science. Wasagu (1999) and Ivowi (1992) identified one of the major causes of poor performance in science as being the clash between learners' worldview and school science view as learners are struggling to incorporate the two.

The recognition of the existence and value of indigenous knowledge systems has been an important aspect of the curriculum developments that have taken place in education in South Africa. When the New Curriculum (commonly known as C2005) was introduced in Grade 10 – 12 in South African Schools in 2006, considerable emphasis was laid on developing learners' abilities as creative and critical thinkers. Statements of intended results of learning and teaching are called Learning Outcomes (DOE, 2002) and recently termed Specific Outcomes in the Curriculum and Assessment Policy Statement (CAPS) by the Department of Basic Education (DoBE, 2011). They describe knowledge, skills and values that learners must acquire. According to the National Curriculum Statement document (DOE, 2002) for Physical Sciences, for a learner to achieve a Learning Outcome; they need to demonstrate that they are able to combine theoretical knowledge and practical methods to respond to a particular problem or creative task. Learners must also demonstrate an understanding of the personal and social relevance of the particular work being done.

Of the three Learning Outcomes in Physical Sciences, Learning Outcome 2 is about knowing and applying science knowledge, yet despite the science claim made for indigenous knowledge systems, there is no indigenous knowledge systems included in the content/ syllabus prescribed for Learning Outcome 2, either in the national curriculum statement or in the syllabus depicting what is to be taught in the three FET grades of Physical Sciences. Learning Outcome 3 deals with the nature of science and its relationships to technology, society and the environment, where a learner should identify and critically evaluate scientific knowledge claims and the impact of the knowledge on the quality of socio economic and human development. Assessment Standard 1 of Learning Outcome 3 is about evaluation of knowledge claims; this involves the learner being able to discuss knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge. For learners to achieve this assessment standard they should for example be able to use scientific knowledge to explain the importance of some traditional practices. The teacher in the process is challenged with having to integrate IKS with science.

Underlying the study was the postulation that integrating two clearly different worldviews would result in cognitive conflict in the minds of the learners and therefore a well-developed instructional intervention could help revolutionize such a conflict. In the same streak, it was hoped that the intervention (dialogical-argumentation) would smoothen the progress of the process of border crossing between the perceptions of lightning that learners bring into school and what they learn in school science. Some scholars have argued that traditional worldviews are hindrances to the effective learning of science. They claim that learners, instead of accommodating the scientific conceptions, hold on to their traditional ideas. The study was aimed at improving learners' understanding of the two systems of thought (through dialogues) as well as help them develop critical thinking, which is an important endeavour for teaching science.Through using argumentation, it is hoped that the gap between science and indigenous knowledge would be bridged.

The study investigated the role of Indigenous Knowledge Systems (IKS) in teaching and learning science as well as how learners dealt with conflicts that might have occurred in the teaching and learning process. Focus of the study was on the beliefs that learners have about lightning. Dialogical argumentation was used as an intervention. The beliefs of the learners were integrated with the teaching and learning of electricity in order to promote conceptual understanding of electricity so as to gain insight of the scientific view of lightning.

1.2 Motivation for the study

South Africa is a multicultural country. Culture encompasses the knowledge, belief, art, morals, laws, customs and habit acquired by the people and society (Jegede and Okebukola, 1991). Learners' worldview is constituted from indigenous knowledge drawn from their traditional and cultural beliefs and superstitions of society. Science on the other hand drives people to seek sensible answers to many mystifying natural phenomena through observation and experimentation.

A shift from learners' worldview to school view requires a cultural border crossing. Cultural border crossing presupposes that a lack of connection exists between learners' worldview and school view and that impinges directly on the learning of science. For science to make sense, the worldview of the learner must be taken into consideration. The cultural background of a learner has a greater effect on learning than does the subject content (Okebukola, 1995).

Science education is about helping learners develop essential valuable skills and attitudes, thinking in clear and logical ways and solving practical problems. All these processes, skills and attitudes are acquired through the medium of inquiry approach whereby learners are exposed to situations that stimulate their curiosity and interest to identify problems in their own environment and attempt to solve them.

Learning Outcome 1: Assessment Standard 3 in Physical Sciences requires learners to communicate information and present scientific arguments with clarity and precision. According to Erduran, Simon and Osborne (2004) the central part of the Nature of Science (NOS) is to construct a sound argument backed with practical evidence. The same view has been stressed by a number of scholars (Ogunniyi, 2007 a and b; Osborne, et al, 2004). In the same vein, Learning Outcome 2 is about construction and application of scientific knowledge where a learner is given opportunities to be able to state, explain, interpret and evaluate scientific knowledge and apply it in everyday contexts. Learning Outcome 3: Assessment Standard 3 expects learners to evaluate knowledge claims by discussing the knowledge claims and indicating the link between indigenous knowledge systems and scientific knowledge (DOE 2004:8). The issue of applying scientific knowledge to learners' everyday context is a recognition of the importance of relating school science to the life worlds of learners. Learning Outcome 3 is perhaps the closest to the central focus of this study i.e. it is relating school science to learners' beliefs, values and ethos. Teachers are therefore required to integrate science with learner's Indigenous Knowledge System (IKS). However, the document does not specify how this outcome is to be achieved; as a result most teachers are still using old methods of teaching.

There is a consensus in literature (Erduran, et al, 2004; Ogunniyi, 2007) that, by engaging in argumentation, learners will enhance their ability to think and argue about issues related to science and consequently improve their understanding of scientific concepts as well as to relate what they have learnt to their daily endeavours. Underlying the study was the postulation that integrating two clearly different worldviews would result in cognitive conflict in the minds of the learners and therefore a well-developed instructional intervention could help revolutionize such a conflict. Hence, it was hoped that the intervention (DAIM) would ameliorate the border crossing process between the perceptions of lightning that learners bring into school and what they learn in school science. Some scholars have argued that traditional worldviews are viewed as possible hindrances to the effective learning of science. They claim that, instead of accommodating the scientific conceptions learners hold on to their traditional ideas. The study hope to improve learners' understanding of the two systems of thought (through dialogues) as well as help them develop critical thinking, which is an important endeavour in teaching science.

Even after the conceptualisation and implementation of the New Curriculum, Grade 12 results in Physical Sciences have continued to show a downward trend. Of the 13 611 candidates who wrote Physical Sciences in the Western Cape in 2008 only 9 690 passed. In 2009, there was also a drop in the number of learners who sat for the exams, 7 064 out of the 13 349 who wrote the examination passed with very poor marks. Just in two years, there was an 18.2% drop in the results. Consequently, few learners enrolled in science fields in institutions of higher learning mainly because they did not meet the entry requirements. It is against this backdrop that this study is situated. The driving force behind this study was to look at the conflict and possible resolution to the infusion of science and IKS. When learners have to absorb modern school science at the same time holding on to their traditional knowledge, conflicts may arise therefore holding back their understanding of the topic. Concordant with the above, lightning was chosen with the understanding that static electricity is the foundation of the study of electricity and that learners hold multiple beliefs about lightning and electricity.

The study was conducted in township schools on the outskirts of Cape Town. The teacher – learner ratio was 1:35 per class. Consequently, the learners do not get that one on one teacher attention. There is only one laboratory for science for all the learners. Because of poor results in science, programs such as the National Strategy for Learner Attainment (NSLA) and the Dinaledi program were organized by the Western Cape Education Department and the Department of Basic Education for underachieving schools in mathematics and physical science.

The learners at both schools were English Second language learners. The language of instruction was English, and all the textbooks were in English as well. Learning through the use of a second language is a barrier to many learners because they tend to experience difficulties comprehending and conceptualizing what is taught in the classrooms. Admission into higher education in South Africa is based mainly on learners' Grade 12 results. A poor performance in science leads to learners' not meeting the entry requirements of most science faculties. Despite decades of educational reform in our schools, current statistics (WCED, 2010) indicate that not every learner is being adequately prepared for their future (Makgatho and Mji, 2006).

The recurring poor performance in science therefore calls for a concerted effort in measures that will help improve the status quo. The curriculum change in the education system was redefined by transforming the desired teaching strategies into practical classroom practices (Herrenkohl and Guerra, 1998; Stoffels, 2005). The National Curriculum Statement emphasizes the development of critical thinking skills through learner-centered teaching methods that promote high learner participation (Department of Education, 2003), but still many teachers are unsure about what this requires of them (Sanders and Kasalu, 2004; Khoali and Sanders, 2006). The curriculum also expects integration of Indigenous Knowledge System with school science. Teachers have not been adequately trained on how to integrate school science with Indigenous Knowledge System and this poses a challenge for teachers as they have been taught and trained to accept the scientific view as the only rational form of knowledge (Liphoto, 2008). Teachers are also facing a dilemma in implementing these new strategies because the syllabus is still content ridden and exam orientated.

1.3 Statement of the problem

Traditional worldview and scientific worldview are often incompatible and irreconcilable; therefore uniting the two worldviews tends to be a challenge for teachers as they have been taught and trained to religiously accept the scientific worldview (Jegede and Okebukola, 1991). They also asserted that, teachers were neither consulted nor involved in the whole process of the new curriculum until the implementation stage. They were never trained on how to integrate school science with indigenous knowledge when they teach, and that is one of the shortfalls on the implementation of the new curriculum. The suggested instructional strategies depicted in Curriculum 2005, such as the use of discussion, reflective practice, process skills stand in sharp contrast to the old examination oriented curriculum, which teachers were used to and were well trained in.

The driving force behind this study was to unpack the conflict and possible resolution to the infusion of science and IKS. As learners have to engage in modern school science at the same time holding on to their traditional values

1.4 Purpose of the study

The purpose of this study is to investigate the effect of dialogical argumentation instruction on Grade 10 learners' understanding of lightning. More specifically, the study sought to determine:

1) The effect of a dialogical argumentation instructional strategy on learners' understanding of lightning in terms of the characteristics and the effects of the phenomenon.
2) The nature of the conceptual change demonstrated by the learners as they performed the various tasks set up for them on lightning.

Furthermore, this study explores how the learners shifted from one level of understanding of lightning to another as a result of a dialogical argumentation instruction.

Hence the study attempted to answer the following questions:

1. What scientific and personal views do grade 10 learners hold about lightning?
2. How effective is a dialogical argumentation instructional model (DAIM) in enhancing the learners' understanding of lightning?
3. What cognitive shifts are noticeable between the learners' pre-test and post-test conceptions of lightning?

Learners' beliefs about lightning were integrated into the lesson on electricity. This was done with the intent to enable them gain a better understanding of the concept of lightning. Learners were also exposed to different ways to protect themselves against lightning strikes. In their communities, the learners were exposed to instances where people were accused of sending lightning to kill other people. This may be an indication that lightning was not perceived as a natural phenomenon and there was no connection made between lightning and the concept of electricity. The integration of learners' beliefs on lightning in this study was aimed at promoting their conceptual understanding of electricity so as to help learners make informed choices with regards to issues involving lightning.

1.6 Significance of the study

Learners come to a Science classroom with some conceptions about natural phenomena that are not scientific. This is mainly due to the learners mind full of traditional beliefs and social and cultural practices. The conflicts between the two views impede the meaningful learning of Science if it is not addressed in a Science classroom.

This research seeks for the scientific and the personal views that grade 10 learners hold about lightning and for a way of resolving these conflicting views about lightning and electricity. The findings of the study would also help us to understand how Dialogical Argumentation Instructional Method (DAIM) enhances the learners' understanding of lightning when integrated with the Indigenous Knowledge Systems.

As the new curriculum seeks to infuse Indigenous Knowledge Systems in Science Education, the study hoped to bridge the gap between Indigenous Knowledge and modern science. It was therefore our belief that by using argumentation, learners will have a better understanding of scientific concepts from their own views and therefore hopefully it would have an impact on their performance, improving the status of science in the school.

1.7 Thesis outline

In the introductory chapter, I have attempted to present the rationale of the study which looked at how the study was chosen and the rationale behind the topic of lightning and argumentation. That was followed by the motivation for the study, statement of the problem which discusses the issues recounting on the implementation of indigenous knowledge into science curriculum in schools. The purpose of the study critically examined the research questions of the study and lastly the significance of this study in science education was provided.

In Chapter 2 related literature on lightning as a natural phenomenon was reviewed. The chapter also looked at how learners tackle the conflicting conceptions of lightning explained from their worldviews as against school science. A discussion of how learners handle the conflicting views between the two world views (border crossing) and how argumentation had an effect on that. The theoretical underpinning to the study was also discussed here. The literature reviewed was also used in the discussion of the findings in chapter 4.

The next chapter focuses on the research methods employed to pilot the study, the research design used and the selection of the sample and population used in the study. Qualitative and quantitative methods were used as tools to gather data as to find answers to the questions. Lightning as a natural electrostatic phenomenon was the context in exploring the research questions. This study aimed at investigating learners' beliefs on lightning so as to integrate their beliefs when teaching electricity. It is also elaborated in this chapter how data was collected, interpreted and analysed using both qualitative and quantitative methods.

Description of what transpired during the argumentation lessons and learners' views and how they compare to the literature on lightning is also elaborated here. Lastly, ethical considerations undertaken in the study are presented.

In chapter 4 the interpretation of results and comparison of learners' pre and post views after being exposed to argumentation as an instructional method is presented. The findings of the data were also discussed in this chapter. The focus on chapter 5 is on the conclusions made from the discussion of the findings, implications of the findings of the study to other people and also recommendations to other research.

1.8 Conclusion

In many rural areas in South Africa lightning deaths are normally associated with the practice of witchcraft. According to research that has been done on lightning (Mahapa, 2002) a large number of people have been killed or persecuted especially in the villages as they were accused of practising witchcraft. It is generally believed that people can send lightning to strike others. In the area where I come from in the Eastern Cape most people believe that one person can cause lightning to strike another if they have had a fight with them or simply because of jealousy.

Most of the learners involved in the study came from the Eastern Cape Province in South Africa and therefore do not perceive lightning as purely a natural phenomenon. They do not seem to know the link between lightning and electrostatics hence the need for them to be made aware of the scientific concept of electrostatics. It is hoped that this study will contribute to efforts directed at improving learners' scientific understanding of lightning which ultimately could have a positive ripple effect within their larger indigenous communities.

Chapter 2

Literature Review

2. Introduction

As previously mentioned in the last chapter, this chapter looked at the related literature on lightning as a natural phenomenon. It also looked at how learners tackle the conflicting conceptions of lightning explained from their worldviews as against school science. A discussion of how learners handle the conflicting views between the two world views (border crossing) and how an argumentation can have an effect on that. The theoretical underpinnings to the study are also discussed. This reviewed literature will be used in the discussion of the findings in chapter 4.

2.1 Lightning

Lightning, as noted by Holle (1999), is possibly the most dangerous natural hazard due to its unpredictability and frequency of strikes. South Africa has one of the highest lightning ground strike densities in the world. Deaths related to lightning in South Africa are about four times higher than the global average (Blumenthal, 2005). Figures from the South African Weather Service (SAWS) also show that 28 people died after being struck by lightning between January and November 2010. This was more than double the 12 killed in 2009, while nine died in 2008. The highest number of lightning deaths was in 1999 where 32 deaths were reported (Blumenthal, 2005). In 2004, 31 people died and 2005 was the hardest hit year with a record of 44 deaths reported. There are different views about how lightning is formed or what causes lightning; some areas have been badly affected as these areas are prone to lightning strikes.

There are frequently published articles on our newspapers about stories on lightning and below is an extract from one newspaper:

> Seven people in adjacent houses were killed in a lightning strike in Eshowe, in KwaZulu-Natal, on Sunday. Police said the victims - among them were four children, including two toddlers - they burned beyond recognition.
>
> In the neighbouring Eastern Cape, four people were killed and 20 injured when lightning struck a family gathering on New Year's Day. Four more died, also in Eastern Cape, when a commemorative ceremony was hit on the same afternoon.
>
> The incidents were the latest in a series that has included the incineration of a marquee during a party in Ntuthuko village, KwaZulu-Natal, in November.
>
> Severely burnt bodies were still stuck to their plastic chairs when emergency services arrived at the scene. Seven people died, and more than 60 were injured.
> Dube, who is the KwaZulu-Natal executive for co-operative governance and traditional affairs, claimed deaths from lightning were a "growing phenomenon" in rural areas.
>
> "We will carry out an investigation with a view of trying to identify the causes of the recent upsurge of fatal lightning incidents in the province," she was quoted as saying in the Sowetan newspaper.
>
> "We will talk to the department of science and technology on what is the cause of the lightning. (The Harold Newspaper, 5 January 2011, p.10)

The above article shows how extremely dangerous lightning is. It is also evident that people do not know much about lightning and what causes it. It is not only the ordinary people but also people who hold high positions in the government that are ignorant about what causes lightning.

Witchcraft is one of the hideous socially unacceptable traditional practices in the Xhosa society. Witchcraft is practiced by people called amagqwirha who are believed to have contact with malicious powers and can take the form of causing misfortune and death through poisoning, directing lightning, and the use of familiars such as the lightning bird impundulu. A female witch (*igqwirha*) reputedly inherits this dreaded familiar, such as the lightning bird from her mother (Hirst, 1990).

If a person is caught or suspected of witchcraft, that person is cogently removed from the village or publicly humiliated or killed. If one evokes lightning to kill or destroy other people's properties he or she is regarded as a witch. Whether there is any amorous subjective evidence to suggest that a witch can manipulate lightning, as it is the case in most cultures and is believed that such tales subsist.

The concept of lightning is at conflict with school science. The above is just a fraction of knowledge that learners bring to school, which some researchers have argued that it should be replaced by school science. This study therefore bores into the differences between the traditional and the scientific views of lightning.

2.2 Scientific explanation of lightning:

According to the South African Weather Services, this is how lightning is formed:

When storm clouds gather, the wild air turbulence inside them causes a separation of electrical charges. Usually negative charges accumulate in the lower part of the cloud, while positive charges build up in the earth and in the upper part of the cloud. As air is a poor conductor of electricity, the resistance in the air is often overtaken by the attraction of charges resulting in lightning (Hyndman and Hyndman, 2009). Lightning happens when these opposite charges become strong enough to bridge the gap separating them. The most frequent lightning flashes occur within the atmosphere in the form of cloud-to-cloud flashes but the most destructive are the cloud-to-ground flashes. It has been said that the average flash has enough energy to keep a 100 Watts light bulb lit for three months. The flash of light heats the air around it to nearly 28 000°C, which is hotter than the surface of the sun. This scorching heat forces the air to expand in an explosion of thunder (Blumenthal, 2005).

2.3 Traditional View Lightning:

All cultures have their deep-seated, fixed, fast belief systems surrounding lightning. Mahapa (2002) has noted that in many rural areas in South Africa lightning deaths were perceived as a result of witchcraft. The greatest number of lightning casualties occurs in the open rural areas (former Transkei). Many people are being killed and victimized in villages and farms as they are accused of witchcraft. In such communities people believe that lightning can be sent through the practice of witchcraft to kill an enemy. Even though rapid urbanization took place in the country in the last few decades, many people still live in the rural areas or in poorly constructed dwellings in the urban areas. All the above, together with poor education about lightning safety and the fact that South Africa is a lightning-prone country (Evert and Schulze, 2005), are the primary reasons for the elevated lightning-related death rate.

According to the Xhosa people, the lightning bird known as impundulu is about the size of a man, white or black in colour with a large hooked beak, long legs and red feet. Impundulu is frequently employed by witches as it cannot resist a woman and is easily influenced by their cunning tricks. The power of the impundulu is immense. It flaps its wings and thunder roars, it spits and forked lightning flashes. Where impundulu strikes, the ground is burnt and here it lays its eggs. These eggs are about the size of a hen's once laid, the egg sets about tunneling through the ground to the nearest stream or river where it lies in the water. There it swells until it bursts and releases a new, full-grown impundulu. Sometimes the bird likes to show off to the ladies and it dresses in a red and black suit and mingles with beer drinkers. But it is soon discovered as it cannot drink beer. Then it quickly vanishes.

Maselwa's (2004) study on lightning shows that cultural beliefs about lightning held by communities in Limpopo is that; children should not play with electrical appliances when there's a lightning storm; they should not drink water, eat pap with milk (umphokoqo), eat eggs (as these perishables are white in colour and lightning does not go with white), they are not allowed to play outside, wear red clothes, talk to each other or sit next to each other, sleep and lastly they are told to cover mirrors, no shiny objects must be handled, a motor car tyre should be placed on the roof and they should never stand under a tree and never throw soapy water through the door. The Xhosas resort to being doctored with protective medicines and charms (*ukuqinisa* which means to strengthen or protect) when they believe that they have been bewitched (Hirst, 1990)

This study attempts to establish the indigenous beliefs of lightning held by the learners that I teach and which beliefs they hold fast so as to answer the first research question of this study.

2.4 Lightning in the school curriculum:

In schools, the topic "lightning" is introduced as static electricity. The chapter dealing with static electricity includes concepts like protons and electrons. The learners have to be able to differentiate between these charges as being positive and negative and how like charges repel and unlike charges attract each other, what are insulators and conductors of electricity as well as electrostatic induction. They are also expected to be able to explain how a cloud charges and discharges itself and that is resembled to how lightning is scientifically formed. Learners are also expected to carry out and observe some experiments based on the above.

As part of one of the learning outcomes in the science syllabus, learners are also required to come up with their own experiences of the phenomenon of static electricity. The scientific views on lightning that are taught in school are very different from the traditional views and are at discord with each other and might cause confusion and clash on learners' minds and most teachers are struggling to bring synchronization between the two views.

Despite the rich history of lightning research in the country and the multi-disciplinary active research that is taking place, people and animals are still being injured and killed by lightning. It is important that myths related to lightning activity do not hamper attempts to ensure better safety. For this reason, it is essential that the traditional view of lightning is well understood by the scientific community and that this knowledge is used to bridge the gap between the traditional and the scientific views.

The driving force behind this study was the conflict and possible resolution to the infusion of science and IKS. When learners have to absorb modern school science, while at the same time holding on to their traditional views, conflicts may arise which can hold back their understanding on the topic. In consonant with the above, lightning is chosen with the understanding that static electricity is the foundation of the study of electricity and that learners hold multiple beliefs about lightning and electricity. Therefore, this study's main objective is to determine if integrating traditional beliefs about lightning using argumentation in teaching electrostatics will rally round learners' understanding of the scientific view of lightning.

2.5 Protection from lightning:

There are many myths that are still perpetrated which compromise lightning safety. Researches on protection against lightning have revealed that the behaviour of lightning is impulsive and arbitrary therefore education is needed to protect oneself from lightning. Some of the myths held about lightning make people believe that some places outside are safer than others but according to Roeder (2001) 'no place outside is safe with thunderstorms in the area'.

It has also been noted that majority of women in other countries are killed by lightning when removing clothes from clotheslines during a storm or are in close proximity to a clothes' line during a storm (Henry, 1990). In the past, individuals died mostly while farming or gardening, whereas in present time, numbers of lightning related fatalities increased while individuals partook in leisure activities like sports (Holle, 2005).

Understanding the ways in which the human body can be struck by lightning is a fundamental part in dispensing improvement strategies for lightning safety. There are six ways in which the human body can be struck by lightning: direct strike, side flash, touch voltage, step voltage, subsequent stroke, and connecting leaders. A direct strike occurs when lightning directly strikes and discharges on the human body. A side flash occurs when a current creates a channel through an object to the ground as well as to another object. The current will then attempt grounding through both objects. If a human is standing within range, they may become the additional object. Cooray (2007) reckons that this accounts for at least 50% of all lightning injuries that occur outdoors.

Touch voltage strikes occur when a human is holding an object that is struck. The current will flow through the object, to the human, and ground through the human. The current will continue to flow outward, and if a human is standing within this radius, they will experience the current flow up one leg and down the other, causing minimal injuries. Subsequent stroke strikes are direct strikes which follow a step voltage strike, or being struck twice in two different ways. The final way to be struck by lightning is through a connecting leader strike. When a lightning strike occurs, it begins with a step leader from the cloud and is met by a connecting leader from the ground. If a human is in the path of that connecting leader, they will be struck and most likely struck again by the return stroke. The return stroke occurs once both step leader and connecting leader meet, resulting in a flash. Both return stroke and connecting leader can cause injury or death (Cooray *et al*., 2007).

The National Lightning Safety Institute (1997) suggests that even though 100% protection against lightning is impossible, these are some of the protection measures that can be followed during a lightning storm:

- Do not go out-of-doors; seek shelters in buildings that are protected against lightning, enclosed metal trains/cars/boats/ships; Avoid places with little or no protection like barns, sheds, tents;
- Avoid: hilltops, top of buildings, open sports fields, parking lots, swimming pools, wires (fence, electrical appliances, telephone);
- Do not ride in open boats tractors, bicycles, scooters, etc.

Lightning is a risk and some people still do not take safety measures to alleviate that risk. Previous research states that 42% of deaths from lightning are caused by a lack in lightning safety knowledge (Lengyel, 2005).

2.6 Myths about lightning:

Lightning as a natural phenomenon from the cultural perspective of learners or from their home view which is not taken as the same as what they are taught in science at school

(Liphoto, 2004; Mahapa, 2006). This proves that the same phenomenon can be viewed differently: scientifically and culturally as that is the core of this study.

Some of the myths associated with lightning as investigated by Roeder (2008) include:

- People believe that rubber tires or rubber soled shoes protect you from lightning by insulating you from the ground. This can mislead people to not seek a safe place, or think that some unsafe locations are safe, e.g. convertibles, motorcycles, bicycles, etc.
- Metal attracts lightning (cell phones, i-pods, under wire bras, etc.) this is misleading people into thinking wrongly that they are safe outside and thus avoid a safe place, or waste time shedding metal rather than rushing to safety;
- Cell phones: Attract lightning because they are metal; attract lightning because the radio waves ionize the air and create a conducting path; Increase injuries because they are metal touching the skin, which channels more of the lightning current inside the body. All this can mislead people to think that they are safe outside near thunderstorms if they do not have a cell phone. This can also cause people that are outside not to use their cell phones to call for a ride when thunderstorms are threatening;
- Lightning would not strike if it is not raining or cloudy can mislead people to think that they are safe outside when thunderstorms are in the area. About 1/3 of lightning strikes occur outside the rain;
- Lightning never strikes the same place twice. This sometimes leads to flawed advice to run to where lightning has just struck, rather than an appropriate safe place;
- A person who was just struck by lightning can electrocute you if touched. This can mislead people to delay or not provide lifesaving first aid;
- Lay flat on the ground if lightning is about to happen. This is misleading people to stay outside longer than they should when thunderstorms are in the area.

Many of these myths unfortunately compromise lightning safety as they continue to persevere. This shows just how lightning safety education is needed in order to burst these myths as lightning also inflicts life-long incapacitating injury on many more than it kills

(Cooper, 1995). Many of these myths mislead people into thinking that some places outside may be safe under some situations (Roeder, 2007b). This study will therefore explore how these myths and other lightning claims can be taught, in order to enable learners to make informed decisions in relevant situations.

Learners' indigenous knowledge which they bring to class should be part of what is taught in their science classrooms. In most of classrooms in South Africa, the knowledge that learners bring from home maybe an obstruction in learning school science in a meaningful way (Aikenhead, 1996). This may be caused by the difference in the interpretation of the same phenomenon indigenously and scientific. Ogunniyi (1988) therefore suggests that, to minimize any difficulties the indigenous explanations should be incorporated into school science. The next subsection, indigenous knowledge systems will be discussed in detail.

2.7 Indigenous Knowledge System

From the history of science perspective, science is a human explanation of nature (Erduran, 2006). In contrast to the above, learners' views are ignored when they come to school. They are regarded as "empty bowls" waiting to be filled up by teachers who are transmitters of knowledge (Lew, 2001). Social constructivist theory, for instance, posits that learners learn concepts or construct meaning through their interactions with things around them. Therefore, using an instructional strategy in which learners are not given a platform to connect what they learn in the classroom to their prior knowledge or related events in their community result in learning by rote. This prevents a deeper understanding of what may be involved. Learning involves construction of knowledge through experience. According to Kilpatric (1999), learners acquire knowledge when they can incorporate new experiences into existing mental structures. When these structures are reorganised they can be used by the learner to solve more problematic experiences.

Waldrip and Taylor (1999) took note of the fact that, western explanation of natural phenomena could be very different from traditional explanation or indigenous ways of interpreting the same phenomena. To a great extent indigenous knowledge has scientific explanations that can enhance learning in science; hence, to enhance effective learning of science among our learners, it is necessary to incorporate indigenous knowledge into western modern science. Wasagu (1999) and Ivowi (1992) have identified one of the major causes of poor performance in science as being the clash between learners' worldview and school science view as learners are struggling to incorporate the two. In the light of this, the recognition of the existence and value of indigenous knowledge systems has been an important aspect of the curriculum developments that have taken place in education in South Africa. When the New Curriculum was introduced in Grade 10 – 12 in South African Schools in 2006, considerable emphasis was laid on developing learners' abilities as creative and critical thinkers.

Underlying the study was the postulation that integrating two clearly different worldviews would result in cognitive conflict in the minds of the learners and therefore a well-developed instructional intervention could help revolutionize such a conflict. In the same streak, it was hoped that the intervention (DAIM) would ameliorate the border crossing process between the perceptions of lightning that learners bring into school and what they learn in school science. Some scholars have argued that traditional worldviews are viewed as possible hindrances to the effective learning of science. They claim that, instead of accommodating the scientific conceptions learners hold on to their traditional ideas. The study hope to improve learners' understanding of the two systems of thought (through dialogues) as well as help them develop critical thinking, which is an important endeavour in teaching science.

Indigenous Knowledge Systems (IKS) form part and parcel of traditional communities in South Africa and elsewhere in the world. In South Africa IKS was deprived of inclusion in the school curriculum before the democratic privilege in 1994. Massaquoi (2001) viewed this segregation of IKS as due to the western attitude of viewing IKS as primitive, uncivilized, and barbaric and the assumption that local people have nothing to offer. As a result of this, Ogunniyi (2004) and Odora-Hoppers (2002), as well as a lot of other science education researchers have embarked on studies on how to integrate Indigenous Knowledge Systems (IKS) with school science.

When Curriculum 2005 was introduced, it stressed the need to incorporate science and IKS. The reasons mentioned for the integration was that: IKS reflects the wisdom about the environment developed over the centuries by the population of South Africa, much of the valuable wisdom is believed to have been lost in the three decades of colonisation and it now needs to be rediscovered and used to improve the life of South Africans.

The quintessence of this study was to integrate IKS with the Science Worldview (SW). The instruments on lightning as basis of electrostatic electricity used in the study had both aspects of IKS and science which was used to check how learners incorporate the two, as another important facet that the study explored was how the learners dealt with the two ill-assorted worldviews. Different cultures around the world have different beliefs and myths about the lightning phenomenon. In Liphoto (2008) it is reported that some of these beliefs include that of the Ugandans, who believe that there are elders who have the power to summon lightning and guide it to punish thieves (Nzita and Niwampa, 1997). Sluijs (2001) has advocated that even in Europe myths about lightning exist as in some parts of France, if one kills a wren, that the person would be struck by lightning and lightning would destroy his dwelling. According to Liphoto's study, in the Basotho knowledge system, lightning lays eggs and urinates wherever it strikes.

Indigenous knowledge is defined by Ocholla and Onyancha (2005) as shared knowledge, skills, and attitudes belonging to a community arising from personal and community experiences. It is the local knowledge that is unique to a given culture or society, but recurrently predisposed by internal ingenuity and contact with external systems. The National Curriculum Statement of Physical Sciences Grade 10 – 12 (DOE, 2003) defines IKS in the South African context as a body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years. UNESCO (2001) noted that all the definitions of IKS are making it clear that is locally bound and indigenous to a specific area, culture specific, non-formal knowledge that is orally transmitted from generation to generation without being officially documented.

UNICEF (2004) has emphasized the fact that each and every child has a right to education as well as a to an education system that values the child's culture, language, community and access to schooling. Recent studies (Cajete, 1995; Kawagley, 1995) have recommended that IKS be renowned in the school science curriculum, this will connect school science to the learner's cultural background and help to improve their learning as participation from learners becomes insightful and active. In South Africa, our Physical Sciences policies are mostly based on western cultural definitions, and that way IKS is marginalised. Inclusion of IKS into the school science curriculum will hopefully help bridge the gap between the learner's school experiences and their home experiences while at the same time giving an opportunity to develop their abilities to full potential, gain confidence and self-esteem, use their creativity to gain life skills as well as making informed decisions (UNICEF, 2004).

Mqotsi (2002) has also indicated that indigenous beliefs have social and psychological functions as they enforce morality; they constitute a manner of adapting to the environment; they also act as anxiety-relieving mechanisms. Atkison and Fleer (1995) view learning as human construction where children try to make sense of their world through active explanation of their environment and social interchange with people around them. Mcleod and Mills (1990) believe that if we can draw upon the everyday local and often taken for granted experiences of learners, each successive experience can be exploited towards enquiry and understanding in order to develop a higher level of scientific literacy.

IKS is treated as the primary sources of information by most communities, especially in rural areas where most of the learners involved in the study originally came from. Indigenous knowledge is not a formalised information system; hence it has remained invisible to science education (Raseroka, 2002). Watts (1991) reckons that integrating IKS in school science problematizes the insufficient integration of personal and public knowledge of learners.

Science education in South Africa is of great concern as the number of learners passing science is decreasing drastically and the results are getting poor and poorer. South African learners have been performing badly on international surveys such as the Trends in International Mathematics and Science Study (TIMSS). Jegede (1999) suggests that in order to remedy such situations and through collateral learning; teachers need not to condescend and discredit the indigenous knowledge that learners bring to the classroom for the reason that it serves as the support against which they learn science.

The main aim of this study is to integrate indigenous beliefs learners hold about lightning with a scientific concept of electrostatics so as to monitor the transition between the two. Most of the textbooks that are used at schools do not provide the integration of indigenous beliefs even though it is expected of teachers to include this in their teaching by the Department of education. It is commonly known that when learners come into a classroom, they come with their own different experiences and beliefs nevertheless most Physical Science educators believe that the scientific worldview is the only one that represents a proper knowledge. Ogawa (1995) refers to the difference between modern science and indigenous knowledge as not only existing in the content, but in the ways of knowing and the interpretative framework underpinning such knowledge.

Referring to the topic on electrostatics; lightning was only mentioned as an example and no further explanations was provided but at the same time the teacher is supposed to implement it in their teaching. Some textbooks do raise questions related to IKS but there is no integration whatsoever between IKS and science. Mahapa (2004) agrees that integration is not just about acknowledging learners' prior knowledge but it is about doing something about the learners' prior knowledge. The integration of learners' prior knowledge therefore implies that there should be comparison between the two world views because promoting use of IKS has been identified as one of the principles on which the National Curriculum Statement for the Further Education and Training (FET) phase for all subjects in the South African curriculum was based.

Research that has been conducted in science education has revealed that culture plays a great role on learning and achievement in school as the cultural environment represents the link between what the learner knows and what they learn in school. How learners perform in science also depends on how they learn school science. At the moment, learners learn by going through the ordeal of memorising what is necessary to pass tests and examinations after which they return to the security of their traditional beliefs.

Jegede (1999) reckons that a learner can perform outstandingly in a Western science classroom without assimilating the associated values and that any science curriculum that does not take particular account of the indigenous worldview of the learner risks destroying the framework through which the learner is likely to interpret concepts. The South African curriculum policy has included indigenous knowledge in the curriculum statement; referring to it as a way of trying to bridge the gap between the two world views. Ogunniyi (1988) also recommended that if the scientific world view wants to succeed in traditional cultures, it should not try to take over from or degrade the traditional culture but it should try and help people meet modern challenges.

Another obstacle facing African learners, according to Shizha (2005), is the language used for instruction in schools. Language is very important in the learning and teaching of science. Jones (2000) pointed out that language is important for learners in order to develop their scientific knowledge and for teachers to understand the learning of their learners. The language used for instruction in South African schools is English which is not the indigenous language of most learners in the country and that of the learners used in this study. Rollnick (2000) considers English as being crucial for international communication and also as means of explaining scientific concepts but unfortunately the decisions that concern the use of language in classrooms are often not based on findings that are related to the best practice in education and classrooms but are often made on political grounds rather than educational grounds (Rollnick, 1998).

Science is, as noted by Rutherford (1999), one of the most linguistically demanding subjects for second language learners due to new uses of familiar word and unfamiliar words. Teaching using the learners’ indigenous language or mother tongue is very important in the teaching and learning process as has been confirmed by findings from many other researches e.g. Pattanyak, (1986); Brock-Utne, (2000) and Heugh, (2000). In as early as in 1968 UNESCO claimed that:

> It is through his/her mother tongue that every human being first learns to formulate and express his/her ideas about himself/herself and about the world in which he (she) lives. Every child is born into a cultural environment; the language is both a part of and an expression of, that environment. Thus, acquiring of this language, his/her mother tongue is part of the process by which a child absorbs the cultural environment; it can, then, be said that this language plays an important part in moulding the child's early concepts. He/she will, therefore find it difficult to grasp any new concept which is so alien to his /her cultural environment and that it cannot readily find expressions in his /her mother tongue (p.690).

A person's language is said to be vital in order to understand the cultural reality that surrounds that person. Studies in an assortment of countries have shown the positive value of incorporating indigenous languages into science teaching. Many educational issues are crucial when teaching and learning science using second language. In South African communities, many learners encounter English for the first time in school and never use it in their everyday lives. Ogawa (2004) believes that the use of English may affect the success of learning subjects as the problem of learning science through a second language is also compounded by other factors contributing to disadvantage, such as teachers who are not proficient in English and the lack of good science textbook. Halliday and Martin (1993) have found that even first language English speakers recognize scientific discourse as a type of English that is different from what they commonly use.

Cajete (2000) has found that when we incorporate indigenous languages into the science curriculum, that helps learners in understanding scientific principles better as well as being able to link western science to indigenous ways of knowing, consequently sustaining indigenous languages and heritage at the same time. When learners are moving from their everyday culture into the school science culture, cultural border crossing occurs as referred to by Aikenhead & Jegede (1999). This will be discussed further in the study.

Shizha (2005), in one of his studies on science and cultural beliefs in Africa, has concluded that the teaching and learning of science in school is not successful because the subject is not linked to everyday life experiences and the language of instruction alienates learners, this was also agreed upon by other scholars (Osborne, 1999; Clark and Ramahlape, 1999). The study goes on further to say that a learner whose mother language is not being used in scientific discourse has added difficulties of cognition and understanding as the learner must embark on dual translation to make sense of what they learn, that is, they have to translate what is taught in a western language to their indigenous language and then retranslate to the western language in order to communicate their ideas to the teacher.

The learners who are subjects in the study are mostly Xhosa first language speakers and they go through the same thing as above mentioned by Shizha. The learners also come across translation problems, and some concepts used in science have different meanings when translated into Xhosa. Also, some terms used in electricity have double meanings and learners end up not knowing which term is suitable. Clark and Ramahlape's (1999) study, conducted in South Africa, found that one of the main reasons that South African learners underachieve in science is because science teaching is dominated by English as the medium of instruction and that the subject is stereotypically presented in conventional textbooks as a fixed body of knowledge and as the utter truth.

Learners are at crossroads when at school as they come to school with their pre-existing ideas about natural phenomena and they are taught something different from what they know. What teachers teach in a science class is often unfamiliar to learners when they are at home. Aikenhead (1996) suggests that learners live two realities - at school and at home and they flip back and forth between these two realities and he refers to this as border crossing.

2.8 Border Crossing

Gregory Cajete (2006) reckons that a good thing about conceptual border crossing is that one is keeping true to their own culture but at the same time can cross borders into science to take what is good for their own culture. The belief that true learning comes by testing new knowledge against previous knowledge means that there has to be a connection between the two as learners fail science because they do not see how science connects with the actuality of their lives when they are at home or in their communities.

A Harvard Interim President Derek Bok and author of the book 'Our Underachieving Colleges' once noted that learners remember just 20% of the content of class lectures a week later. He continues to suggest that learners will be more motivated to learn if they see connection with the kinds of problems, issues and questions they encounter in real life. When learners do not connect the two, they do not then see the significance and in the process they lose interest towards learning. The alteration therefore from a learners' life into a science classroom is a cross-cultural experience for learners. Aikenhead (2007), the leading scholar in border crossing found that a major influence on science education as identified by learners in developing industrialized countries is that they feel that school science is like a foreign culture to them.

In trying to bring the conflicts between Western and African worldviews together Ogunniyi (2008) argues that although Western and African Sciences both deal with trying to interpret the natural world, they are found on contradictory intangible models. He goes on to say that "Science is based on a mechanist explanatory model and the traditional view is based on an anthropomorphic explanatory model". He also suggests that further studies should be attempted in order to determine the traditional view of various cultures to determine a curriculum of science education.

Jegede (1994) also agrees that there are many cultural factors involved in teaching and learning science. He mentioned some of these factors as being: the traditional worldview and how society views western science as being incompatible with their own views. He also goes on to comment that the best way to improve science education in Africa is to apply situated learning by being scientific to local culture. He suggested how this can be achieved in facilitating learning as understood in western society and it includes: generating information about the African environment to explain natural phenomena; identifying and using indigenous, scientific and technological principles, theories and concepts within the African society as well as teaching values of typical African human feelings in relation to and in practice technology as a human enterprise.

Aikenhead (1997) also uses cultural border crossing as picturing learners from an indigenous background in the process of learning modern science. When explaining this he said that each culture has its own personal science. Therefore, it is difficult for some learners to cross to the culture of modern science.

When looking at the implications of cultural border crossing in science teaching, Jegede & Aikenhead (1999) see collateral learning as a vivid example of border crossing as learners navigate their way from their indigenous home experience to that of a science classroom. These authors construe collateral learning as the ability to hold in the long-term memory the unresolved conflict of two explanations of everyday phenomena. They suggested that this conflict can be moved towards a resolution by firstly contextualising the science curriculum within the learners' daily lives, using a culturally sensitive instructional strategy, using indigenous language when teaching science, acknowledging contributions of non-western scientist and by building bridges between indigenous science knowledge and modern science. In other studies done as well it is believed that all this can be achieved if border crossing can be implicit rather than explicit and the teacher acting as the cultural broker than just being a jug full of knowledge.

2.8.1 The cultural context of learning:

Phelan (1991) defines culture as the values, the norms, beliefs, expectations and action of a group of people. Science classes have their own cultures that are highly influenced by that particular society's major culture of a particular area. Learners have cultures that are the same as their families, community and peers. According to Spindler (1987) the culture of a learner is usually dissimilar from that of school science culture and that to learn science is to attain the culture of science, its norms, values, beliefs, expectations, and actions of the science community.

Hawkins and Pea (1987) note that when learners' cultural distinctiveness harmonizes with the culture of science, that process is called enculturation which is when scientific thinking enhances the learners' everyday thinking. Larson (1995) argues that when cultural transmission occurs, science thinking dominates the learner's everyday thinking and he referred to this diffusion as Fatima's rules: where learners defy incorporation as they concentrate on just passing rather than understanding the scientific content in a meaningful way.

Acculturation on the other hand is referred to as when learners adopt some content from science as it appears to their daily lives. This happens when learners replace their own pre conceptions by constructing science conceptions and their everyday thinking ends up being integration of their common sense scientific knowledge (Aikenhead, 1997).

Anthropological learning is when a learner learns science but does not allow it to rule his/her thinking. He/she uses only scientific explanations when they are useful to him therefore the learner's thinking is always guided by the context he finds himself in.

Learners can be said to border cross through their experiences with school science. Border crossing for learners can either be smooth (enculturation), manageable (acculturation) or hazardous (anthropological). Aikenhead (1996) states that success in science depends on: the degree of cultural difference that students perceive between their cultural world and their science classroom, on how effectively students move between their cultural world and the culture of school science. Jegede and Aikenhead (1996) suggest that how we as teachers assist our learners in making transitions from their cultural world into the school science culture is also an important factor in border crossing.

2.8.2 Levels of difficulty in border crossing:

Jegede and Aikenhead (1999) have identified four types of border crossing that correspond to the level of difficulty that learners experience when making the transition from their world view culture to school science culture. The categories that learners fall into when associated with the levels of difficulty in border crossing include:

1. Smooth border crossing: This is experienced by learners whose world view is not congruent to school science and they can easily move from one culture to another as they experience a smooth transition. These learners are called Potential Scientists.
2. Manageable border crossing is experienced when the world view of the learner is not too different from the science view. This transition is easily managed by the leaner. Learners who go through this border crossing are referred to as other smart kids.
3. Hazardous border crossing occurs when the two cultures are very different from each other and learners who undergo this transition are called ‘I do not know’ learners.
4. Impossible border crossing is when the two cultures are in total disagreement with each other and learners find it impossible to cross from one culture to the other as a result these learners are completely alienated from science are referred to as outsiders.

A learner coming from a rural background into a science classroom is not likely to find the scientific worldview coinciding with their culturally embedded worldview. When the cognitive experiences of border crossing involves conflicting schemata held at same time in long memory of learners, this is referred to as Collateral learning (Jegede, 1995).

2.9 Collateral Learning

Jegede and Aikenhead (1999) have explained that sometimes conflicts arise as a result of the differences between learner culture and school science. This is referred to as Collateral learning. There are four types of collateral learning identified that signify the degree of how the conflicts can be resolved. These are parallel collateral, secured collateral, dependent collateral and simultaneous collateral learning. Parallel collateral learning is when learner`s choose to use science or their own view depending on the context: Learners use scientific explanations while at school then change to their beliefs when at home.

- Secured collateral learning happen when both different view`s interact to resolve a conflict resulting sometimes in a whole new concept being developed.
- Dependent collateral learning happens when a learner is not conscious of the conflict between the two domains of the knowledge and is not aware that he/she is moving from one to another.
- Simultaneous collateral learning is in between parallel and dependent collateral learning, it takes place when learners experience a situation where they learn a concept of one view and facilitate learning of a similar concept in the other view and this can lead back to parallel or depended collateral learning.

A view of cultural border crossing and collateral learning is that most learners from cultural backgrounds are performing poorly in science as a result of lots of problems that they have to contend with as they struggle their science. Therefore this study hopes to come up with ways that teaching and learning science can be facilitated in order for the learners to experience smooth border crossing.

Backhouse, Haggarty, Pirie and Stratton (1992), citing Ausubel (1968), also have discovered that "The most important single factor influencing learning is what the learner already knows, ascertain this and teach him and teach him accordingly." On other research conducted on the matter; most researchers are of the conformity that learning becomes meaningful for most learners only if they see the direct relevance of what they are taught at school to their daily lives and that way it becomes easy to facilitate cultural border crossing by integrating what they already know the unknown school science. Therefore this means that science teachers have to guide learners to affectively cross cultural borders so as to attain the desired form of collateral learning.

2.10 Argumentation as an Instructional Tool for Resolving Conceptual Conflicts

From the foregoing I have attempted to show the efforts that have been made by scholars to understand how learners, especially those from indigenous cultures, try to resolve the conflicts between their cultural beliefs about natural phenomena and that of science. In this regard I have identified theories such as collateral learning and border crossing (Aikenhead & Jegede, 1995; Jegede, 1995) as examples that researchers have used to explain how learners navigate between conflicting worldviews such as science and indigenous knowledge (IK). However, these well-known theories are argumentation theories which form the central concern of this study.

In chapter 1, I have motivated why argumentation is chosen as a framework for the study; the rationale being that it is an effective means for self-expression and for resolving conflicting ideas (Erduran, Simon & Osborne, 2004; Ogunniyi, 2007a & b). In the following section two argumentation that has received increased interest among researchers are the Toulmin's Argumentation Pattern-TAP (Erduran *et al.*, 2004) and Ogunniyi' Contiguity Argumentation Theory-CAT (Ogunniyi, 1997, 2007a & b). However, while TAP is suitable for analysing logical arguments it is not suitable for analysing non-logical or culturally nuanced arguments (Diwu & Ogunniyi, 2012; Ogunniyi, 2007a). This issue will be expanded in the section that follows.

2.11 Toulmin's Argumentation Pattern and Contiguity Argumentation Theory

For practical reasons, and as has been indicated in the preceding section, this study is underpinned by a dialogical argumentation framework as espoused by Toulmin's Argumentation Pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT). These two theoretical frameworks are chosen because of their amenability to classroom discourses dealing with substantive arguments as well as non-logical deductive/inductive metaphysical discourses embraced by Indigenous Knowledge Systems where there is a possibility that learners might be holding conflicting worldviews (Ogunniyi, 1997, 2007a).

Argumentation requires learners to engage with data or evidence, to make claims based on these and to weigh the extent to which others' claims can be substantiated (Erduran, Simon and Osborne, 2004). Through dialogical argumentation the teacher is able to attend to the learners' points of views as well as to the school science view. Toulmin (1958), cited by Simon, Osborne, & Erduran, (2003), describes a good argument as one that supports a particular point of view in a logically consistent manner. However, not all arguments are amenable to logical reasoning since learners hold multiple worldview conceptions of natural phenomena.

Teaching science involves introducing learners to the ways of talking and thinking of the science community. In light of the above, it is believed that argumentation helps teachers to move from a situation where learners understand little or nothing about science concepts to one where they are able to talk and think about the concepts themselves. A cross-cultural instructional approach integrates school science with knowledge customary in the socio cultural environment of the learners. It combines scientific and traditional worldviews about natural phenomena in a holistic manner. According to Aikenhead and Jegede (1999), learners negotiate and resolve cognitive conflicts caused by infusion of school science and traditional views through cognitive border crossing.

If learners are not given the chance to talk to one another and debate their ideas, it makes it difficult for them to learn science concepts. Therefore argumentation is essential to understanding the nature of science. Newton, Driver & Osborne (1999) and Driver, Newton & Osborne (2000) have strongly expressed that argumentation is a critically important epistemic task and discoursed process in science.

Argumentation is central to the study as the intervention as it is hoped that it helps learners to use their indigenous knowledge about lightning in understanding the scientific explanation about the concept. Studies have shown that, learners from socio-cultural backgrounds experience school science differently than those otherwise exposed. Dialogical argumentation as a teaching and learning method, therefore, is proposed to facilitate the border crossing.

The central role of argumentation in doing science is to engage learners in strategies that enhance decision-making about controversial issues in science, and to do so they need to understand how evidence is used to construct explanations. They also need to understand the criteria that are used in science to evaluate evidence. These views are also supported by psychologists (Kuhn, 1993) and philosophers of science (Siegel, 1995) as well as science education researchers studying the discourse patterns of reasoning in science contexts (Kelly, Chen, & Crawford, 1998; Lemke, 1990).

Argumentation is also seen as a reasoning strategy and it also falls under the general reasoning domains of informal logic and critical thinking. There is an increasing evidence in science education that argumentation is a powerful strategy for teaching and learning (Kuhn, 2005). Argumentation requires learners to engage with data and evidence, to make claims based on these and to weigh the extent to which other’s claims can be substantiated (Erduran, Simon and Osborne, 2004).

Through dialogical argumentation, the teacher is able to attend to the learners’ points of views as well as to the school science view. In Simon, Osborne, & Erduran, (2003), Toulmin (1958) describes a good argument as one that supports a particular point of view in a logically consistent manner. Argumentation is a process of linking evidence to a claim. It requires learners to externalise their thinking (Kuhn, 1992) therefore, as pointed out by Erduran *et al.*

(2006), when they understand the relationship between claims and warrants, their ability to think critically in scientific concepts is sharpened.

Learners should be able to engage in decision-making about controversial issues in science, and to do so they need to understand how evidence is used to construct explanations. They also need to understand the criteria that are used in science to evaluate evidence. Therefore, there is a need for them to be educated about the scientific world-view – seeing science as a distinctive and valuable way of knowing. This shift in emphasis requires that teaching of science focus more on the nature of science and on the evidence and arguments for scientific ideas, and help learners develop skills of engaging in prolific argumentation.

Teaching of argumentation through the use of appropriate activities and teaching strategies can provide a means of promoting a wider range of goals, including social skills, reasoning skills and the skills that are required to construct arguments using evidence (Osborne, Erduran, & Simon, 2004b; Simon, Erduran & Osborne, 2006). To change the emphasis in teaching science to incorporate argumentation, educators must adopt a more dialogic approach that involves learners in discussion (Mortimer & Scott, 2003; Alexander, 2005).

Toulmin (1958) developed a model of argument that has been drawn upon by educators and science educators in particular, to identify the components and complexities of learner's arguments. He describes the structure of an argument as comprising an interconnected set of claims which are conclusions whose merits are still to be established, data or grounds which supports the claim, warrants that provide a link between data and the claim, backing to strengthen the warrants and rebuttals which point to the circumstances under which the claim would not hold true. When learners engage in argumentation and support each other in high quality argument, the relations between the personal and the social dimensions promote reflexivity, requisition and the development of knowledge, beliefs and values. To clutch the connection between evidence and claim is to understand the relationship between claims and warrants and to sharpen children's ability to think critically in a scientific context, preventing them from becoming blinded by unwarranted commitments (Quinn, 1997).

An argumentation based instruction creates a positive learning environment that enables learners to participate actively in class and that can lead to the attainment of cognitive optimum. Research has also explored the use of argumentation and Toulmin's Argumentation Pattern as a methodological tool for the analysis of classroom based verbal data in science classroom (Scholtz, Sadeck and Hodges 2004).

Toulmin's framework of argumentation is used as it is a crucial instrument involved in the growth of scientific knowledge (Kitcher, 1988) as well as a crucial component of scientific discourse (Pera, 1994). Argumentation plays a central role in the building of explanations, models, and theories (Siegel, 1995) as scientists use arguments to relate the evidence they select to the claims they reach through use of warrants and backings (Toulmin, 1958).

TAP illustrates the structure of an argument in terms of an interconnected set of a claim; data that support that claim; warrants that provide a link between the data and the claim; backings that strengthen the warrants; and finally, rebuttals which point to the circumstances under which the claim would not hold true. According to Ogunniyi (2007) "a claim is an assertion put forward publicly for general acceptance." Grounds are "the specific facts relied on to support a given claim." Backings are "generalizations making explicit the body of experience relied on to establish the trustworthiness of the ways of arguing applied in any particular case." Rebuttals are "the extraordinary or exceptional circumstances that might undermine the force of the supporting arguments.

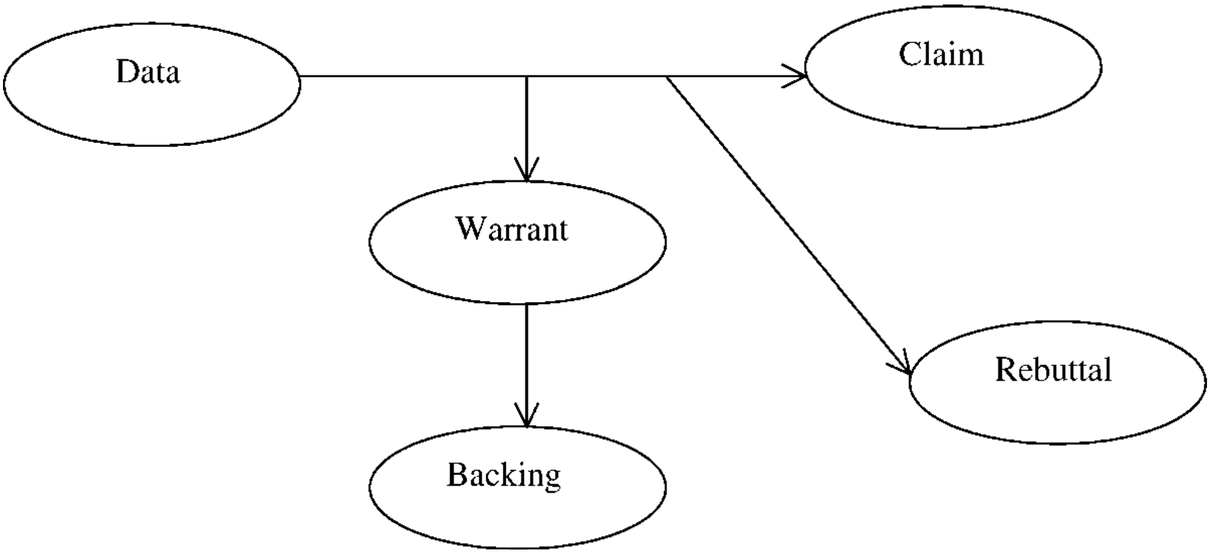


Figure 2.1: Toulmin's Argument Pattern (Toulmin, 1958) cited from Erduran and Osborne 2004

Kelly, Druker, and Chen (1998) have found that organizing learner discourse into Toulmin's argument components require a careful attention to the contextualized use of language. Kelly *et al*. (1998) argue that, while the Toulmin model makes distinctions among statements of data, claim, warrant, and backing, the scheme is restricted to relatively short argument structures and the argument components pose ambiguities. Statements of claims can serve as a new assertion to be proven or can be in service to another claim, thus acting as a warrant.

Toulmin's Argumentation Pattern has also been applied as a methodological tool for the analysis of a wide range of science curricula but it is more applicable to deductive- inductive classroom discourse than what is required when Indigenous Knowledge Systems is being integrated into school science (Ogunniyi, 2007a). The Contiguity Argumentation Theory (CAT) is used in addition to the TAP in the study as it deals with logical and scientifically valid arguments as well as non- logical metaphysical discourses embraced by Indigenous Knowledge Systems.

According to Ogunniyi & Hewson (2008), CAT asserts that the two different co-existing systems of thought, such as science and IKS, tend to readily link with each other in the mind of the learner to create a most favourable cognitive state. CAT also holds that claims and counter-claims on any subject matter within fields like science and IKS can only be justified if there is no system that is dominant to the other. That way, learners will be able to negotiate the meanings across the two distinct systems of thought so as to integrate them. CAT is used in this study as a framework to analyze and explain how learners resolve conflicts arising between the scientific and indigenous views of lightning. CAT recognizes five categories that describe the way conceptions can move within a learner's mind when dealing with conflicting worldviews: science and IKS. These five categories also explain the movement of conceptions amongst learners involved in dialogues warranting the conscription of scientific and IKS-based conceptions. Concepts move in the mind of a learner in five different ways in response to the arousal context as follows:

1. Dominant- a powerful idea effectively explains or predicts facts, or resonates with an acceptable social norm and a sense of identity;

2. Suppressed- an idea becomes suppressed in the face a more convincing evidence, or established social norms;

3. Assimilated- a less powerful idea might be assimilated into a more powerful one in terms of the of the persuasiveness or adaptability of the dominant idea;

4. Emergent- there may be circumstances where no prior knowledge about a phenomenon exists and new knowledge has to be acquired as is the case with many science concepts; and

5. Equipollent- when a learner's worldview is influenced by two competing and/or co-existing worldviews e.g. science and IK with comparably equal intellectual force without necessarily resulting in cognitive dissonance (Ogunniyi, 2007a).

Ogunniyi (2005) also contends that the five cognitive states above exist in a dynamic flux and can change from one form to another. Hence, the context in which a given discourse takes place dictates what cognitive states an individual displays. The study will attempt to determine whether these states of cognition are exhibited during the argumentation lesson as the learners will be trying to understand the concept of lightning from two distinctly different worldviews (western science and IKS). The Contiguity Argumentation Theory is a philosophical discription of constructivism, whilst Toulimin's Argumentation Pattern is a pedagogical tool. Therefore the Contiguity Argumentation Theory provides justification for intergrating science with indigenous knowledge systems whilst Toulmin's Argumentation Pattern provides instructional educational structure. Before concluding this chapter it is apposite to cite some actual studies that have applied the two theories namely, TAP and CAT to help learners resolve the conflicts they experience between their own ideas about diverse phenomena and that of school science.

2.12 Some Studies Using TAP and CAT as Theoretical Frameworks

This study follows at the feet of a number of studies that have been carried out where dialogical argumentation has been used as a teaching strategy to implement an IK filled science curriculum (Diwu & Ogunniyi, 2010; Angaama, 2013, Riffel, 2013). Some of the studies have involved pre-service teachers who were trained in argumentation in order to implement it in their science classrooms (Ogunniyi & Hewit, 2008; Siseho, 2013). Liphoto, 2008; Mahapa, 2002; Maselwa, 2004; Pabale 2008 and Moyo, 2012, are studies that are more related to this study as they have dealt with conceptions of lightning in an IK-science worldview. In this section I examine the above research studies as they have used dialogical argumentation to enhance learning in science education classrooms with TAP and CAT as a theoretical framework.

Many of these studies have shown that argumentation is a useful tool that enhances learners' conceptual understanding. Driver *et al.*, 2000; Ebenezer, 1996; Erduran *et al.*, 2004 are some examples that have shown that in the past decade, Toulmin's Argumentation Pattern (TAP) has been one of the most frequently used argumentation models by science teachers in order to enhance learners' understanding of the nature of science. As mentioned earlier in the study, TAP is more applicable to a deductive-inductive classroom discourse than what is required when IK is to be integrated with school science. The Contiguity Argumentation Theory (CAT) on the other hand deals with both logical and scientifically valid arguments as well as non-logical metaphysical discourses that are embraced by IK. CAT proclaims that conflicting worldviews such as science and IK tend to readily pair with, or recall each other to create a harmonious worldview.

In the study by Liphoto (2008), he looked at the effect of a cross-cultural instructional approach on the learners' conceptions of lightning and attitude towards science. The study explored the Basotho tribe, one of the tribes in Lesotho, conceptions of lightning and thunder under the themes: nature of lightning, protection against lightning, animalistic behaviour of lighting and nature of wounds inflicted by lightning.

In order to allow the learners to evaluate each worldview against its applicability in their everyday life, they were given the scientific and the traditional conceptions of lightning with no intention to demean or prefer one over the other. This, the researcher claims, was done to avoid conceptual imposition and that the scientific conception was presented as an alternative to what the learners had already known about lightning. In this regard, the learner is afforded the opportunity to reflect before deciding whether or not to apposite another view different from what they initially hold. This can be explained in terms of Ogunniyi's (2004) CAT which goes beyond Jegede's Collateral Learning (Jegede, 1997) where the traditional and the scientific conceptions of a phenomenon are put side by side with minimal interference or interaction.

The learners in the study were introduced to the scientific interpretation of lightning as presented in the science curriculum of Lesotho using a cross-cultural instructional approach based on Jegede's (1995) cross-cultural pedagogical paradigm. This approach entails using a combination of knowledge about lightning prevailing in the learners' socio-cultural environment with school science. The researchers used this approach in order to see if the learners have displayed any of the five types of CAT namely the dominant, suppressed, assimilatory, emergent and equipollent. Ogunniyi (2004) contends that, learning by contiguity is an intellectual process in which similar or opposing perceptions are dynamically associated or combined to attain a higher form of consciousness. Findings of the study revealed that:

(a) Some learners hold scientific views about lightning even prior to classroom instruction about static electricity. (b) Some learners hold only traditional beliefs. (c) Most learners hold both scientific and traditional conceptions. (d) Learners oscillate between scientific and traditional conceptions of lightning in their responses.

The findings of this study exhibit that if learners experience a conflict between conceptions, they will either reject the new information based on school science experience while in other circumstances, the learners will partially accommodate the scientific view within their traditional worldview. The traditional doctors, learners, teachers, expert of Sesotho language, and chairperson of the National Science Panel who were all involved in the study supported the integration of the scientific and the traditional worldviews about lightning and thunder.
Van Wyk (2002), Kibirige and van Rooyen (2006) and Cimi (2009) indicate that the inclusion of everyday experiences enables the community members to participate in education and pass on their knowledge to the learners.

In a study conducted in Namibia, Nanghonga (2012) has investigated how eliciting and integrating learners' cultural beliefs and experiences about lightning in conjunction with practical activities enables or constrains meaning making in static electricity. The study has revealed that learners possess a lot of prior everyday scientific and non-scientific knowledge and experiences about lightning that they have acquired outside the school. The study has also revealed that engaging the learners in their cultural beliefs and experiences enhanced participation and facilitated learners' understanding of the natural phenomenon of lightning.

Pabale (2006) affirmed in her study which explored integration of indigenous knowledge with science topics (electrostatics) that incorporation of everyday knowledge and experiences could be one way to draw learners into active attitude to the learning of science topics. She, however, mentioned that conceptual transformation is not easily achievable. Ogunniyi (2007) argues that the inclusion of indigenous knowledge brings in cognitive conflicts which were evident in this study since learners adhered to their cultural beliefs even though they were not scientifically correct.

The focus on Nkopane (2006) research was to identify learners' conceptions of lightning and to elicit, describe and assess the learners' process of learning Western conception of lightning. The findings of study were that learners experience a type of cultural clash whenever they attempt to learn science meaningfully and a substantial number of learners indicated that the cultural view prohibits them from learning the scientific view of lightning. These learners see the two views of lightning as completely different entities. Aikenhead

(1999) describes this cognitive setting as collateral learning because learners are learning something in a school cultural setting that is in conflict with their indigenous knowledge.

A study done by Siseho (2013) was aimed at investigating the effect of an argumentation instructional model on the pre-service teachers' ability to implement a Science-IK curriculum in four selected South African schools. The study used TAP and CAT as a theoretical framework. The pre-service teachers involved in the study were trained in argumentation through the bi weekly workshops held by the SIKSP group in the University of the Western Cape. The researcher reported that the pre-service teachers involved in the study faced problems in teaching the new content on Indigenous knowledge in the new school curriculum. This was reportedly due to inadequate information in the curriculum document, particularly about scientific principles embedded in Indigenous knowledge. Experienced teachers in schools have also been complaining that the new curriculum does not cater for the needs of science-IK integration.

According to Siseho (2013), the curriculum design lacked a theoretical foundation, which could guide the specification of desired principles in the curriculum document. The reasons include curriculum designers' lack of adequate knowledge of what IK entails or the assumption that teachers have such details for themselves. This results in teachers not being able to integrate IK with science and to make the learning meaningful to the learners. Some prospects mentioned that emanate from engaging in indigenizing the science curriculum include:

1. Addressing issues of diversity across cultures in South Africa (thereby providing scientific programs that are relevant to both culture and science);
2. Teaching science by using locally available resources from various places in South Africa;
3. Training school teachers and teacher-educators to validate and document their self-created knowledge which conform the science agenda, and also
4. Boosting self-concept, identity, and self-determination among both teachers and learners.

This study therefore seems to agree with earlier studies that, argumentation instruction requires sufficient exposure of those who want to use it as an instructional approach (e.g.

Erduran et al, 2004; Simon et al, 2006; Ogunniyi, 2004, 2007a &b, 20011; Simasiku & Ogunniyi, 2011, 2012).

Research studies done on argumentation had been mostly with high school learners (e.g. Eskin, 2008; Kelly et al. 1998; Maloney, Simon, 2006*)*. Philander (2012) conducted her study with young children from the age 4-9 years old using an argumentation instruction and has found that argumentation instruction enhanced learners' understanding of various concepts in science and helped them to overcome their misconceptions in science.

Maloney & Simon (2006) state that learners learn how to reason, assess options, and justify claims through evidence and argumentation. According to them, argumentation is dialogic in the sense that it is done individually, thereafter co-constructed in the group, considering the claims of other group members. Learners can argue naturally, but to argue scientifically, they need a definite guidance. Therefore, teachers need to plan the activities to such an extent so that the learners can argue even if they have limited science knowledge. Other research has also established that the quality of the argument depends on the learners' content knowledge in order to be able to cite the necessary data to back a claim, and adequate warrants to justify the connection with it (Acar, 2008, von Aufschnaiter et *al*., 2008; Sadler & Fowler, 2006).

Learners, who are exposed to argumentation, are more able to reason scientifically and excel in it. Kuhn (1993) and Osborne *et al* (2004) agree that learners need to be explicitly taught argumentation in order to be able to effectively use it as a tool to construct knowledge. In several studies (e.g. Ogunniyi, 2004, 2005, 2007a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008) it was found that primary and secondary school teachers who were exposed to a dialogical argumentation instruction have improved not only their understanding of the nature of science but they have also developed a greater enthusiasm and appreciation for IK.

2.13 Summary

In this chapter we have reviewed the literature relevant to the research project. The discussions covered the literature on both Scientific and Traditional views of lightning, Indigenous Knowledge System (IKS), border-crossing, collateral learning, TAP and CAT and the reviews were done on studies using CAT and TAP as theoretical framework.

This study is underpinned by an argumentation framework as espoused by Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT). The two theoretical frameworks are chosen because of their amenability to classroom discourse dealing with phenomena on which learners might be holding conflicting worldviews. These frameworks also provide the necessary context for inductive, deductive and analogical reasoning.

According to Ogunniyi and Hewson (2008) the TAP and CAT as argumentation models involve creativity and discursiveness. These two models have been found to encourage teachers and learners to discuss ideas by being vocal about their viewpoints. The studies reviewed have shown that teaching with argumentation differs from the 'chalk and talk' method. Using argumentation to teach or discuss science and IK helps learners to recognise and appreciate their IK, e.g. Liphoto (2008). Some studies have shown that continuous use of argumentation improves learners' understanding about scientific concepts embedded in IK. The CAT as a dialogical framework has been found to help one engage in an internal argument concerning conflicting ideas (Ogunniyi, 2007a).

Chapter 3

Methodology

3. Introduction

The purpose of the previous chapter was to review the literature dealing with the integration of indigenous knowledge (IK) with school science using dialogical argumentation instructional model (DAIM) as an instructional tool. A related view was to determine to what extent DAIM had succeeded in enhancing grade 10 learners' conceptions of lightning using 'electrostatics' as a topic, in the curriculum which is as an entry point.

This chapter outlines which research design was used in the study, how sampling was done and how data sets were collected and analysed. According to Leedy (1993), research methodology depends on the nature of data to be collected and the nature of the research problem.

3.1 Research setting

The study was conducted in two schools situated at the outskirts of the Wine land Boland area of Cape Town, in the Western Cape. Both schools fall under the West Coast/ Winelands district of the Western Cape Education Department (WCED). Due to ethical considerations the schools are fictitiously called, Winelands High School and Boland Secondary School. The area in which the study was conducted can be classified as a semi- urban and is solely occupied by Black people of mostly Xhosa ethnic group staying mostly in shacks made of zinc. Most of these informal housing structures have no electricity or proper running water. The parents or guardians of the learners are from a wide range of socio-economic backgrounds: the unemployed, domestic workers, middle class and professionals. Most members of the community in the area are seasonal grape farm labourers as the area is situated around grape farms.

The majority of the learners from both groups were Xhosa home language speaker, and a handful of Zulu and Sotho. The home language of the learners is the language that the learners speak at home with their families and community. Both schools use English as a medium of instruction during lessons. Majority of the learners are originally from the rural area of Eastern Cape which is where their parents grew up and where most of them spend their school vacations. There are three feeder primary schools for the two secondary schools that are involved in the study. These primary schools provide both high schools in the study with learners who have passed grade seven and are ready to start grade eight.

The experimental group

Winelands High School was chosen as the experimental group. The school is a typical township school and has 1500 learners in grades 8 – 12 with 35 teachers. Each class has an average of 35 learners, which gives teacher- learner ratio of 1:35. There are two security guards at the school who are responsible for safety and monitoring of the gate. Four caretakers were employed to take care of the cleanliness of the school. They are responsible for the cleaning of grounds and classes in the school. The school has two science laboratories. These laboratories were being used as classrooms as there were not enough classrooms to accommodate all the learners at the school. The laboratories did not have enough laboratory equipment hence it was easy to use them as classrooms.

There are only two qualified Physical Science teachers at the school for all the grades. The school had very poor results in Physical Sciences and Mathematics ranging with an average mark of 20% to 35% between 2010 and 2012. Due to this high failure rate in Physical Science and Mathematics, the Western Cape Education Department (WCED) put the school under the National Strategy for Learner Attainment (NSLA) program.

The NSLA program was organized by the Western Cape Education Department for underachieving schools in Mathematics and Physical science. The school is also part of the

Dinaledi (a Sesotho word meaning 'stars') project, through which the government attempts to increase the quality and quantity of learners doing science. The Dinaledi project was established by the then Minister of Education, Naledi Pandor shortly after she became Minister of Education in 2004.

The schools selected to be part of the Dinaledi project receive additional support in the form of funding, extra teachers and special tutoring in Mathematics and Science beyond normal school hours. Through this extra support it is assumed that the schools would be equally placed in terms of personnel and resources and therefore focus on classroom practices would be less likely to be thinned by issues related to scarcity of resources and shortage of personnel. Despite all these interventions, Winelands High School still has a high failure rate in Mathematics and Physical Sciences. The school has two Physical Science teachers, of which I am one of the two. The experimental group was taught by me due to my training in the usage argumentation as a teaching method at the bi weekly seminars and workshops held by the SIKSP group at the University of the Western Cape.

The control group

Boland Secondary school represented the control group of the study. This school was a fairly new school. It was built because of the influx and overcrowding of learners in Winelands High school. It was built in order to ease the workload of teachers at Winelands High. Due to overcrowding, the learners in the community were forced to attend schools outside the township. The community therefore requested the department of education to build a new school as they were concerned about their children's safety due to the long distance of about 30 km they had to travel to attend schools outside the township.

When the new school (Boland Secondary) was built, half of the staff was taken from Winelands High. The new school has a population of 900 learners and 27 teachers. The teacher-learner ratio is 1:32. The school has not yet had a science laboratory therefore the science teachers could not perform any practical activities or tasks. The teacher teaching the control group has a degree in teaching and has been teaching for almost ten years.

3.2 Population and sample of the study

Population is the group of interest to which the results will be ideally generalised and where information will be collected and conclusions drawn (Gary and Airasian, 2003). The population for the study consisted of fifty six grade 10 learners. According to Barbie and Mouton (2001), there are two types of sampling a researcher may apply, either by developing a criterion relatable to the study before doing the study or do a preliminary study prior sample assortment. The sample for this study was selected on a very simple criterion: the school where I worked because as a full-time teacher it was impossible to carry out a research study outside my daily routine. Although this is a major limitation a concerted effort was made to be objective as much as possible.

Physical Science was chosen as a learning area as electrostatics falls on the grade 10 syllabus as basis of electricity studies which are carried up to grade 12. In grade 12, this part of work carries thirty per cent of the externally examined physics paper. Therefore if learners master the topic in grade 10, it would be easier for them to answer questions based on electricity in the external examinations.

It was also easy to conduct the study on grade 10 learners as they are usually not under the demand of the externally written matric examinations. In fact, the Western Cape Education Department (WCED) and schools do not usually allow research to be conducted in grade 12 because the learners in that grade have an examination-driven syllabus and no interruptions are allowed to disturb them.

Sample for the study was 56 grade 10 learners, consisting of 28 grade 10 Physical Science learners in two classes. One class was from Winelands High School and was used as the experimental group. The second class were learners from the neighbouring school Boland High school and they made up the control group. Hence this was an experimental study, the selection and experiences of the learners were the same in both groups. The two schools involved in the study were from the same community and the learners' backgrounds were similar. Their performance was almost the same and the teachers teaching them had the same level of teaching qualifications and the same experience teaching Physical Science. The only difference was that, the experimental group was exposed to Dialogical Argumentation Instruction (DAIM) as a teaching method and the control group was taught using the normal teacher chalk- talk method.

As discussed in chapter 2, the two argumentation models underpinning the study, Toulmin's Argumentation Pattern (TAP) and Ogunniyi's Contiguity Argumentation Theory (CAT) require that it is pertinent to first examine the biographical data of the learners involved in the study. The biographical data collected of the learners showed that the study group consisted of 19 boys and 37 girls with ages ranging from 14 – 20 years with an average on 15-16 years. 40 of the learners indicated that they originally came from the rural Eastern Cape Province which is highly prone to lightning strikes, 14 were from the Western Cape, 1 from Gauteng and 1 came from Lesotho which also has a high rate of lightning strikes. Most of the learners indicated that they were staying with only their mothers and a few with grandparents. The highest educational qualification of the parents of the learners involved in the study is in the secondary level.

The grade 10 classes were chosen for conducting the study because the elementary basis of the electrostatics are covered in the grade 10 syllabus or scheme of work according to the NCS document. Electrostatics as a topic is then expanded upon in grade 11 and grade12 when learners are taught 'electricity'. By focussing study on grade 10 learners, the study envisaged that the process will help them understand the topic better and that they will be able to apply that knowledge in the higher grades (11-12), thereby improving their performance in the subject as well.

3.3 The research instruments

The main purpose of the study was to have a comprehensive look at how to effectively integrate indigenous knowledge with school science regarding lightning using argumentation.

The questionnaires aimed at determining learners' cultural or indigenous beliefs about lightning, and what they already knew about Electricity. It was therefore administered before the teaching of the topic.

The questions were translated to Xhosa. The purpose was to help learners to understand these questions so that they could provide relevant information. Learners were also allowed to respond in Xhosa so that they could provide as much information as possible and the responses were translated to English. Semi structured interviews were also conducted with the experimental group learners afterwards to ascertain their views on argumentation. These interviews sought to identify learners' perceptions on argumentation and their understanding of its significance. The interviews were also used as a means of identifying any changes that had occurred before and after the intervention. The interviews were recorded and transcribed.

The teacher who taught the control group was provided with the same teaching and learning materials on lightning, which meant that both groups were exposed to the same content of work. The only difference was that she used her own teaching style.

I arranged and managed to observe some of the lessons of the control group so as ensure that our earlier teaching content and agreements were implemented and that IKS was integrated in her lessons. The lessons were also video recorded, this was done so as to get an unblemished view of the treatment and also allowed for a contemplative assessment of the lessons.

Interviews were designed for the learners of grade 10 to determine the effects of using a dialogical argumentation instruction on grade 10 learners' understanding and conceptions of lightning. These interviews also sought to identify learners' perceptions on argumentation and their understanding of its significance. The interviews were also used as a means of identifying any changes that had occurred before and after the intervention. Interviews enabled the learners to answer questions in my presence. That way I could follow up ideas, probe responses and investigate motives and feelings that a written instrument cannot do. The way a response is made can provide information that a written word would obscure. Lesson observations also took place during the lessons and at the time of the interviews.

Interviews were also used to collect learners' ideas and opinions about lightning. They were not concerned with obtaining coded answers to certain questions. They allow the participant the freedom to answer questions and the researcher more freedom in the way she asks questions. A semi-structured interview schedule involved a set of open questions, which were phrased in such a way as to allow a participant to answer relatively freely (Fontana & Frey, 2000: 652). The interviews were tape-recorded in order to capture the exact words of the interviewee to prevent loss of data. Before the interview the learners were encouraged to be at ease and to speak freely as reinforced by Adler and Clark (2008), who believed that when you encourage a learner to elaborate having given an answer increases their personal involvement in the interview and not feel like a machine producing wrong or right answers to questions. A set of questions that answered some of the research questions were presented to the learners, any brief response or when the response does not make sense, probe questions was asked. This reinvigorated the learners to speak freely, thereby providing a richer account of their personal thoughts and experiences concerning the question.

3.4 Research methods

In the study both quantitative and qualitative research methods were used and all the data were derived from the learners' performance scores and written responses in the pre and post-test on the Conceptions of Lightning questionnaire (COLQ), Science Attitude questionnaire (SAQ), Beliefs about Lightning questionnaire (BALQ) and the Science Achievement Test on Lightning (SATOL).

3.4.1 Quantitative Data Collection

Quantitative research investigates relationships and study cause-effects phenomena. It presents statistical results presented with numbers. Results are more readily analysed and interpreted (Schumacher and McMillan, 1993).

Hence there were two groups involved in the study; one group was the experimental group and the other the control group. The experimental group was taught using the Dialogical Argumentation Instructional Method. The experimental group learners were trained on argumentation through a series of lessons before the lessons started. This was done to familiarize the learners to the argumentation process so that by the time the study started the learners were confident in using argumentation. The experimental group lessons used activity worksheets that was based on Toulmin's Argumentation Pattern writing frames. In the worksheets individual learners had to make their claims about lightning, giving reasons and warrants and backings. In all the lessons the learners were divided into groups of five or six in a group and each learner in the group was given individual activity that they had to complete first then had to discuss each learner's claims in the group. Afterwards each group had to report their consensus arguments to the whole class. The whole class then discussed the group's claims and arguments. As the teacher I was the facilitator of the process and voice recorded all the arguments presented by the learners. The control group was taught using normal teaching methods by the other teacher in the other school.

3.4.2 Qualitative Data Collection

Qualitative research method was also used because it was designed to build knowledge. It stems from the anti-positivistic interpretive approach. It is holistic in nature and its main aim is to understand social life and the meaning that people attach to everyday life (Schurink, 1998).

According to Best and Kahn (1993) qualitative research describes events without the use of numerical data. It is more open and receptive to the subjects than quantitative method. Tuckman, (1994) also suggested that the use of qualitative methods provides the opportunity to have direct contact and get closer to the learners under the study.

A questionnaire was conducted to find out if using dialogical argumentation as an instruction method had an effect on grade 10 learners' conceptions of lightning. The questionnaire also tried to establish how learners handle the conflicting traditional and scientific conceptions of lightning. The questionnaire included both close and open-ended questions. This was done in order give learners the opportunity to answer the question in their own words. The questionnaires also aimed at determining learners' cultural or indigenous beliefs about lightning, and what they already knew about Electricity, hence it was administered before the teaching of the topic. The questions were translated to Xhosa. The purpose was to help learners to understand these questions so that they could provide relevant information. Learners were also allowed to respond in Xhosa so that they could provide as much information as possible and the responses were translated to English.

3.5 Validity of instruments

The instruments used in the study to collect data in order to answer the research questions were the Conceptions of Lightning questionnaire (COLQ), Science Attitude questionnaire (SAQ), Beliefs about Lightning questionnaire (BALQ) and the Science Achievement Test on Lightning (SATOL). Validity of the research instruments was done during the piloting of the instruments. Using numerous instruments for data collection subsidises the trustworthiness of a study. It was also suggested by Stake (1998) that using multiple instruments to collect data secures an in depth understanding of the phenomenon as well as contributing to the validity of the study as it adds thoroughness, breadth and depth to an investigation. This is supported by Anderson and Burns (1989) who say that 'when corroborative evidence results from multiple sources, the quality of evidence is enhanced.

During the interview process, although the interviews were recorded, extensive note taking also took place and that also contributed to the validity of the study. This is described by Joseph Maxwell (1992) as means of achieving primary descriptive validity as it observes behaviour as well.

To attain validity, data was collected over a period of 4 weeks which was divided into 4 to 5 lessons a week, depending on the time table. Notes were also taken after the lessons, as they were videotaped in order to know which areas needs improvement. McMillan and Schumacher (1993) also stress that it is important to take into account the participants' language; therefore learners were encouraged to fill in the questionnaires using the language they are most comfortable with.

They also concur that when research is conducted in the natural setting of the participants it allows the participants to reflect on the reality of their life experience more accurately especially during the interviews. Because of this, the study was conducted in the schools where the learners were familiar with everything and free to express themselves.

3.6 Research Design

According to McMillan and Schumacher (2001), a research design refers to a plan for selecting subjects and data collection procedures to answer the research question. It shows which individuals will be studied, when and under which circumstances (Babbie, 2001). The main purpose of the study was to have a comprehensive look at how to effectively integrate indigenous knowledge with school science, regarding lightning using argumentation. Therefore, the quantitative research design that was used in the study was the quasi-experiment model.

O_1	X	O_2	(Experimental Group)
O_3		O_4	(Control Group)

Figure 3.1: A quasi-experimental control group design

O_1 and **O_3**, represent the pre-test while **O_2** and **O_4** represent post-test observations. The vertical observations, **O_1** and **O_3** were assessed simultaneously at the pre-test stage while **O_2** and **O_4** were assessed simultaneously at the post-test stage. 'X', is the treatment condition, which was the dialogical argumentation instruction method. **O_1** was the grade 10 learners at my school and **O_3** was the learners of the nearby school. I felt it was pragmatic for the two groups not to be at the same school so as to avoid contamination in the results. The techniques used include questionnaires, open ended interviews and group observations during the practical activities. From the data collected learners' responses from the questionnaire about lightning were analysed. The pre- test and post- test responses were compared to see if learners' ideas about lightning have changed or not.

3.7 Data Analysis

Data analysis was eclectic, both qualitative and quantitative methods were used. The data collected was accurately scored, and systematically organised in a manner that facilitated analysis. The quantitative data set was analysed using the SPSS statistics programme version 22 (Field, 2009). This allowed for the re-check of the reliability values and normality of data sample scores in order to decide whether parametric or non-parametric statistics will be used. For qualitative analysis, the grouping of learner answers was done according to Toulmin's Argumentation Pattern (TAP) as well as the Contiguity Argumentation theory (CAT) descriptions. The TAP classifications were used mainly in the quantitative analysis while CAT was used mostly in the qualitative analysis of the data.

The pilot study was used to identify determine the fitness of techniques of data analysis in the study. The pre and post tests were marked and scores compared. Questionnaires and the interview questions were the administered instruments. Learners' conceptions of lightning were gathered using the COLQ and BALQ questionnaires. Both the control and experimental groups completed the same pre and post questionnaires. Initial conceptions about lightning were collected using the pre-tests of both questionnaires. The learners were asked to respond to each questionnaire with questions relating to lightning.

A Likert scale was used to find conceptions of learners on lightning. Learners were given statements where they had to choose whether they "Strongly Agree (SA), Agree (A), Disagree (DA) or Strongly Disagree (SD)" with the statement and give a reason for their choice. These were given ordinal numbers 4-1 respectively. The learners also had to identify their source for the reasons given e.g. personal, religion, culture or science. For the experimental group, the statements they chose were regarded as their claims and their reasons were the evidence or data supporting the claims made. The two groups also wrote a pre and post SATOL which was mostly syllabus orientated. This was used to determine learners' performance in science on the topic of electrostatics. The post test was used to determine effectiveness of the material in influencing conceptual change.

3.8 Pilot study

Prior to the main study, a pilot study was conducted at the school using the other grade 10 class while the other class was to be used as the experimental group. The pilot study served as a trial to the planned procedures, identify problems and find suitable solutions, (see Fraenkel and Wallen, 1996). This was done so as to check validity and simplicity of the questionnaire and interview questions so that they are not too difficult or too easy for the learners and that they can answer the research questions in the time set. The instruments were also piloted and checked by the SIKSP group in UWC and were improved accordingly. I chose a grade 10 class from another school as the control group so as to avoid contamination because if the control and the experimental group are at the same school contamination of results will definitely happen as learners will share information with each other.

3.9 Reliability

Reliability of the instruments was done through a series of strategies.

1. The instruments were examined by physical sciences colleagues from my school and the cluster in which the school belongs. This was done so as to determine the content related issues on the questionnaires and to check whether the SATOL reflects what was outlined in the syllabus on the NCS science content document for grade 10.
2. The SIKSP group from UWC helped to determine and construct related evidence of the BALQ and COLQ and some items were cut off and others were reconstructed.
3. The learners' statements have been quoted verbatim even with spelling errors so as to ensure validity of the interpretations of the data.
4. Xhosa statements were also cited and then translated in English.

For further reliability, the COLQ, BALQ and SATOL were subjected to Conbach Alpha co-efficient on the SPSS. The items were found to have an alpha value close to that of 0.72 for both groups. The table below shows the cronbach's alpha reliability co- effiences for the pre and posts tests for both groups on the SATOL.

Table 3.1: The reliability statistics of SATOL for both groups: pre tests

control group (pre- test)	
Cronbach's Alpha	N of Items
.735	20

Experimental group (pre- test)	
Cronbach's Alpha	N of Items
.685	20

Table 3.2: The reliability statistics of SATOL for both groups: post tests

Reliability Statistics control (post -test)	
Cronbach's Alpha	N of Items
.715	20

Reliability Statistics experimental (post -test)	
Cronbach's Alpha	N of Items
.697	20

In order to determine whether parametric or non- parametric statistical procedures were going to be employed in analysing the data, the pre and post- tests of the SATOL of both groups were exposed to the Kolmogorov-Smirnov test. This test was used to define whether the data was normal or non-normal. It was found that the pre-test of the control and post-test of the experimental group values were greater than the p value which is .05, according to Field (2009); such result means that the sample distribution is not significantly different from the standard normal distribution.

The table below shows the Kolmogorov-Smirnov significance of the two groups.

Table 3.3: The normality test for the SAT at the post- test stage

Control group						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Science Achievement Test Totals for Control group	.127	28	.200*	.942	28	.128
Post-test Control Group Science Achievement Test Totals	.212	28	.002	.894	28	.008

Experimental group						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Science Achievement Test Totals for Experimental group	.202	28	.004	.924	29	.039
Post-test Experimental Group Science Achievement Test Totals	.073	28	.200*	.980	29	.842

3.10 Lessons

Data was collected over a period of 3 weeks with 50 minute lessons each. The lesson plans (Appendix F) gave a comprehensive guidance to the teacher concerning the materials and equipment needed, the group sizes, the way to divide the learners, the tasks learners should do and the way to assign the tasks and the approximate time activities were expected to last. This is where the learners were introduced to the argumentation method. The lessons were designed in a way so that the learners would complete the worksheets on their own, then would discuss or share their individual responses with their group members and come to a consensus a the group. Each group would then choose a member to present their consensus claims and backings to the whole class for a whole class discussion. The class group discussions were video and audio taped for in-depth analysis of learner's discussions.

It has been found by many scholars that learners that come from different socio- cultural backgrounds experience school science as being different from what they are accustomed to. For smooth border crossing between the two world views, the CAT and the TAP have been used as the guiding frameworks in this study. The learners' worksheets that were completed were adapted from the TAP and the CAT so as to find out what are the claims, grounds and rebuttals made by the learners and what evidence they have for making those claims.

3.11 Interviews

The interviews consisted of seven open-ended questions (Appendix E). These questions allowed the researcher to follow up questions so as to have a better understanding of reasons the learners gave for holding certain views about lightning. Since the learners could not express themselves well in English, interviews were done in both English and Xhosa languages in which they expressed themselves well. The main purpose was to facilitate the verbal communication process by the learners as suggested by Shilongo (2007). Moreover, scientific terms were pronounced in English so that learners could be acquainted with scientific concepts that they had developed during the learning process.

Prior to the administering of the interview questions, they were piloted with the grade 10 learners of 2010 in the school as well as a grade 10 class of a school in Stellenbosch in order to find their beliefs on lightning. The four science educators at the schools agreed that seven of the 10 questions were answerable, clear, straight to the point and could answer the research questions. The interviews took place after the lightning lessons and were recorded with the permission of the respondents.

3.12 Questionnaires

Conceptions of Lightning (COLQ) and Beliefs about Lightning (BALQ)

The questionnaire had two sections. Section A was about the learners biographical data. This section had five questions which asked the learners about their age, sex, background and parents' education background and qualifications. Section B was about their beliefs and conceptions of lightning. These were answering research question 2 and 3. Section B had 10 questions which aimed at determining the learners' beliefs about lightning and whether they associated lightning with electricity. The questionnaires were administered before and after the lightning lessons (Appendix D and G).

The questionnaires required learners to answer questions asked as their claim and gave their reasons for their answer as the evidence to their claim and they also had to choose the source of information to support their reasons. The questionnaires were both in English and Xhosa for learners to provide relevant information as much as possible.

Piloting of the questionnaires took place at the same time as the interviews and was adjusted according to the results, comments and suggestions made. A pre and post-test of the same questionnaire was administered before and after the teaching of the topic. This was done so as to check if there was any change in the learners' responses after the lessons as well as to determine whether learners would have a better understanding of lightning from the scientific view after they have been taught using argumentation as a teaching and learning method.

Science Attitude Questionnaire (SAQ)

The Science attitude questionnaire (Appendix B) is aimed at determining the learners' attitude towards science and their culture and which of the two do they use most in their daily lives. The questionnaire had 5 questions where the learners had to write down what is their attitude towards science and had to give reasons for their choice of feeling. In the BALQ learners had to choose which statements from those given to them do they; Strongly Agree (SA), Agree (A), Disagree (DA) or Strongly Disagree (SD). These were allocated ordinal numbers 4-1 respectively except for when the statement was negative, the ordinal numbers changed to 1-4 respectively. The SATOL was syllabus orientated. It was used to determine the learners' performance in Physical Sciences' electrostatic topic. The questions included questions that are usually in the learners' physics question papers. The SATOL also aimed at determining whether the learners could recall the observations made and explanations during the practical activities in class and if they could apply the knowledge in similar situations.

Both the experimental and control groups wrote the same pre and post-tests at the end of the teaching. The paired sample t-test was done at 95% confidence level in order to determine the effectiveness of the materials in influencing conceptual change. Learners' responses were categorised into the 5 cognitive categories of CAT framework. According to Diwu (2010) the CAT categorises the responses of the learners depending on whether the statement chosen by the learner is more scientific or more on the IKS worldview.

3.13 Data analysis

3.13.1 Analysis of the questionnaire

Analysis of the questionnaires was done in order to find common cultural beliefs of lightning held by learners of the school where the study took place. The responses written in Xhosa were translated to English. Similar beliefs held by the learners were grouped together and put in a table and discussed to answer research question 2. The worksheets completed in class gave an idea of what learners understanding about lightning were both culturally and scientific. The pre and post questionnaires were used to compare the learners understanding of lightning and electricity prior and after the argumentation intervention. I analysed the learners responses according to their beliefs before and after the lessons whether they changed or not so as to see if their knowledge about lightning and electricity had improved and if they recognize the link between lightning and electricity. The pre and post questionnaires were analysed using the CAT as espoused by Ogunniyi (2007).

3.13.2 Analysis of Videotapes and Audiotapes

The videotapes and audios that were used to collect data were listened to after the lessons and relevant information was recorded for analysis. The audios were transcribed and recorded and the Xhosa responses translated to English. The videotapes helped the researcher to analyse and interpret the involvement of the learners in the lessons as well as their body language. These allowed me as the teacher to observe and improve my facilitation skills. I could also observe how learners interact with each other in their groups and the discussions that took place; all these were used as part of the discussion of the results.

3.13.3 Analysis of the Interviews

The interview tapes were also transcribed and analysed to answer research question 2, 3 and 4. As the interviews took place after the lessons, I used them to determine if the learners had a different or better understanding of the scientific view of lightning after the IKS incorporation and the discussions that they had or whether they did not change their views at all.

3.14 Data coding

All the variables were coded in accordance with requirements of the Statistical Package for the Social Science (SPSS) version 22 (Pallant, 2001)

The items of COLQ, BALQ and SATOL were coded and given nominal scales (see Appendix B and C)

Table 3.4 SPSS data coding of leaner questionnaire

Gender	Home language	Other language	Original Province	Type of Area	Guardian	Educational background	Frequency of reading books
Male= 1 Female= 2	Xhosa= 1 English= 2 Sotho= 3	Xhosa= 1 Zulu= 2 Sotho= 3	Western Cape= 1 Eastern Cape= 2 Gauteng= 3 Lesotho= 4	Urban= 1 Rural= 2	Mother= 1 Father= 2 Grandmother= 3 Grandfather= 4 Sister= 5 Brother= 6 Aunt= 7 Uncle= 8	Never= 1 Primary= 2 Secondary=3 Diploma= 4 Degree= 5	Never= 1 Once a week= 2 Once a month= 3 Once a year= 4

3.15 Research Ethics

All necessary steps were taken to meet the ethical requirements set up by the University of the Western Cape where I undertook my higher degrees study as well as the Western Cape Department of Education. An application was made to the WCED to conduct the research in the school as it is in its protectorate. Approval to conduct the study was granted by the principal and the governing body of the school as well.

The study took place during school hours so as not to disturb the day-to-day running of the schools and their timetables. As the physical science teacher I had to adapt the study to fit into the actual school curriculum so that on the long run no learner was disadvantaged. The learners selected to participate in the study were given consent forms to sign. The consent forms informed them about the general nature of the research as well as assured them of their anonymity and confidentiality of what would be collected. In this regard the schools involved were given fictitious names for the school where the experimental group was selected in order to protect the school’s identity.

3.16 Summary

How authentic a study is, depends on the strength of the research design (Naidoo, 2011). Hence in this chapter a strong argument was presented for the choice of the design used. This chapter has revealed the paradigm used as being that of constructivism using the theoretical framework of the TAP and CAT. The research design chosen was the quasi experimental as I was looking at two groups being taught the same content of work but using different methods. Data were collected from two groups coming from different schools but with similar backgrounds. One group was the experimental which was taught using dialogical argumentation, and the other was the control which was taught using the traditional chalk and talk method. Data were collected using various instruments: interviews, SAQ, SATOL, BALQ and the COLQ. In addition some lessons were observed and worksheets were completed by the learners.

This chapter also outlined the research methods used in-order to determine the effects of dialogical argumentation as an instructional method to teach electrostatics (including conceptions derived from the learners' IKS). Both qualitative and quantitative methods were used to analyse the data collected. Lastly, all necessary ethical requirements were strictly adhered to throughout the period of the study. The next chapter deals with the presentation and analysis of the results.

Chapter 4

Results and Discussions

Introduction

The focus of this chapter is to elaborate on the worldviews of the learners as revealed by their responses to the various instruments and the observations made during the lessons. Moreover, the chapter focuses on how learners deal with conflicting worldviews about lightning. The interpretation of results as well as comparing learners' pre- and post-test views after being exposed to argumentation instruction is presented in this chapter. For lucidity, the analysis of the results is framed around the research questions of the study, mentioned in chapter 1.

1. **What scientific and personal views do grade 10 learners hold about lightning?**

2. **How effective is a dialogical argumentation instructional model (DAIM) in enhancing the learners' understanding of lightning?**

3. **What cognitive shifts are noticeable between the learners' pre-test and post-test conceptions of lightning?**

In order to give a more robust quantification, analysis of the quantitative data is presented first followed by the qualitative data. As much as possible the findings are discussed within the framework underpinning the study.

4.1 Learners' scientific and IKS-based views of lightning

As discussed in the previous chapter, the learner's conceptions of lightning were gathered using the Conceptions of Lightning Questionnaire (COLQ). Both the control and the experimental groups completed the same pre- and post-test questionnaires. Initial conceptions of lightning were collected using the pre-test questionnaire. The learners were asked to respond to each questionnaire with questions relating to lightning.

The questions for the COLQ were derived from questions 6 to 10 in the Learners' Conceptions of Lightning questionnaire. The first question asked the learners if they believed there is a relationship between lightning and electricity. Question two asked if they believed that lightning was caused by witches. The third question was based on the dangers of lightning and asked if the learners believed that the effects of lightning could kill a person. The fourth question was on the explanation of the lightning phenomenon, the learners had to choose whether they believed that science or traditional belief explains lightning better. The last question asked if it helps to cover mirrors during a lightning storm.

Each question had four alternative response choices to which learners had to decide whether they were in agreement or disagreement with the statement. The Likert scale for the options is: **(SA)** = Strongly Agree; **(A)** = Agree; **(DA)** = Disagree; **(SD)** = Strongly Disagree. The conceptions about lightning were gathered from a group of fifty-six learners of which twenty-eight were from the control group (C) and the other twenty-eight were from the experimental group (E). The data were collected before and after the learners had been exposed to Dialogical Argumentation Instructional method (DAIM) or traditional teaching method. For ease of reference learner 1 (C 1) to learner 28 (C 28) represent the control group while learner 29 (E 29) to learner 56 (E 56) represent the experimental group.

4.1.1 Lightning and electricity

The learners' scientific and IKS-based views of lightning which are taken from conceptions of lightning questionnaire (COLQ) were analysed in table 4.1 below. For simplicity, the learners' responses to each question are classified into two- "agree" i.e. a combination of agree and strongly agree or "disagree" i.e. disagree and strongly disagree. This section focusses on the views of the learners from both the control and the experimental group in terms of the relationship between lightning and electricity. It also discusses how the learners back their claims or explain their views.

Table 4.1 Learners' pre-test conceptions of lightning

Category	Group	Agree	%	Disagree	%
There is Relationship between lighting and electricity.	C E	17 21	61 75	11 7	39 25
Lightning is caused by witches.	C E	4 7	14 25	24 21	86 75
Lightning can kill you.	C E	13 4	46 14	15 24	54 86
Scientific explanation of lightning is better.	C E	24 24	86 86	4 4	14 14
It helps to cover mirrors during lighting strikes.	C E	20 25	71 89	8 3	29 11

More than two-thirds of the learners in both groups believed that there is a relationship between electricity and lightning. About sixty percent of the learners in the control group believed that there is a relationship between lightning and electricity whereas 75% of the learners in the experimental group believed that there is relationship between the two. Even though there is a difference in the degree of their belief it is evident that both groups of learners believed that there is a relationship between the two.

About 64% of the learners from both the control and the experimental group did not believe that there is a relationship between electricity and lightning. It is therefore important to look at the reasons that they gave for their beliefs. Below are some of the reasons that these learners gave.

Learner E46: Because when it is lightning our parents used to say switch off the TV, so there is no relationship between them.

Learner E52: Lightning is caused by God when He is angry.

Learner E49: Well, I grew up believing that lightning is electricity because they have the same name in Xhosa (umbane). You cannot touch any metal while it is lightning because metal is a strong conductor of electricity. You would be struck by lightning if you touched the metal.

The learners who disagreed that there is a relationship between lightning and electricity seem to believe that lightning has nothing to do with electricity. However, they all acknowledge how dangerous lightning is. For instance, one learner (Learner E47) said, "there is a need to protect yourself from lightning because it damages your electrical appliances hence they need to be switched off when there are lightning strikes".

Another aspect about lightning that confused the learners was that in the Xhosa language, lightning and electricity use the same term (umbane) this makes it difficult for people to differentiate between the two and will not know which one is being referred to. According to these learners, umbane refers to two different things- electricity and lightning. Hence they claim that there is no relationship between the two. Some of these learners backed their claim by saying that lightning is natural whereas electricity is man-made. Hence, there is no relationship. Others back their claim by referring to what should be done when there is lightning but did not explicitly state why they believe that there is no relationship.

Most studies that dealt with cultural issues or indigenous knowledge highlighted that African learners experience a problem in understanding science concepts. During the study, it became evident that the learners experienced some difficulties in expressing themselves in English. During the learner-centred argumentation class discussions, some of the learners did not feel free to respond in English, those that tried to respond in English did not have enough vocabulary to express themselves in English and in most cases they resorted to speaking Xhosa. For this reason the questionnaires were translated in Xhosa. The use of the word *umbane* which refers both to lightning and electricity in Xhosa is one example that shows that English as the medium of instruction can be a learning barrier.

Fatnowna and Pickett (2002) argue that, when you control the learning and use of language you control the way in which people see and relate to the world around them. Other researchers believe that use of code switching (the use of more than one language in discourse) in science teaching can improve teaching and learning.

The language issue as a problem was also mentioned in Maselwa's (2004), thesis in which he investigated the effect of prior knowledge about lightning in the teaching of electrostatics. He argued that, some learners could be reluctant to give views because of lack of proficiency in English, which was the medium of instruction. Mahapa (2002) also highlighted the problem of English as the language of communication in schools. He suggested that learners should be encouraged to use the language they understand better in responding to questions (p.65); and that where necessary, the language of materials must be translated into local languages (p.176). According to Needo *et al*. (2002), code switching allows learners to think, to argue, and to classify their thoughts; it is a tool to understanding (p.312).

Some of the learners in both the experimental and the control groups seemed to have a dominant scientific view about lightning and could explain how lightning is caused by referring to formation of clouds and charges between the clouds. Another common belief was the avoidance of the use of electrical appliances when there are lightning strikes. This was explained as a relationship between lightning and electricity. We have seen that most learners believed that there is a relationship between lightning and electricity. Some of the learner's reasons for their view are listed below.

Learner C20: Lightning is caused by electricity. At the same time it is natural we find lightning in nature.

Learner C2: If there was not electricity there would not be lightning.

Learner E45: "They do have a relationship, except for the fact that electricity can be connected in our homes but they are similar in their effects e.g when shocked by electricity is the same as when shocked by lightning".

Learner E34: When there is lightning things that we use that uses electricity can be destroyed by lightning. Electricity attracts the lightning.

These learners, that are from both the control and experimental group, believed that lightning and electricity are interdependent though they acknowledge that lightning is a natural phenomenon whereas electricity is man-made. According to these learners electricity is the cause of lightning and there is no lightning without electricity. Some of the learners tried to back their claim using the fact that these two have similar effects and others argued that electrical appliances are destroyed by lightning and hence there is a relationship between electricity and lightning.

The findings in this section of the study suggested that for the majority of learners, the cultural worldview differs from the worldview of school science. Aikenhead (1999) describes this cognitive setting as collateral learning because learners are learning something in a school setting that is in conflict with their indigenous knowledge.

These findings can be aligned with the rainbow illustration of Jegede (1995) stating that "in the culture of Western science, learners learn that refraction of light by droplets causes rainbows; while in some African cultures, a rainbow signifies a python crossing a river or the death of an important chief. Therefore, for these learners, learning about lightning in science means constructing a potentially conflicting idea in their long term memory."

4.1.2 Causes of lightning

Learners from both the control and the experimental groups share similar views regarding the cause of lightning. As can be noted from table 4.1, about eighty percent of the learners from both groups believed that lightning is not caused by witches. However, the number of learners in the experimental group was more than those learners in the control group who believed that lightning was caused by witches. Only a quarter of the learners in the experimental group whereas about 14% of the learners in the control group believed that lightning were caused by witches. It is evident that most of the learners in both the control and the experimental groups did not believe that lightning was caused by witches. Below are excerpts of their responses from both groups.

Learner C4: It is caused by God and scientists.

Learner C 2: That's impossible to happen, lightning is nature. No one can cause it.

Learner C20: Lightning is caused by charges in the sky but in rural areas lightning is caused by witches when they want to kill someone.

Learner E52: Lightning is caused by God when He is angry.

Learner E49: True lightning is different from witchcraft lightning. True lightning can last up to hours but witchcraft lightning last up to a few minutes.

Learner E45: There is no such thing, there is only one person that can cause the lightning is God. Traditional doctors and also human being how can they do such a thing.

Some of these learners believed that lightning is natural and it is caused by God. According to these learners God sends lightning when he is angry. Others claim that it can also be caused by scientists but could not back their claims. Some of the learners claimed that there are two types of lightning. According to these learners there is one that lasts a few minutes (caused by witches) and another that lasts longer. However, some learners backed their claim saying that lightning is caused by charges. It is evident that some of these learners are backing their belief scientifically whereas others do not.

About twenty percent of the learners from both groups believed that lightning is caused by witches. Some of them claimed that it is caused by witches and traditional doctors. Some learners believed that it is only witches that cause lightning whereas others claim that it can also be caused by God. Nevertheless, all these learners claim that it is an act that resulted from anger. Some of these learners that are from both the control and the experimental groups gave the following reasons:

Learner C15: Traditional doctors are also selling the lightning to people who want to kill other people.

Learner C21: If someone says or do something you do not like, you can send lightning to the person.

Learner C16: Nobody can make lightning without witches.

Learner E34: In my village, when there is lightning there will be a person who dies because of lightning sent by witches.

Learner E47: Lightning is caused by traditional doctors to beat someone. There is lightning caused by God sometimes when He tells us that it is enough.

It is evident from these explanations that, the learners coming mostly from the rural areas of the Eastern Cape believe that lightning is sent by witches and traditional doctors when they want to kill someone they hate. These learners can be categorised as possessing a dominant IK view as Van der Linde (2010) has indicated that a conception becomes dominant when it is the most adaptable to a given situation.

4.1.3 Effect of lightning and protective measures

In the belief system of the Xhosa people, the ancestors were believed to be keeping watch over the living all the time. It was therefore mandatory for the living people to make sure that the link with the ancestors was kept viable through constant prayers or worship of them, for instance, slaughtering animals. It was believed that in return the ancestors protect the family from dangers such as lightning. Xhosa people believe that there are safety procedures that can be taken against lightning. This item was used to find out learners' belief on the preventive measures that one can take to protect their house from being struck by lightning. Below are the pre-test excerpts from the control and the experimental groups.

Learner C22: We always put a motorcar tyre on the roof. My grandmother says if there is a tyre on the roof the whole house is protected.

Learner C18: Cover all shiny things. Shiny things like mirrors can make lightning and burn your house.

Learner E29: You must consult a traditional doctor to give you muthi (traditional medicine) for protection because if lightning was sent to you it will come to you and burn the house and kill people, only a traditional doctor can help.

Learner E34: Ask a priest to pray for your house. Since I believe that lightning was caused by witches, only God can help chase the evil away.

Learner E31: The conductor is the best way to help to prevent lightning hit.

A great number of the learners in the experimental group felt that it is imperative that one protects him/herself from lightning by not standing next to the mirror or shiny things as these things tend to attract lightning. Some of these learners mentioned that their grand - mothers always told them to cover mirrors during lightning because if the lightning hits the mirror everything in the house will be damaged. In the control group, a number of learners believed that lightning is very dangerous and burns people to ashes and therefore the ancestors will not recognise them in such an instance. Some of the learners in the control group believed that "no matter how much you protect yourself, when witches want to kill you your protection will not work".

The learners in both the control and the experimental groups seemed to believe that putting a motorcar tyre on top of the roof of a house protects one from lightning strikes. They could not explain how this method of protection works, their claims are warranted by tales they heard from their grandparents who believed that burning a tyre calls the ancestors and chases lightning away.

In the experimental class, some learners suggested that when a small piece of a tyre is burned, it chases the evil spirits and hence it chases away the lightning. According to these learners lightning is an evil act. The learners who believed that lightning was caused by witches said that, going to traditional doctors is the best protective measure to avoid being killed by lightning.

The above section has shown that learners do come to science classroom with some prior everyday knowledge and experiences (Maselwa & Ngcoza, 2003; Maselwa, 2004; Pabale, 2006; Rennie, 2011) about natural phenomena in particular, lightning in the context of this study, which they have acquired from their community. Pabale's (2006) emphasized that when learners' cultural beliefs and experiences are included as examples when teaching science, it has an advantage of drawing learners' attitudes into the learning of science topics.

The results from the pre –test seem to indicate that the learners from both groups hold the same traditional views about lightning. These learner's statements above can be said to be in par with the findings in other lightning related studies. In Mahapa (2004); Maselwa (2002); Liphoto (2008) and Nanghonga 2012) in terms of how to protect one from lightning, it shows that learners even though coming from a different ethnical background have similar or common cultural views when it comes to this natural phenomenon. It was also reported in the above studies that; tall trees conduct lightning, people want to steal food or bag of mealy-meal, it is easy for witches to get into a hut made of grass than into main house, white objects attract lightning, bright objects attract bright light of lightning, mirrors conduct lightning, glass conducts lightning, mirrors reflect lightning and colour attracts lightning, red clothes conduct lightning.

The learner's post conceptions of lightning are discussed in the following section.

4.2 What cognitive shifts are noticeable between the learners' pre-test and post-test conceptions of lightning?

As mentioned in the previous chapter, both the control and the experimental group were introduced to the scientific view of lightning. A chalk and talk method (TLM) was used for the control group whereas a dialogical argumentation instructional method (DAIM) was used for the experimental group.

4.2.1 Lightning and electricity (post-test)

This section focusses on the views of the learners from both the control and the experimental group in terms of the relationship between lightning and electricity after they have been exposed to these two different teaching methods. The table below presents the learners' post- test responses to the COLQ. The post- test was administered after both the experimental and the control groups were exposed to the two teaching methodologies DAIM and TLM respectively.

About sixty-eight percent of the learners from the control group believed that there is a relationship between electricity and lightning after they have been exposed to chalk-and-talk instructional method. This was about sixty percent at a pre-test level. However, about 86% of the learners from the experimental group believed that there is a relationship between electricity and lightning at post-test level. The percentage increase for the control group is about 8% and is about 11% for the experimental group. Some of the learners from the control group who believed that there is a relationship between electricity and lightning gave the following reasons:

Learner C17: (SA): They can both cause fire or death and the things you must not do when there is lightning is the same with electricity.

Learner C6: (SA): Lightning attracts electricity, if you hold your phone when lightning, lightning will strike you. They make a mess when together.

These learners believed that the relationship between lightning and electricity as lightning attracts electricity. They said that one cannot use electrical appliances when there is lightning because the appliances will be attracted by lightning and get damaged. C6 makes an example that if you use a phone during a lightning storm, lightning will strike you. This shows that the learners have changed their view to a more scientific belief. In term of CAT, this is identified as a science dominant view.

Table 4.2 Learners post-test conceptions of lightning

Category	Group	Agree	%	Disagree	%
There is Relationship between lighting and electricity.	C E	19 24	67.9 85.7	9 4	32.1 14.3
Lightning is caused by witches.	C E	3 4	10.7 14.3	25 24	89.3 85.7
Lightning can kill you.	C E	3 1	10.7 3.6	25 27	89.3 96.4
Scientific explanation of lightning is better.	C E	26 28	92.9 100	2 0	7.1 0
It helps to cover mirrors during lighting strikes.	C E	22 24	78.6 85.7	6 4	21.4 14.3

According to these learners the effect and protective measures of both lightning and electricity are similar. These learners also believe that electric or electronic appliances such as mobile phones attract lightning. To these learners using such appliances is dangerous. The reasoning at the post-test level is similar that of the pre-test one. At the pre-test level, according to some of the learners from the control group, there is a relationship between lightning and electricity because: lightning destroys electric appliances when it strikes hence they must be switched off, electricity attracts lightning therefore it is advisable that one avoids being close to or use electric appliances during a lightning storm. It is evident that even at the post- test the reasons given by some of the leaners from the control group do not have strong backing as they make claims without warranting them or backing them with valid scientific evidence. Even though the learners' responses did not have strong data to back the claims made, their statements are evidently IK suppressed into science.

It is also important to see how the learners from the experimental group back their claim about the relationship between lightning and electricity. Some of the learners from the control group who believed that there is a relationship between electricity and lightning gave the following reasons:

Learner E50: (SD): Lightning is formed by charges when raining; electricity is made with coal and used to light our houses. Electricity is not very dangerous like lightning.

Learner E46: (SA): If you are busy using electricity while it is lightning, you will die because there is a relationship.

Learner E41: (SA): Lightning is also static electricity and there are charges involved in formation of lightning.

The learner who did not believe that there is a relationship between lightning and electricity backed their claim based on different grounds: one said that lightning is formed by charges in the clouds and electricity is made of coal therefore there is no relationship between the two. The learner also mentioned that electricity is used positively as it used as a source of light and energy whereas lightning is dangerous. It is evident that this learner sees lightning and electricity as two different entities that cannot be compared.

The learners who agreed at the existence of a bond between lightning and electricity based their arguments at the similarities in the formation of both electricity and lightning raising the scientific fact that they are formed by charges attracting each other. It is evident from this study that the learners who were exposed to the dialogical argumentation instruction method gave more scientific reasons regarding the relationship between lightning and electricity than those who are exposed to chalk-and-talk instruction method. These learners who took part in argumentation activities showed evidence of having made significant conceptual gains with regard to the explanation of a relationship between lightning and electricity. This corroborates the findings of Skoumios and Hatzinika (2009). In terms of the CAT it is evident that the reasons that the learners gave are more scientific. Therefore they seemed to express a dominant science worldview in the CAT classification.

4.2.2 Causes of lightning (post-test)

At post-test level most of the learners from each group did not believe that lightning is caused by witches. More than 85% of the learners from each group believed that lightning is not caused by witches. The number of learners who believed that lightning is caused by witches has decreased from four to three in the control group whereas the number of learners from the experimental group was decreased from seven to four.

When learners had to give their opinion based on the statement that: lightning can kill you, the results were as follows. About eighty-nine percent of the learners from the control group in the post-test believed that lightning cannot kill them whereas more than 95% of the learners from the experimental group believed that lightning is something that can be avoided by taking some protective measures and hence it cannot kill them. These protective measures are discussed at a later stage in the chapter.

All the learners from the experimental group believed that science explains lightning better whereas about 93% of the learners from the control group believed so. However, in terms of covering mirrors during a lightning storm, it was evident that most of the learners from both groups believed that a mirror attract lightning hence it has to be covered during a lightning storm. These learners believe that shiny items attract lightning. This is a belief believed to be picked up from their grandparents. Even though during the lessons there was no scientific evidence regarding covering of mirrors, the learners seemed to still believe that mirrors should be covered during a lightning storm. Jegede (1995) mentioned that learners will accept the scientific truth as a fact when at school, but they will revert to their original beliefs when at home. According to Cobern (1996), most learners practice what he calls ‘cognitive apartheid’, he believes that they simply wall off the concepts that do not fit their natural way of thinking. He says,

> The learners create a compartment for scientific knowledge from which it can be retrieved on special occasions such as a school exam, but in everyday life it has no effect… the compartment walls hold as long as there is pressure such as a pending exam … once the pressure is relieved (exam is over) the walls go and the concepts revert to forms more consistent with the learners’ worldview or simply deteriorate for lack of significance (p.588).

In this item both groups seemed to portray an underlying equipollent worldview in the CAT classification. An equipollent conception is said to occur when two competing ideas or worldviews exert comparably equal intellectual force on an individual (Van der Linde, 2010). These ideas or worldviews tend to co-exist in the learners mind without necessarily resulting in a conflict.

4.2.3 Scientific beliefs and cultural beliefs on lightning

As depicted in the table 4.3 below, the learners in both groups were classified into three-

(1) Those that have scientific belief only,

(2) Those who have cultural belief only and

(3) Those that have both cultural and scientific beliefs.

Two learners from the control group shifted from a cultural to scientific belief. Nevertheless, two learners were stuck between the cultural and scientific belief. The number of leaners who possess the scientific belief was increased by three in the experimental group. One learner shifted from cultural belief to scientific whereas two more learners shifted from both cultural and scientific to scientific.

Jegede (1995) states that, the African metaphysical thought will investigate as to why an incident has occurred while both the Western and African thought rely on objectivity. For example, when lightning strikes a person that is usually interpreted in personal terms in an African perspective. These personal terms refer to other humans (witches or traditional doctors), ancestors, a spirit or a god. This implies that when lightning strikes, it can be explained in western terms as a discharge of charges and that will be logical but a learner from non-western origins will go further and say: who sent the lightning?. More learners in the experimental group were found to have shifted to the scientific belief as compared to those that were in the control group.

A possible contributing factor to the experimental group's change of conceptions could probably be because of the intervention method (DAIM) which was used to teach the experimental group. Research studies that have shown that learners who use dialogical argumentation strategies acquire higher and more permanent cognitive gains, amongst others, include Asterhan & Schwarz, 2007; Diwu, 2010; Skoumios & Hatzinika, 2009; van der Linde, 2012 and Aufschnaiter et al., 2008. The DAIM, as an enquiry method, involves learners actively in constructing knowledge through the argumentation activities.

Table 4.3 Learners' pre- and post-conceptions of lightning

Group	**Scientific belief only**	**Cultural belief only**	**Cultural & Scientific Belief**
Control: Pre-test	17	9	2
Post-test	19	7	2
Experimental: Pre-test	21	5	2
Post- test	24	4	0

None of the learners from the experimental group believed in both scientific and cultural belief at the same time whereas there were two leaners from the control group who believed in both. It is evident from this study that Dialogical Argumentation Instructional Method gives an opportunity to make sense out of two conflicting views. It also helps learners to reason out and internalise the conception and have a stronger belief being it cultural or scientific.

4.2.4 Learners' beliefs about lightning

The beliefs about Lightning questionnaire (BALQ) were also used to determine noticeable cognitive shifts between learners' pre- test and post- test conceptions of lightning. The aim of the questionnaire was to find out how learners' conceptions about lightning changed from the pre-test stage to the post-test stage. The learners wrote the pre-test before the instructional intervention took place. It can therefore be assumed that the pre-test conceptions are their own beliefs. On the other hand, their post-test beliefs reflected their beliefs after the intervention. The questions or stories constituting the BALQ were cited within the cultural ambiance of the learners and had the following themes: causes of lightning; behaviour of lightning; protection against lightning and the nature of wounds inflicted by lightning. It was up to the learners to decide whether or not their responses to a story would be based on scientific or indigenous knowledge. The data was analysed using Toulmin's Argumentation Pattern (TAP) and Contiguity Argumentation Theory (CAT) in order to identify the cognitive shifts. The results are presented below.

The Beliefs about Lightning questionnaire (BALQ) was used to gather the learners' beliefs about lightning. An independent sample t- test was conducted to compare the learners' pre- test beliefs about lightning between the two groups. The results show that there was no significant difference in scores between the control and the experimental group. In the experimental group: (M= 12.9310, SD=1.6). In the control group: (M=13.2, SD=1.8). $t(55)= -.695$, $p=0.4$ ($p>0.05$). The magnitude of difference=0.32; 95% CI -1.24 to 0.601 was very small. This shows that before the DAIM was implemented, both groups were comparable.

4.2.4 Definition of lightning (pre and post- tests)

The first question in the Beliefs about lightning (BALQ) asked learners to give a definition for lightning. After the pre-test was administered and different methods used, the learners completed a post test on the same questionnaire (BALQ).

Below are the excerpts from the learners' responses.

Experimental group responses:

Learner E29 (pre): **Claim:** Lightning is caused by witches

Evidence: Because witches use lightning to kill people and it is caused by amagqirha (traditional doctors).When people are having a fight they go to a traditional doctor and pay them money or goat so that they send lightning to hit their enemy.

Learner E29 (post): **Claim:** Lightning is a natural phenomenon.

Evidence: Lightning is caused by the negative and positive charge because when the clouds become dark the charges attract each other.

Learner E31 (pre): **Claim:** Lightning is a natural phenomenon sent by God when he is angry

Evidence: It just happens and only God knows when it is going to happen.

Learner E31 (post): **Claim:** Lightning is a large spark.

Evidence: Because lightning conducts positive and negative charges

IKS-Dominant view

CAT interprets an interaction of ideas as an attempt to attain cognitive harmony or equilibrium through a coupling process similar to that of competition, accommodation, integrative reconciliation and adaptation (Ogunniyi, 1988).

In the pre- test, a majority of the learners claimed that lightning is caused by witches or sent by traditional doctors. They believe that the witches and traditional doctors use lightning to kill people they have disagreements with. Their beliefs come from their experiences from the areas they grew up in. Other learners believed that lightning is a natural phenomenon which no one has control over. This belief then rebuts the claim that lightning is caused by witches or traditional doctors. Learner E31 further says that only God controls what happens around us therefore He is the only one who knows when there is going to be a lightning storm/strike. Learner E29 believes that witches use lightning to kill people.

Science- Dominant view

Twenty four learners of the experimental group, who were exposed to the Dialogical Argumentation Instruction Method (DAIM), seemed to prefer the scientific conception over that of IKS when explaining how lightning is formed. According to the Contiguity Argumentation Theory (CAT) that means that the scientific conception of lightning became dominant.

In the post test the learners from the experimental group showed a great shift in their beliefs about lightning from traditional view to the scientific view. In twenty four learners, the scientific conceptions of lightning became dominant while the traditional one was suppressed. For four learners, the traditional conceptions were the dominant ones while the scientific one was suppressed. None of the learners in the experimental group exhibited the equipollent state.

Control group pre- test responses

Learner C18: Claim: Lightning is natural

Evidence: It happens naturally so there is nothing that can cause lightning.

Learner C22: Claim: Lightning is caused by witches

Evidence: When witches are fighting someone, they make lightning and send it to that person.

In two learners of the control group both competing ideas (scientific and traditional) were seen to put forth equal force in the learners' mental state (equipollent stance). Thus learners used them both in responding to some questions. Ideas in the equipollent stage are said to co-exist, without possibly resulting in any conflict (Ogunniyi, 2007a; Ogunniyi & Hewson, 2008).

In the control group, the learners also had the same beliefs as the experimental group. The most dominant belief was that lightning is caused by witches. The pre- test indicated that both groups showed the same conceptions of lightning; there was no major difference between the two groups. A majority of the learners come from the Eastern Cape where it is mostly reported on newspapers that people are being killed as they are believed to be witches that cause lightning. When a house gets struck by lightning and someone dies, a witch will be blamed for the act and hunted down and killed.

4.2.6 Protection from lightning

Another item on the questionnaire dealt with how one would protect their house from being struck by lightning. This is one of the post-test responses:

Learner E32: Claim: Use a lightning conductor

Evidence: When there is a lightning storm, a lightning conductor will attract the lightning to it and therefore protect the house.

At post-test level this learner from the experimental group seemed to believe that the best way to protect your house from being struck by lightning is to use a lightning conductor. Evidence to back the claim was based on how the lightning conductor works. The learner believed that the lightning conductor will attract all the lightning to it and the house will be protected.

In this item the learners seemed to exhibit the equipollent comportment of CAT as they accepted both the traditional and scientific methods of protection from lightning. Below is the summary of the methods or precautions that learners believe should also be observed during a lightning storm.

- Never play outside the house when there is a lightning storm.
- Do not play or hide under the trees especially tall trees.
- Never touch water, lightning likes water.
- You must not eat mphokoqo and amasi (maize meal porridge with sour milk…this is the staple food for Xhosas and is eaten every day in the rural areas).
- You are not allowed to read or open books during a lightning storm as lightning attracts white things.(hence you are not allowed to eat during a storm because you will show your teeth and therefore call lightning to you)

- Do not sit next to a window as lightning is strong when coming in, it will hit you if you are sitting next to a window. It is also believed that, there must be a window that is open so that if lightning comes in by mistake it can go out again.
- Cover all mirrors and shiny things. For example: spoons are shiny, hence you are not allowed to eat during a lightning storm.
- Do not switch on electrical appliances especially the TV.

These kinds of explanations indicate that the learners hold strong cultural beliefs about lightning. These beliefs have been found to have developed through learners' interaction with their community members. According to the Contiguity Argumentation Theory (CAT) this implies that in the pre-test on ways of protection from lightning, the learners hold a dominant indigenous knowledge view and the science view was emergent.

These findings also validate the fact that when a learner experiences a conflict between some conceptions, the learner tends to either castoff the new information based on school science experience. This is called the assimilation stage. In other circumstances, the learners will somewhat accommodate the scientific view within their cultural worldview as in the case with the above. Learners who fall under this category are said to be in an equipollent state. It is evident from this study that leaners come to classrooms with some pre-conceptions about lightning and that indeed the ideas that learners bring to science classrooms need to be addressed through appropriate learning programmes as also espoused by Mahapa (2002).

During the argumentation lessons with the experimental group, a few of the arguments made by the learners had only a claim but not evidence to back the claim made. These claims had no grounds or rebuttals. According to the Toulmin's Argumentation Pattern (TAP), these arguments can be classified as Level 1 arguments. A Level 1 argument is an argument that involves a claim with no grounds or rebuttals. An example would be a claim made by Learner E34 who when asked to give a cause of lightning, she said 'lightning is caused by witches'. This learner had no backing or warrants for her statement.

Most of the arguments made by the learners can be classified as Level 2, arguments with claims or counter claims with grounds but no rebuttals. This was evident when learners were discussing the ways in which one can protect himself/herself from lightning. The grounds on which their claims were based came from their life experiences and traditional beliefs. For instance, Learner E35, to justify her claim that we should cover mirrors during a lightning storm: she said that 'the mirror is shiny and lightning attracts shiny objects or material, therefore to protect yourself from being struck by lightning all shiny objects (including mirrors) must be covered'.

Other grounds based on the same claim stated that: if your mirror is not covered witches will see you on the mirror and make lightning strike you. According to Jegede (1995) the socio-cultural background of the learner may have a greater effect on education than does the subject content. It is evident that the ideas that the learners come with are experiences shared with the community. Jegede (1995) espoused that learners will accept the scientific truth as a fact when at school, but they will revert to their original beliefs when at home.

There were only a few learners who were opposing this claim on the grounds that only God can protect us from lightning as he is the One causing lightning and controlling everything on earth. Some learners came with a question that asked: how would one protect themselves when they are driving a car? They said that a mirror in a car are used by the driver to be able to see other cars on the road, therefore you cannot cover them. This therefore means that you are not protected from a lightning storm when you are driving a car. As a counter claim, it emerged that when you are in a car, you are protected by the tyres of the car hence some people burn car tyres in their homes to protect themselves from lightning.

Van Wyk (2002) argues that learners' everyday knowledge and nature of science supplement one another. During the argumentation lessons the learners were collaboratively working in small groups. This gave learners an opportunity to share ideas and to reflect on what their parents used to tell them about lightning. They were thus able to think intuitively and synthesise their cultural beliefs and experiences from their own context. According to Hewson, et al. (2009), prior everyday knowledge directly impacts the learners' ability to accept new ideas.

4.3.1 How effective is DAIM in enhancing the learners' understanding of lightning?

This question aimed at finding out if there was any difference between the changes in conceptual understanding of lightning by the learners exposed to dialogical argumentation instructional method (experimental group) as compared with those not exposed to it (control group). The null hypothesis was that there was no difference between gains in conceptual understanding of lightning by the experimental group learners and control group learners. The alternative hypothesis was that there would be a difference between the two groups. In comparing the experimental and the control groups, the pre- test and post test results of the beliefs about lightning (BALQ) which tested the learners' conceptual understanding of lightning and the Science achievement test (SAT) which tested the physical science content on static electricity taught during the science lesson as prescribed by the Department of Education.

Below are the inferential statistics using the paired sample t-test to compare the two groups. The t critical value for both groups was found to be 2.05. The experimental group's mean rank score was significantly higher at 14.9 as compared to the control group's mean rank score of 3.6. Independent group t-test value gave a significance at t = 2.42; p = 0.023 for the control. For the experimental group t was 7.19 with a significant value of .000.

Table 4.5 Pre-post-test paired sample of the control and the experimental groups

Group	Mean	Std. Dev	t	Df	$Sig_{(2\text{-tailed})}$	$t_{critical}$
Control	**-3.6**	**7.9**	**-2.42**	**27**	**.023**	**2.05**
Experimental	**-14.9**	**11.2**	**-7.19**	**27**	**.000**	**2.05**

Alpha at .05

The results above indicate that the experimental group which was exposed to the Dialogical Argumentation Instructional Model (DAIM) show a significantly higher improvement in the results than the control group. This was based on their conceptual understanding of lightning in the pre and post-test results of the Science Achievement Test (SAT). Both groups wrote the same test. Therefore this shows that the experimental group learners learned the concepts of lightning better than their counterparts in the control group. The experimental group learners exposed to a DAIM participated fully in all the activities and argued their points of view freely. As opposed to the experimental group, the control group learners were always expected by their teacher to give correct scientific answers. This seemed to have had a negative effect on the learners' performance as shown by the results (Ogunniyi et al, 1995).

Table 4.6 Post-test results of Mann-U test on SAT and COL

Group	Variable	N	Md	Z	U	P	Conclusion
Control Experimental	SAT (Post)	28 28	38.5 55	-2.335	260	0.020	Significant (difference=16)
Control Experimental	COL (Post)	28 28	22 25	-4.709	114	0.00	Significant (difference=3)

A Mann- U test was also conducted on the post test of the science achievement test on lightning and on the conceptions on lightning questionnaires. The Mann-U test was chosen in order to compare the median between the two groups. In the post–test of the science achievement test on lightning the Mann-U test revealed a significant difference. In the control group: (Md=38.5, N=28). In the experimental group: (Md= 55, N= 28): U= 260, z = -2.34, p = 0.020 and diff = 16.

The results of the Mann- U test reveal that the experimental group performed better than the control group in both the science achievement test and on the conceptions on lightning questionnaire. A contributing factor to the better performance of the experimental group might be as a result of the instructional method (DAIM) that was used to teach the experimental group. Argumentation is an effective instruction in enhancing learners' understanding of science and has been well supported by these studies Ogunniyi, 2004, 2005, 2007a & b, 20011; Osborne et al, 2004; Simon et al, 2006 and Erduran, et al, 2004.

To evaluate the impact of DAIM on learners' conceptions on lightning, a paired- samples t-test was conducted. It was found that there was a statistically significant improvement in scores of the experimental group in the conceptions of lightning questionnaire. Pre-test showed (M= 20.44, SD=3.59) whereas in post-test (M=22.7, SD= 3.85) t (56) = 3.097, p= .003(two-tailed). The mean increase in the COL scores was 2.26 with a 95% Confidence Interval ranging from -3.73 to -.799.

A Wilcoxon Signed Rank Test also revealed a statistically significant positive improvement. In the science achievement test scores, following the learners in the experimental group being taught in the DAIM. The results showed that Z= -5.166, p< .001, the median score on the SAT increased from pre-test (Md=38) to post-test (Md=45).

In all the tests conducted above, the experimental group performed better than the control group. The experimental group showed a significant improvement on the mean rank scores and the median scores of the COL and SAT. A factor that might have contributed to the experimental group's better performance is the instructional method used to teach the group. The experimental group was exposed to the DAIM and hence, it can be concluded that the DAIM might have been responsible for the high performance of the experimental group.

4.4 Results from learners' interviews

Learners from the experimental group (E) were chosen to take part in the interview session. The interviews took place after the learners were exposed to dialogical argumentation as a teaching method. The interviews were meant to determine what the learners had learned from DAIM as a teaching method so as to help answer research question 3 as well. They were also interrogated on how this teaching method affected the way they took decisions on relevant daily issues. The interview questions focused on:

- The learners' view before and after the use of DAIM.
- How DAIM might have impacted on the learners views.
- Whether or not a continued use of DAIM would make any difference in their understanding of lightning.

- Whether or not the integration of IK with science improve their understanding about the similarities and differences between the scientific and the indigenous conceptions of lightning.

In response to the question that asked about the learner's views on lightning before being exposed to DAIM, an analysis of their responses showed that majority of the learners said they believed in the traditional view of lightning. Most of the learners said that lightning is caused by witches. This knowledge came from stories told by grandparents and members of the community. After being exposed to the DAIM some learners had accepted the scientific definition of lightning but some were stuck to the traditional way of protecting themselves and their homes from lightning. A few believed in the traditional view claiming that they had experienced and had evidence that people can send lightning to others. Responses that the learners gave for the questions are presented below.

1. What were your views about lightning before the science lesson?

Before the science lesson, fifteen learners said they believed that lightning was made by human beings, such as Sangoma (traditional doctors) and witches who in their opinions would create it to kill fellow human beings, or could be as a result of a fight between a witch and a traditional healer**.**

Learner E55: I know that lightning is the light that is done by witches and traditional doctors fighting with their mates.

Learner E29: Lightning can be sent to someone by a sangoma. If I am angry with someone in this class I will go to traditional doctor to hit him or her by the lighting.

Learner E38: Lightning is when God is speaking to his people.

Learner E37: I thought it is made by ancestors when they are angry and I also thought it is made by witches as well.

Learner E47: My views about lightning was that when clouds in the sky meet or attract each other cause a big sparks that called lightning.

Five learners believed that the lightning was caused by God either when he was angry or wanted to speak to his people. Four learners believed that lightning is a natural phenomenon caused by charges that are in the atmosphere when they attract each other in the sky and cause it. Two learners believed that lightning was caused by the ancestors when they were angry and wanted to punish someone. Two learners believed that it was caused by Impundulu or augurs for its coming.

Aikenhead, (2002) contends that learners bring into the science classroom, their ideas about diverse phenomena, which they have learned through traditional beliefs, values and practices. In this question it became evident that a majority of the learners believed that lightning is caused by witches, traditional doctors, ancestors and God.

In terms of CAT, these learners can be said to be in the emergent worldview. They have not been exposed to any other explanation of the cause of lightning; therefore the science explanation does not exist yet in their world. Only four learners seemed to be exposed to the science explanation.

2. **What are your views now (after the lesson)?**

To the question regarding the learners' views at post-test and if they have changed; all 28 learners of the experimental group acknowledged that their views had changed. The learners tried to show how their views had changed by explaining how lightning occurs. They voiced how they now believe that lightning is not man made. Four of the learners claimed that their views remained unchanged.

Learner E55: I know that lightning is formed by water droplets, clouds and positive charge and negative.

Learner E29: Yes I learned more about lightning. I am well aware about lightning, I also know now that it has nothing to do with witchcraft. I understand how it works and I know how it is formed.

Learner E38: **I still believe the way I believed before; I have not changed anything about my beliefs.**

Before the DAIM was administered, a majority of the learners believed in the traditional causes of lightning (IKS world view) as most of them believed that lightning was caused by witches. At the post-test the same learners had changed their beliefs to the more scientific worldview ('I know that lightning is formed by positive and negative charge'). In terms of CAT it can be argued that the learners had suppressed or assimilated the traditional view and had changed to the more scientific explanation. This also shows the effectiveness of DAIM that learners came to class with different views but due to sharing ideas and arguing about their views, they came to a consensus and also changed their views to be more scientific.

3. **Has argumentation had any influence in your thinking?**

This question wanted to find out if arguing about the topic with other learners has made any impact on the learners' views. Twenty four learners responded that it had an impact, while four learners responded that it did not make any impact. Subsequently of those who responded that arguing made an impact or influence, eight learners believe that the sharing of ideas made them to understand better and twelve learners were convinced that sharing ideas made them change their views.

Learner E33: I believe in the fact that by arguing and debating you can gain something you did not know before and therefore learn new things.

Learner E45: When I started hearing that lightning was not happening when sangomas are fighting, I thought that physical science is lying but when we discussed as group I ended up understanding that it was not possible for sangoma to send lightning.

The four learners who said that argumentation did not make them change their views about lightning possess the dominant IKS view. These learners did not change from their previous beliefs even after arguing and being taught about the scientific view of lightning. They still hold strong traditional or cultural views. The rest of the learners responded that argumentation made a positive impact in their understanding of the topic of lightning. This made them to change from their previous claims that lightning was caused by witches to the scientific explanation (suppressed worldview). They claimed that argumentation also improved their sense of understanding based on the information shared with other learners. One learner went further to say "in my class we have different cultures, therefore different opinions about lightning. During argumentation we all shared our views and came to a consensus about one belief.

4. **Will argumentation make you understand science better?**

Newton, Driver and Osborne (1999) and Driver, Newton and Osborne (2000) strongly expressed that argumentation is a critically important epistemic task and discourse process in science. On the question of knowing if arguing about science topics can make them understand the topics better; twenty seven learners believed that by arguing about science topics, they get different opinions, which in turn make them understand better what they are learning. One learner seemed to think that arguing will only result into getting wrong ideas.

Learner 44: Basically science is the subject that is always concerned about arguments, by arguing we can understand things more easily.

The learners seemed to have the same view that 'using argumentation in science topics made me understand better as others come with many different views that I did not know and some explained the topic clearly' (said one learner). Another said 'Now I know how to protect myself properly from lightning because we all talked about it and shared our views, I no longer believe in the traditional method because there is no evidence about it'. These learners believed that argumentation helps them to talk with each other and share ideas. They get to learn from each other therefore making it easy to understand the topic being taught.

When learners are taught using argumentation through the use of appropriate activities and teaching strategies, that can provide a means of promoting a wider range of goals, including social skills, reasoning skills and the skills required to construct arguments using evidence (Osborne, Erduran, & Simon, 2004b; Simon, Erduran & Osborne, 2006). Incorporation of argumentation also involves learners in discussion (Mortimer & Scott, 2003; Alexander, 2005).

Only one learner seemed to be against using argumentation in science and preferred the teacher to do the talking. His reason was that when we rely on other learners for information, they might give us wrong information. This learner's reasoning seemed to be based on trust issues. It seemed as if he does not trust what his peers might be saying, whether they are right or wrong therefore he prefers the teacher to use the traditional method (chalk and talk). Kuhn, (2005) is one of the many researchers who are of the view that argumentation is a powerful strategy for teaching and learning science education.

5. **Should traditional knowledge be infused into science lessons?**

Twenty four learners in their response to this question thought that traditional knowledge should be infused in science lessons as they have some similarities. Four learners did not agree with the idea, they argued that traditional knowledge is not proven and somehow confusing; hence it cannot be infused in science lessons.

Learner 47: Yes because some of the traditional knowledge are similar with science and therefore traditional knowledge makes understanding of science easier.

Learner E35: No, because some of our traditional knowledge is not true so they could be confusing at some points.

The learners who wanted science to be infused with IK believed that would make them understand science better. They argued that IK is easier to understand as it is knowledge they grew up with and science is something new that they do not know. It would be easier to teach the 'new' using the 'old' they said. One learner made mention that their class had a lot of different cultures therefore it was interesting to hear beliefs of others in class. Some learners said that IK has a lot of science in it but people seem not to be aware of that. They believed that most of the things that people do are mostly scientific. They made mention of covering of shiny objects during a lightning storm: covering mirrors is believed to be traditional knowledge, but the idea that lightning attracts shiny things is scientific. Therefore these learners can be classified according to CAT as portraying an equipollent worldview in terms of science – IKS.

Two of the learners who were against using IK in science lessons came with reasons that: IK is old knowledge; therefore it will confuse learners and make them not to understand science. They also seemed not to believe in the traditional knowledge saying that it was not a true knowledge because it cannot be proven but everything in science can be proven. Therefore they said that infusion of science and IK is not a good idea. These claims can be classified as level 2 in terms of TAP and in terms of CAT these learners can be classified as possessing a dominant worldview in favour of science.

The other two learners portrayed a dominant worldview in favour of IK. They said that science can learn a lot from IK. IK has been there since the beginning therefore can be trusted. They also made mention of the fact that some of the things that science doctors cannot do, traditional doctors can do. It was also raised that IK is wide and therefore involves a lot of cultures; therefore it would be difficult to infuse the two. As previously mentioned there were learners from different cultures (Xhosa, Sotho and Zulu) in the experimental class, therefore these learners believed that it will be confusing trying to infuse every culture into science.

During the interviews, it was evident that the learners' responses were compatible with Maselwa and Ngcoza's (2003) findings in their study that, working collaboratively in small groups provided them with an opportunity to share ideas. It gave them an opportunity to reflect on what their parents used to tell them about lightning. They were thus able to think intuitively and synthesise their cultural beliefs and experiences from their own context. Van Wyk (2002) also contends that learner’s everyday knowledge and nature of science supplement one another. According to Hewson, et al. (2009), such prior everyday knowledge directly impacts the learners' ability to accept new ideas.

Effect of DAIM on learners’ attitude towards science

The Science Attitude Questionnaire (SAQ) was used to determine the attitude of learners towards science. Both the experimental and the control group were given the same questionnaire to complete. The pre and post-tests showed that the learners had a positive attitude towards science. The learners also mentioned that they believe that science is relevant in our real lives as everything around us involves science.

Table 4.7 Comparison of learners' pre- and post-test attitudes towards science

Category	Group	Agree	Disagree
Interest in Science	**C**	**28** **28**	
	E	**28** **28**	
Understanding Science through IKS	**C**	**23** **19**	**5** **9**
	E	**24** **24**	**4** **4**
Relevance of Science in real life	**C**	**26** **25**	**2** **3**
	E	**22** **24**	**6** **4**
Believe in IKS than Science	**C**	**12** **8**	**16** **20**
	E	**8** **4**	**20** **24**
Use Science only for exam purposes	**C**	**7** **6**	**21** **22**
	E	**6** **4**	**22** **24**

During the interviews most of the learners in the experimental group had strong views about the inclusion of IKS in science lessons. Some showed a science dominant worldview while others displayed an IK dominant worldview. A majority of the experimental group seemed to be in favour of inclusion of IK into science learning, therefore showing a science-IK equipollent worldview. Below is a table showing the pre and post test results.

The results from the table are scrutinised below.

Interest in science

Interest is a key factor that contributes to the learners' participation in teaching and learning of science (Millar & Osborne, 1998). According to Duschl et. Al, (2006) the learners' attitude towards science plays a vital role in science learning that result in deeper understanding of science. According to table 4.7 the learners in both the control and experimental group showed that they had a positive attitude and interest towards science at pre and post- test. The excerpts below

Learner C11 Pre: Science is interesting because it gives many opportunities than other subjects.

Post: We learn interesting things in science

Learner E52 Pre: It makes us see the world differently

Post: We explore a lot of things we did not know about. Also it is fun.

Other factors that affected learner's interest in science are the tactics used by the teacher to teach science (Odubumni & Liphoto, 1999). The use of DAIM did not seem to have an effect on the attitude of learners towards science since the learners were already positive about science.

The learner excerpts above show that there was no significant difference between the two groups. Therefore it can be concluded that all the learners in the study had a dominant worldview in terms of interest and attitude towards science.

Understanding science through IKS

At pre-test, twenty three of the learners from the control group said using IK made them understand science better, whereas five learners disagreed. The learners who disagreed said that using IK and science at the same time confuses them as they do not know which one to believe in. These five learners can therefore be classified as holding a scientifically dominant worldview. At the post-test the number of learners with the dominant scientific worldview increased to nine. This increase might have been caused by the instructional method used by the teacher in the control group. Luft (1998) suggests that if there is a lack of cultural examples in science, it may result in learners holding views that they cannot participate in science. According to Hewson, Javu and Holtman (2009), IK enables learners to learn science within their cultural context. This can be viewed as giving the learners an opportunity to work with the resources that are familiar to them. As a result their understanding is facilitated so that they can find science enjoyable.

In my observations during the control group lessons, some of the control group learners seemed to hold the misconceptions that IK is just old knowledge and the teacher did not engage the learners in a discussion in order to address such issues.

Learner C22 Pre: **No, IKS does not help me understand science better. It has nothing to do with science because in most cases they say opposite views.**

Post: **When I am using my indigenous knowledge, I get confused about science. They do not get together like oil and water.**

Ogunniyi (2007) argues that learners are loaded with a lot of science from home and teachers should not ignore it. This argument is supported by Ogunniyi and Hewson (2008) and Ogunniyi (2007) that indigenous knowledge offers what western modern science has not yet prepared to offer. For example, Ogunniyi and Hewson (2008) reveal how scientists also value IK as a useful method for environmental sustainability in non-western society. In the experimental group: at pre- and post-test twenty four learners out of 28 said that science can be understood better if nuanced with IK worldview.

Learner E52 Pre: **I think natural knowledge helps in science but you have to read lot.**

Post: Sometimes indigenous knowledge adds a lot of unknown things to science and it helps me to understand better.

Four learners did not agree with the statement and argued that: including IKS into science will cause confusion. These are noticeably the same learners who had a culturally dominant IK worldview about lightning. They seem to believe that IK must be left alone as it does not mix with science; they expressed the view that if people change from the IK belief to the scientific belief, the ancestors will not be happy and therefore may make bad things happen.

Relevance of science

Majority of the learners in both groups seem to believe that science is relevant in real life situations. A learner from the experimental group said that "Science is around us and in everything that we do therefore it is useful and relevant". At the post-test, only three learners in the control group and two in the experimental group disagreed with that statement.

The learners' ideas that they share show that they do come to science classroom with some prior everyday knowledge and experiences about lightning which they acquired from their community (Maselwa & Ngcoza, 2003). Kibirige and Van Rooyen (2006) argue that indigenous knowledge is a legacy of knowledge and skills unique to a particular indigenous culture and involving wisdom that has been developed and passed on over generations.

Also Pabale's (2006) findings in her study accentuate that the inclusion of learners' cultural beliefs and experiences as examples when teaching science has an advantage of drawing learners' attitudes into the learning of science topics. Her study explored integration of indigenous knowledge with science topics. She asserts that incorporation of everyday knowledge and experiences could be one way to draw learners into active attitude to the learning of science topics.

Belief in IKS than science

Kawagley (1990) and Ogawa (1995) say non-western learners have acquired a traditional culture of their community and that will interfere with learning western science. This is true for the control group where about 8 learners said that they believe more in IKS than in science (dominant- IK worldview). In the experimental group only about 4 learners believed in IKS than in science. This means that the majority of the learners are leaning on the science- dominant worldview. Therefore the inclusion of cultural beliefs about lightning can be said to have motivated the learners and helped them to develop the understanding of the scientific view of lightning. The belief that people can manipulate lightning though is one of the beliefs that the learners still hang on to. The idea that there are people who use lightning in different ways to strike other people is strongly held by some of the learners.

Use of science for examination purposes only

Majority of the learners in both the control and the experimental group found science useful in their everyday lives and not only for school examination purposes. They believe that most of the science information has been proven, therefore it can be trusted. Jegede (1995) mentioned that learners will accept the scientific truth as a fact when at school, but they will revert to their original beliefs when at home. Most of the learners maintained that they do not believe in the conventional definition of lightning, but they just use it for examinations and school purposes.

About six in the control and four in the experimental group said that they only studied science so that they could pass examinations; however, in their everyday life they make use of their traditional knowledge.

Learner C 27: **I am interested in science because I want to know what is happening in the world not just for school.**

Learner E45: **Science is not just a study it is a belief, therefore it is very important in our lives not just for school examinations.**

For both groups the mean shows that all the learners show a positive attitude towards science as a learning area. A Mann -U test was also done on the pre- test of the attitude questionnaire for the two groups. The Mann- U test revealed a non-significant difference in the results. The control group showed that (N = 28, Md = 14, Z = -511, U = 374.5 and P = 0.609). The experimental group results showed a (N = 28, Md = 15, Z = - 511, U = 374.5 and P = 0.69).
In reference to the findings in this study, I fully agree with Jegede's (1995) belief that even good scientist at school can be a traditionalist at home any without feeling of cognitive permutation.

Summary

In summary, this study has shown that:

Initial conceptions about lightning

- Learners hold traditional beliefs about lightning.
- Learners had common beliefs about lightning being caused by witches who are jealous of other people.
- Lightning is caused by traditional doctors who are hired to bewitch people by sending lightning to strike them.

Effect of the DAIM approach on learners' conceptions

- The DAIM seemed to help the learners in the experimental group to accept the scientific conceptions of lightning more than the learners in the control group.
- The learners in the experimental group were able to identify some of the differences between scientific and traditional interpretations of lightning through argumentation activities.
- Argumentation seemed to have positively influenced learners' interest in science-IK integration.
- It helped the learners to externalize their thoughts, clear their doubts and even made other learners change their conceptions about lightning.

- The learners from the experimental group who were exposed to DAIM performed better in the science achievement test than the learners from the control group who were exposed to TLM.

Attitude towards infusion of science and IKS

- All the learners in the study had a positive attitude towards science.
- A majority of the learners wanted IKS to be included in science lessons.
- The learners believed that using IK made them understand science better.
- Both groups of learners found science useful in their everyday lives and not only for school examination purposes.

Through this study I was able to compare my findings with other researchers' findings which showed some commonalities in terms of learners' observations of their world in relation to the natural phenomenon 'lightning', procurement of new scientific concepts and challenges of integrating prior everyday knowledge with science.

The findings of this study also showed that when argumentation is used in a structured form it could provide a vital link for relating what learners study at school with what they do and learn in their socio-cultural environment.

Chapter 5

Conclusion, Implications and Recommendations

Introduction

In this chapter, the research contained within the ambit of this research project will be concluded and final analogies will be drawn. The research problem will be re-visited to determine if the problem was mitigated as a result of the research. Reciprocally, the research questions and the associated investigative questions will be re-visited to determine whether the research contained within the ambit of the dissertation produced not only feasible but also viable answers to the posed research questions.

5.1 Findings from the study

The purpose of this study was to use a dialogical argumentation as an instructional method to teach the concept of lightning in an indigenous context to grade 10 learners. The questionnaires on both Conceptions of lightning (COLQ) and Beliefs about lightning (BALQ) were used to collect data in from the two groups that are involved in the study. The study has revealed that learners come to a classroom with their own traditional/ cultural and religious views about lightning. Some of the points that have emerged from this research project are discussed below.

5.1.1 Traditional views in contiguity with scientific views

Some of the conceptions that the learners have about lightning are scientific whereas others are based on traditional beliefs. The two views tend to clash with each other. The learners had prior conception about the causes of lightning. This includes how lightning is formed, how it behaves, and how people can protect themselves and their homes from being struck by lightning.

Witchcraft is one of the socially obnoxious traditional practices. Mostly, witchcraft is not tolerable in a society. In general, a person who is being caught or suspected of witchcraft activity, in such a society, is forcefully removed from a village. In particular, a person who evokes lightning to kill or destroy other people's properties is regarded as a witch.

The learners believe that there are two types of lightning: the one that is natural (caused by God) and the one that is caused by traditional doctors and witches. The results have shown that these learners have the scientific and/or the traditional conceptions of lightning. Learners hold traditional/religious beliefs about lightning and these, among others, include:

- Lightning was caused by witches who are being jealous of other people.
- It was caused by traditional doctors who are hired to bewitch people by sending lightning to strike them.
- It is a natural phenomenon and comes from God when He is angry.
- True lightning is different from witchcraft generated lightning. True lightning can last up to hours whereas witchcraft lightning lasts only for a few minutes. Witch craft lightning just hits you and goes back to the witch.

Even though this study was conducted in schools that are dominantly Xhosa speaking learners, some researchers have found similar conceptions among the learners of the Basotho and the Pedi people (e.g. Mahapa, 2002; Maselwa, 2004; Pabale, 2006 and Liphoto 2006). This shows that the cultural belief of learners about the conception of lightning is similar across some cultures.

5.1.2 Shifts in conception

The second thrust of the study was to find out whether or not there was a shift in the learners' conception of lightning after they had been taught the scientific version of lightning in Science classroom. The findings of the study are as describes below.

Some of the learners from the control group have shifted from a cultural to a scientific belief whilst others have been stuck between the cultural and scientific belief. The total number of leaners who had scientific belief prior to the exposure was increased by three in the experimental group. Only one learner from this group has shifted from the cultural belief to the scientific one. Two learners have shifted from both the cultural and scientific view to the scientific view.

It is evident from this study that there are some scientific conceptions within community's cultural beliefs though the scientific explanations might not be known. For instance, children are culturally warned not to stand under a tall tree when there is lightning. It is considered as one of the protective measures against lighting. This is also a scientific measure of protection against lightning as trees are prone to being struck by lightning.

5.1.3 Effects of the DAIM on cognitive conflicts

Another area of interest in the study was to scrutinise the possible effects of the DAIM in enhancing learners' understanding of lightning and in mitigating the cognitive conflicts that might arise when learner's traditional conceptions about lightning come in contact with the school science concepts. Through an analysis of the interviews, it has been discovered that the learners in the experimental group tend to value the science embedded in IKS and the cultural aspect.

Dialogical argumentation method made it easier to ascertain the learner's conceptions about lightning accurately. This is because the DIAM contributes towards bridging the gap between the two conflicting views, i.e. the cultural view and the scientific view. As noted by Diwu (2010), "ideas that are unlinked to the content in an adult scientific logical sense may be linked for the student" (Diwu, 2010). Moreover, arguing, sharing and discussing views and explanations helped the learners to externalize their thoughts, clear their doubts and even made other learners to change their conceptions about lightning.

In this study the learners who were exposed to the dialogical argumentation instruction method gave more scientific reasons regarding the relationship between lightning and electricity than those that are exposed to the traditional method of teaching. All the learners from the experimental group believed that science explains lightning better whereas about 93% of the learners from the control group believed so.

A Mann-U test was conducted on the post-test of the science achievement test on lightning and on the conceptions of lightning questionnaires. The post-test of the science achievement test on lightning revealed a significant difference. In the control group: (Md=38.5, N=28). In the experimental group: (Md= 55, N= 28): U= 260, z = -2.34, p = 0.020 and diff = 16. The results of the Mann- U test revealed that the experimental group performed better than the control group in both the science achievement test and on the conceptions on lightning questionnaire. A contributing factor to the better performance of the experimental group might be as a result of the instructional method (DAIM) that was used to teach the experimental group.

5.2 Implications and Recommendations

Implications for Teachers

When a teacher simply presents a concept in a logical way, as noted by Dykstra (1992), it does not necessarily encourage learning. This is because the teacher's reasoning may not make sense in the context of the learners' own beliefs. If the learners do not share the same conceptual framework as the teacher in a science lesson, the learners may not be able to derive the intended meaning from the instruction.

As a result of the learners' instinctual understanding of the diverse natural phenomena, misconceptions may also arise. Asoko (2002) argues that misconception arises as a result of a poor instruction or as a result of a knowledge that is encountered in school science which does not articulate well with the cultural or common sense experience (as was the case with a few learners in the control group). It is therefore imperative that teachers should not treat a learner as an empty vessel when he/she comes to a science class. Learners do come to school with their own traditional views on matters. Therefore, teachers need to consider their learners' view when planning their lessons so as to overcome such misconceptions.

According to Ogunniyi (1995) when learners hold alternative conceptions, they are resistant to change through the traditional method of teaching. Therefore, learners' explanations should be made clear and presented for reflection. It also needs to be checked and discussed by their fellow classmates and teachers so that their ideas and prior knowledge can be used to develop their thinking skills. The results of this study have confirmed that argumentation can therefore be used to address these issues. Argumentation has also been recommended by many science teachers as a feasible instructional method for science (Ogunniyi, 2007; Kuhn 1993).

Implications for Policy / Curriculum developers

In terms of curriculum development, the argumentation method can also be used in other subjects in the curriculum as a means to promote learning with understanding. This may help learners to improve and excel in different subjects. With respect to pedagogy and active participation of learners in the teaching and learning process, the South African curriculum still needs to change and address these issues. Ogunniyi (2011) argues that there is still a huge gap and difference between the intended curriculum and what is taking place in classrooms (curriculum practice). The curriculum content needs to be established starting by identifying learners' understanding of concepts because knowledge that one has acquired without sufficient structure to connect it together is knowledge that is likely to be forgotten.

The findings of this study has shown that the learners in the control group have had difficulty in understanding the concept of lightning as they have brought their own views and explanation of the natural phenomenon, i.e. lightning, into the class which is different from the scientific explanation. An understanding of these alternative conceptions that learners bring into a science classroom may help for an effective instruction to take place. Curriculum, as argued by Driver (1989), is not that which is to be learned, but it is a programme of learning tasks, materials and resources which enable learners to reconstruct their models of the world to be closer to those of school science.

Implications for IK teaching using argumentation

In this study, the learners have to come with their own explanations of causes of lightning and protective measures against lightning before they were taught the science of lightning. This was done so as to relate the context with their experiences. Many learners have expressed their aspiration for an integrated science with indigenous knowledge during the interviews. According to these learners the inclusion of IKS in the science classes has helped them to understand the concept of lightning better. Dialogical argumentation, therefore, seems to be the better approach that can accommodate such aspirations.

During the study when learners' cultural beliefs and everyday experiences were classified as scientific and non-scientific, it emerged that they had some understanding of the difference between these. This enabled them to learn new scientific concepts whereby prior knowledge was used as starting point (Roschelle, 1995). Learners were also able to make some links between the everyday knowledge and experiences and the nature of science.

This means that the learners were co-constructing their knowledge while making sense of the lessons in relation to their own contexts. This resonates with what Oloruntegbe and Ikpe (2011) said, that if teachers could relate school science to home activities, learners would benefit in learning these examples. Pabale (2006) also has explored integration of indigenous knowledge with science topics and has asserted that the incorporation of everyday knowledge and experiences is one way of drawing learners' attention and having a positive attitude towards learning science topics.

With issues that contradict science, the advantage of inclusion of cultural examples in the teaching and learning of science topics is that it provides both teachers and learners with an opportunity to explore the conflicts between the scientific and the cultural ways of understanding of natural phenomena. This exploration may enhance conceptual development on the part of learners. Kawagley (1990) and Ogawa (1995) note that non-western learners have acquired a traditional culture of their community that interferes with learning western science. Waldrip's (2000) findings also suggest that in science classrooms traditional beliefs exist in parallel but the traditional beliefs are dominated by the school knowledge.

Jegede (1995) also states in his rainbow study that "in the culture of Western science, students learn that refraction of light by droplets causes rainbows; while in some African cultures, a rainbow signifies a python crossing a river or the death of an important chief. Thus for the African learners, learning about lightning or rainbow in science means constructing a potentially conflicting idea in their long term memory" (p.75).

Sluijs (2001) also suggests that even in Europe, these kinds of myths exist. He goes on to say that in some parts of France, if one kills a wren, that person would be struck by lightning and lightning would destroy his dwelling. Therefore, learners should be given a chance to bring in their ideas about science and to be always engaged in 'hands-on', 'words-on' and 'minds-on' activities (Maselwa & Ngcoza, 2003).

5.3 Recommendations

Hewson *et al.* (2009) argues that IK is part of the learners' prior knowledge which directly impacts their ability to accept new ideas. According to Hewson *et al.* (2009) learners' new scientific ideas are built on everyday experiences. It is, therefore, important for a teacher to start with what the learners know to move towards what they do not know so that they build a new knowledge on the prior knowledge. During the process of knowledge building any misconception that is brought by prior everyday knowledge needs to be addressed.

In order to facilitate learners' understanding of scientific concepts, Kibirige and Van Rooyen (2006) suggest that teachers should divert from textbooks' recipes and they advise that teachers should design classroom tasks that bring in elements of IK that connect with science. In other words, the use of indigenous knowledge serves as a strategic point for exploring scientific concepts and inquiry procedures.

Snively and Corsiglia (2001) suggest that teachers need to begin to explore a diversified science instruction with the prior knowledge that learners bring to class. Learners bring ideas to a classroom that are based on their prior experiences and that the learners of different cultural backgrounds frequently interpret science concepts differently from the standard scientific view.

Stears's (2003) research findings indicate that even though the inclusion of learners' everyday knowledge increases learning engagement, both teachers and learners still experience difficulty in making a connection between the indigenous knowledge and the nature of science. According to Stears (2003) this might be caused by the following reasons: firstly, teachers perceive science as different from the learners' cultural lives. Secondly, teachers lack the knowledge of handling the diversity in a classroom especially in one with learners of different cultures or everyday experiences.

He, therefore, recommends that teachers and curriculum designers should work together to develop learning materials that are culturally relevant and that teachers should plan the activities carefully to link activities to learners' everyday experiences. In a research conducted by Ogunniyi (2007), the findings has revealed that there is no model of implementation to which teachers can base their teaching approaches which incorporate learners' prior every day knowledge and experiences. Therefore, if teachers rely on textbooks as sources of information, they would transmit the knowledge to the learners as it is presented in the textbooks or the syllabus. As a result, learners would not make an effort to relate the knowledge that they have acquired from a classroom with their everyday knowledge or experiences.

Maselwa (2004) suggests that teachers need to be well-informed about the science subject content and be attentive to the incorporation of learners' experiences into their teaching and learning practices. This enables a teacher to help the learners to develop scientific concepts and even clear up the misconceptions that might arise from the indigenous knowledge.

Pabale (2006) also argues that the science textbooks that we use in schools do not demonstrate the integration of the nature of science and the cultural beliefs. In terms of lightning, according to Pabale (2006), textbooks hardly include tasks where learners are instructed to investigate the cultural beliefs about lightning that are held by the community they live in. This shows that there is a lack of integration of IKS with Science. According to Pabale (2006), integration means acknowledging learners' prior everyday knowledge and doing something about it.

Hewson *et al.* (2009) suggest that science teachers need to attend professional development programmes which include curriculum designing and developing learning materials. Such programmes would help teachers to develop teaching strategies that will enable them to elicit diverse learners' cultural beliefs and experiences.

5.4 Limitations

The findings of this study do not directly contribute to the general body of education knowledge due to their limiting nature (Isaac & Michael, 1997). The study involved only two schools and a total of 56 learners. Therefore, the findings presented in this study do not represent the large number of the learners in the South African schools since it was limited to a small group of learners in a specific class and it was context specific. Cohen *et al*. (2007), has indicated that it is difficult to generalize findings in such circumstances. These findings were derived from data that were obtained from learners coming from an informal rural settlement; therefore I cannot claim that they hold true for people from wealthy urban areas. It is hoped that they can, however, benefit learners and teachers from the same cultural background.

The use of my own learners may have also affected the results. The learners might have provided the kind of answers that they have thought their science teacher want to hear. However, the use of more than one instrument has helped me to determine the kind of understanding that is developed by the learners.

Language of learning and teaching

The language proficiency of the learners who participated in this study was also a limitation. Due to their poor language proficiency, their participation in the argumentation activities was limited. They could not ask questions or comment adequately in English during the argumentation discussions. This affected their ability to argue their cultural views in a comprehensive manner. This resonates with Probyn's (2004) arguments that English proficiency of the majority of learners frequently does not meet the demands of learning through the mediation of English. Therefore, learners' poor English proficiency lowers their level of understanding and knowledge construction. To overcome this challenge, I used code-switching to help learners understand what I was teaching. However, Probyn (2009) suggests that code switching is not a legitimate teaching strategy.

Using argumentation

The concept of a dialogical argumentation was new to all the learners and the process of argumentation needed to be explained in detail. The majority of the learners thought of argumentation as a means of conflict and were conditioned to believe that argumentation amongst individuals normally ends up in verbal or physical confrontation.

End of year school term

The data was collected in the third term of the year. The normal protocol in any school is to ask permission to conduct the study from the principal. The initial plan was to conduct the study early in the first and second school terms. The principal suggested that the best time to conduct the study would be in the third term. As I was also teaching grade twelve, he felt that conducting the study in the first or the second term would disturb my attention. The first and the second terms are used to try and keep up with the syllabus. This time of the year was also convenient for the control group teacher as electrostatics was covered in the third term as prescribed in the syllabus. Therefore, the timetable of the teacher was not disturbed.

As mentioned earlier in the study, there were only two science teachers at the school with the experimental group. The other teacher was not willing to do extra work by undergoing argumentation training in order to teach the experimental group. Therefore I had to teach the experimental group and asked her to observe my lessons when she had a free period in order to give a feedback.

Location

The study was conducted in an area that was in an informal settlement where the socio-economic status of the learners was not so conducive. Majority of the learners were staying in shack houses which only had two rooms. Because of the level of poverty in the area, most of the learners come to school without money or food for lunch or even not having a breakfast for that matter. This made some learners not to concentrate or show sufficient interest in the class. The parents of the learners were mostly seasonal grape farm labourers. During the seasons when grapes are out of season, the parents would be out of work.

The parents and grand-parents of the learners have come from the rural areas of Eastern Cape. During holidays the learners and their parents frequently visit their rural homes for various reasons, for example, to do traditional ceremonies. It was hoped that, using learners from such settings and socio-cultural backgrounds, valuable information would be gathered from their experiences as they were good candidates for interrogation of Science/IKS conceptions of lightning.

During the course of this study I have learnt that in order to accomplish the objective of the study I needed much patience, tolerance and wisdom to make the whole exercise a worthwhile endeavor. There were many constraints that I faced in the course of this study but it was an exciting journey and a learning experience.

5.5 Concluding Remarks

The constructivist teaching and learning of science is driven by the idea that learners build their own meanings from their own experiences and from what they are taught. It is believed that conceptual learning happens when the learners make their own sense of knowledge.

At the moment in South Africa, the instructional method is dominantly teacher-centred and assessment is based on recalling information that is taught in classroom. Often, such an assessment does not include how learners relate what they have learned to their daily lives. What I observed during the control-group lessons was that the learners were constantly hassled by the teacher regarding right and wrong answers and that they were reminded of the importance of school science as opposed to IK. Often, the teacher did not explain clearly to the learners why a particular response was wrong.

After being exposed to the DAIM, the learners from the experimental group expressed their view about the need for a more argumentative learning environment whereby they would be are able to express their views, share their ideas and learn from other learners. These learners also suggested that an IK infused science instruction did not only help them to understand school science better but also helped them to learn more about their own culture; thus giving them some sense of social identity. Therefore, DAIM seemed to have proved to be a useful and powerful instructional method in enhancing the learners' awareness of the scientific and cultural values of an indigenized science curriculum (Ogunniyi, 2007a & b).

The study also indicated that the explanations of the concepts of electric discharge helped the learners to link lightning and static electricity. However, in spite of perceptual changes among the learners a considerable number still held tenaciously to the belief that witches could cause lightning. At the same time they also accepted the scientific explanation about lightning. This dualistic viewpoint is what Ogunniyi (1988) calls "harmonious dualism" or recently as an "equipollent cognitive stance" (Ogunniyi, 2007a). According to him this mind set is not necessarily good or bad so long as the learners know which worldview is appropriate for a given context. It only becomes a learning obstacle when the two worldviews are incorrectly apprehended (Ogunniyi, 2007b).

An area for future research based on the study includes:

- Conducting a similar study involving more schools;
- Investigate how teachers could be assisted to incorporate learners' cultural beliefs and experiences about lightning as a natural phenomenon in teaching science.

References

Acar, O. (2008). Argumentation skills and conceptual knowledge of undergraduate students in physics by inquiry class. Unpublished Doctoral dissertation, Ohio State University.

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*, 1-52.

Aikenhead, G. S. (1997). Toward a first nations cross-cultural science and technology curriculum. *Science Education, 81*, 217-238.

Aikenhead, G. S. (1999). Students' Ease in Crossing Cultural Borders into School Science. *Science Education*, 85, 180 – 188.

Aikenhead, G. S. (2001). Students' ease in cross-cultural orders into school science. *Science Education,* 85, 180-188.

Aikenhead, G. S., & Jegede, O. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Education, 36*(3), 269-287.

Aikenhead, G.S. & Otsuji, H. (2000). Japanese and Canadian Science Teachers' Views on Science and Culture. *Journal of Science Teacher Education*, 11: 277-299.

Aikenhead, G.S. (2000). Renegotiating the culture of school science. In Robin Millar, John Leach and Jonathan Osborne (Eds.). *Improving Science Education*. United Kingdom: Open University Press.

Aleixandre, J. M. (2005). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education.* 24(11), 1171 – 1190.

Anderson, C. W. (2007). Perspectives on Science Learning. Chapter in "*Handbook of Research on Science Education.*" Lawrence Erlbaum Associates, Inc., Publishers. Edited by Sandra K. Abel and Norman G. Lederman.

Anderson, C. W. (2007). Perspectives on Science Learning. Chapter in "*Handbook of Research on Science Education.*" Lawrence Erlbaum Associates, Inc., Publishers. Edited by Sandra K. Abel and Norman G. Lederman.

Anderson, C. W. (2007). Perspectives on Science Learning. Chapter in "*Handbook of Research on Science Education.*" Lawrence Erlbaum Associates, Inc., Publishers. Edited by Sandra K. Abel and Norman G. Lederman.

Angaama, D. A., Ogunniyi, M. B., & Langenhoven, K. (2012). Using argumentation to explore grade 11 physical science learners' views on selected sound-related concepts. In D. Nampota & M. Kazima (Eds.), *Proceedings of the 20th annual meeting of the Southern African association for research in mathematics, science and technology education*, University of Malawi, Cross Roads Hotel, Lilongwe, Malawi, 16th -19th Jan. 2012, (pp. 264-273). Lilongwe: SAARMSTE.

Angaama, D.A. (2012). *Effects of using a dialogical argumentation instructional model to teach grade 11 learners some concepts of sound by means of indigenous musical instruments.* A master thesis. Bellville. University of the Western Cape.

Asoko, H. (2002). Developing conceptual understanding in primary science. *Cambridge Journal of Education.* 32(2)

Atkinson, S. & Fleer, M. (1995). Science with reason. Heineman Publishers.

Aufschnaiter, C., Erduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to argue: Case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching, 45*(1), 101–131.

Ausubel, D. P. (1968). Educational Psychology: A cognitive view. New York: Holt, Rinehart & Winston.

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

Blumenthal, R., 2005, Lightning Fatalities on the South African Highveld: A Retrospective Descriptive Study for the period 1997 to 2000, *The American Journal of Forensic Medicine and Pathology*, *26,66 – 69*.

Brock-Utne, B. (2002). Stories of the hunt - Who is writing them? The importance of indigenous research in Africa based on local experience. In: C.A. Odora Hoppers, (Ed.): *Indigenous Knowledge and the Integration of Knowledge Systems. Towards a Philosophy of Articulation*. Claremont: New Africa Books (Pty) Ltd. pp. 237-256.

Bybee, R.W. (1997). *Achieving Scientific Literacy: From Purposes to Practices*. Portsmouth, United States of America: Heinemann.

Cajete, G.A. (1999). *Igniting the sparkle: An Indigenous science education model*. Skyand, NC: Kivaki Press.

Christie, P. (2008). The right to Learn: The struggle for education in South Africa. Braamfontein: Ravan Press.

Cimi, P. V. (2009). *An investigation of the indigenous ways of knowing about wild food plants (imifino): A case study*. Unpublished master's thesis. Education Department. Rhodes University, Grahamstown.

Clerk, D. and Rutherford, M. (2000). Language as a confounding variable in the diagnosis of misconceptions. *International Journal of Science Education*, 22(7), 703 - 717.

Cobern, W. W. 1996.: Worldview Theory And Conceptual Change In Science Education. *Science Education*, 80(5): 579-610

Cooray,V. (2007). 27th International Conference on Lightning Protection:ICLP: Elsevier publishers.

Department of Basic Education. (2011). Curriculum and assessment policy statement (CAPS). Physical sciences: Final draft. Pretoria: Republic of South Africa.

Department of Education (2002). C2005: Revised national curriculum statement grades R-9 (schools) policy for the natural sciences. Pretoria:

Department of education, (2003). *National Curriculum Statement Grades 10- 12 (General) Physical Sciences*. Pretoria, South Africa: Seriti Printing (Pty) Ltd.

Department of Education, Republic of South Africa. (2002). Revised National Curriculum Statement for grades R-9 (Schools) - Natural Sciences. Government Gazette, Vol. 443 No. 23406. Pretoria: Department of Education, Republic of South Africa.

Department of Education, Republic of South Africa. (2009). Report of the Task Team for the Review of the Implementation of the National Curriculum Statement: Final Report, October 2009, Presented to the Minister of Education, Ms Angela Motshega; Pretoria, South Africa.

Department of Education. (2002). C2005: Revised national curriculum statement grades R-9 (schools) policy for the natural sciences. Pretoria: Government Printer.

Diwu, C. & Ogunniyi, M.B. (2012). Dialogical argumentation instruction as a catalytic agent for integrating science with Indigenous knowledge systems. African Journal of Research in mathematics, Science and Technology Education, 16(3),333-347.

Diwu, C. (2010). *Effects of a dialogical argumentation instructional model on grade 10 learners' conception of fermentation* .A master's thesis. Bellville: University of the Western Cape.

Driver, R and Oldham, V. (1986). A Constructivist Approach to Curriculum Development. *Studies in Science Education,* 13: 105-122.

Driver, R. (1989). Changing conceptions: Childerns' conceptions and school science. Philadelphia: The Falmer Pres.

Driver, R., Asoko, H, Leach, J., Mortimer, E., & Scott, P. (1994). Constructing Scientific Knowledge in the Classroom. *Educational Researcher*, 23(7): 5-12.

Driver, R., Newton, P. & Osborne, J. (2000). Establishing the norms of argumentation in classrooms. Science Education, 84(3), 287-312.

Duit, R., & Treagust, D.F. (2003). Conceptual change: a powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25(6): 671-688.

Duschl, R. A., Schweingruber, H. A., Shouse, A. W. (eds.) (2006). Taking Science to School: Learning and Teaching Science in Grades K-8. Committee on Science Learning, Kindergarden Through Eighth Grade. *Board on Science Education, Centre for Education, Division of Behavioural and Social Sciences and Education.* Washington, DC: The National Academic Press.

Dykstra, D. (1992). Studying conceptual change. In R. Duit, F. Goldberg, and H. Niedderer (Eds.), *Research in physics learning: theoretical issues and empirical studies* (pp. 40-58). Kiel, Germany: Institute for Science Education at the University of Kiel.

Dzama, E.N.N. and Osborne, J.F. (1999) Poor Performance in Science among African Students: An alternative Explanation to the African Worldview Thesis. *Journal of Research in Science Teaching*, 36 (3): 387-405.

Ebenezer, J.V. (1996). Christian pre-service teachers' practical arguments in a science curriculum and instructional course. *Science Education*, 80(4), 437-456.

Emereole, H.U. and Maripe, K.O. (2003). Inclusion of Relevant Indigenous Beliefs in School Science. In: B. Putsoa, M. Dlamini, B. Dlamini, and V. Kelly (Eds): *Proceedings of the 11th SAARMSTE Conference*, Waterford Kamhlaba UWC, University of Swaziland. pp. 561-569.

Erduran S., Simon S. & Osborne J. (2004). TAPping into argumentation: Developments in the application of Toulmin's Argumentation Pattern for studying Science Discourse. *Science Education 88*: 915 – 933.

Erduran, S. & Osborne, J. (2005). Developing arguments. In S. Alsop, L. Bencze, & E. Pedretti (Eds.), *Analysing exemplary science teaching: Theoretical lenses and a spectrum of possibilities for practice*. Philadelphia: Open University Press.

Erduran, S. (2006). Learning to teach argumentation: Case studies of pre-service secondary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education.* Volume 2:No.2.

Erduran, S. (2006). Promoting ideas, evidence and argument in initial teacher training. *School Science Review,* 87 (321), 45-50.

Eskin, H., Ogan-Bekiroglu, F. (2008). Investigation of A Pattern Between Students' Engagement in. Argumentation and Their Science Content Knowledge: A Case Study. *Eurasia Journal of Mathematics, Science & Technology,* 2009, 5(1), 63-70.

Evert, R. & Schulze, G., (2005). Impact of a New Lightning Detection and Location System in South Africa, *Inaugural IEEE PES 2005 Conference and Exposition in Africa,* Durban, South Africa, 11-15 July 2005.

Fatnowna, S. and Pickett, H. (2002). Indigenous Contemporary Knowledge Development through Research: The Task for an indigenous academy. In: C.A. Odora-Hoppers (Ed.): *Indigenous Knowledge and the Integration of Knowledge Systems. Towards a Philosophy of Articulation*. Claremont: New Africa Books (Pty) Ltd. pp. 209-232.

Field, A.P. (2009). Discovering statistics using SPSS, (2nd ed.), London: SAGE

Fontana, A. & Frey, J. H. (1994). Interviewing: the art of science. In N. K. Denzin and Y. S. Lincoln (Eds.), Handbook of qualitative research (pp. 361-376). Thousand Oaks, CA: Sage Publications.

Fraenkel, J.R., & Wallen, N. E. (2008).How to design and evaluate research in education, (7th ed.), San Francisco: McGraw-Hill.

Gay,L. R. & Airasian,P. (2003). Educational research: Competencies for analysis and applications 7th ed. Upper Saddle River, NJ: Pearson Education Inc.

Geerts, B. & Linacre, E., (1999). Fatalities due to Weather Hazards, www-das.uwyo.edu /geerts/cwx/chap03/nat_hazards.html.

Hawkins ,B. & Pea, R. (1987). The influence of intellectual environment of conceptions of heat. *European Journal of Science Education,* 6(3), 245-262.

Henry,G.T.(1990). Practical sampling: Sage Publications, Inc.

Herrenkohl, L.R. & Guerra, M.R. (1998). Participant structures, scientific structures and student engagement in fourth grade, cognition and instruction: 16(4) 431-473.

Heugh, K. (2000) Languages, development and reconstructing education in South Africa. International Journal of Educational Development, 19: 301-313.

Hewson M.G., & Hewson P.W. (2003). The effect of students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching*, 40, S87-S98.

Hewson, M. G., Javu, M. T., & Holtman, L. B. (2009). The indigenous knowledge of African traditional health practioneers and the South African science curriculum. *African Journal of Research in MST Education, 13*(1), 5-18.

Hirst,P. (1990). A curriculum for social justice. Australian Educational Researcher 17(2) 45-52.

Hlazo, N., Ogunniyi, M.B., & Afonso, E. (2012). Effects of dialogical argumentation instruction method on grade 10 learners' conceptual understanding of lightning. In D. Nampota & M. Kazima, (Eds.), *Proceedings of the 20th annual meeting of the Southern African association for research in mathematics, science and technology education*, University of Malawi, 16th -19th Jan. 2012, (pp. 323-331). Lilongwe: SAARMSTE.

Holle,R.L. (1999). Updated recommendatios for lightning safety. *Bull World Meteor Soc, 80(20), 35-41.*

Howe, K. R., & Moses, M. S. (1999). Ethics in education research. In A. Iran-Nejad & P. D. Pearson (EDs.), *Review of Research in Education* (Vol. 24, pp. 21-59). Washington, DC. American Educational Research Association.

Hyndman,D. & Hyndman, D. (2009). Natural hazards and disasters: Cengage Learning.

Ivowi, U. (1992). Perspectives on education and science teaching. Foremost Education Services.

Jegede, O. (1994). African Cultural Perspectives and the Teaching of Science. In: J. Solomon, and G. Aikenhead, (Eds.): *STS Education: Perspectives on Reform*. Columbia University, New York: Teachers College Press. pp. 120-130.

Jegede, O. (1997). School science and the development of scientific culture: a review of contemporary science education in Africa. *International Journal of Science Education*, 19(1), pp. 1-20.

Jegede, O. J., & Okebukola, P. A. (1991a).The relationship between African traditional cosmology and learners' acquisition of a science process skill. *International Journal of Science Education*, 13(1), 37-47.

Jegede, O., & Aikenhead, G.S. (1999).Transcending cultural borders: Implications for science teaching. *Journal of Science & Technology Education, 17*(1), 45-66.

Jegede, O.J. (1995). Co-lateral learning and the eco-paradigm in science and mathematics education in Africa. Studies in Science Education. 25, 97 – 137.

Jegede, O.J., & Okebukola, P.A.O. (1991b).The effect of instruction on socio-cultural beliefs hindering the learning of science. *Journal of Research in Science Teaching*, 28(3), 275-285.

Jones, M.G., Howe, A., & Rua, M.J. (2000).Gender differences in students' experiences, interests, and attitudes toward science and scientists. Science Education, 84, 180–192.

Joseph Maxwell. (1992). Understanding and validity in qualitative research. Harvard Educational Review, 62, 279-300.

Kahn, M. & Rollnik, M. (1992). Science Education Research in Africa. How can it help us? Proceedings of a Workshop on Research in Science and Mathematics Education, Cathedral Peak, South Africa.

Kawagley, A. (1990). Yuipiaq ways of knowing. Canadian Journal of Native Education,17, 5 – 7.

Kawagley, A.O., Norris-Tull, D., and Norris-Tll, R.A. (1995). The Indigenous Worldview of Yupiaq Culture: Its Scientific Nature and Relevance to the Practice and Teaching if Science. *Journal of Research in Science Teaching*, 35(2), pp. 133- 144.

Kelly, G., J. Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education*, 20(7), 849–871.

Kesamang, E.E. & Taiwo, A.A. (2002). The correlates of the socio-cultural background of Botswana junior secondary school students with their attitudes towards and achievements in science. *International Journal of Science Education*, 24(9): 919-940.

Khoali,T. & Sanders, M. (2006).Using a science-Technology Society approach, with in curriculum 2005 framework. University of Witwatersrand.

Kibirige, I., & Van Rooyen, H. (2006). Enriching Science teaching through the inclusion of indigenous knowledge. Braamfontein: Macmillan.

Kitcher, P. (1988). The child as a parent of the scientist. Mind and language. *Journal of Science Education* 3(3), 215-228.

Kruger ,P. (2006). Alternative Energy Source: The quest for sustainable energy. Wiley.

Kuhn, D. (1992). *Thinking as argument.* Harvard Educational Review 62(1): 155 – 178.

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. *Journal of Science Education, 77*(3), 319-337.

Kuhn, D. (2010). Teaching and learning science as argument. *Science Education, 94*:810. 824.

Kuhn. L. & Reiser, B. (2005). *Students constructing and defending evidence-based scientific explanations.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Dallas, TX.

Larson, M. (1995). Keyhole Reservoir Archeology. University of Wyoming. Laramine.

Leedy, P. (1993). Practical Research: Planning and Design. Mcmillan.

Lemke, J. L. (1990). *Talking science: Language, learning and values*. Norwood, NJ: Ablex Publishing.

Lew, L. (2001). *Development of constructivist's behaviours among four new science teachers prepared at the University of Iowa.* Unpublished doctoral dissertation, University of Iowa, Iowa City.

Liphoto, N. P. (2004). Pupils'conceptions of lightning thunder and hail. In A. Buffler, & R.C. Laugksch (Eds.), Proceedings *of the 12th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*. Durban: SAARMSTE.

Liphoto, N. P. (2008). *The effect of a cross-cultural instructional approach on learners' conceptions of lightning and attitudes towards science*. Unpublished doctoral dissertation, School of Science and Mathematics Education, University of the Western Cape, SA.

Lopez, R.E. & Holle R.L. (1998). Lightning- impacts and safety. Bull World Meteor Soc, 47, (1) 48-55.

Luft, J. A., & Patterson, N. C. (2002). Bridging the gap: Supporting beginning science teachers. *Journal of Science Teacher Education*, *13*, 267–282.

Luft, J. A., & Patterson, N. C. (2002). Bridging the gap: Supporting beginning science teachers. *Journal of Science Teacher Education*, *13*, 267–282.

Mahapa, S. S. (2002). Investigating High School Learners' Lightning and Electrostatic Safety Awareness in the Limpopo Province of South Africa. A Doctoral thesis. Curtin University of Technology.

Makgatho, M. & Mji, A. (2006). Factors associated with high school learners' poor performance: A spotlight on Mathematics and Science. *South African Journal of Education*, Vol 26, No2.

Makgato, M. (2006). New technology curricula for South African FET schools (grades 10- 12). *World Trans. on Engineering and Technology Educ*., 2, 3, 449-452.

Malan, D.J. (1963). Physics of lightning. London. English University Press. P 176.

Maloney, J., & Simon, S. (2006). Mapping Children's Discussions of Evidence in Science to Assess Collaboration and Argumentation. *International Journal of Science Education*, 28(15). 1817-1841.

Martin, J. (1983). Mastering instruction. Boston: Allyn and Bacon, Inc.

Maselwa, M. R. (2004). Promoting Learners' Conceptual Understanding of Electrostatics Through use of Practical Activities in Conjunction with Prior Knowledge of Lightning: A Case Study. A thesis of Master's Degree in Education. Rhodes University.

Maselwa, M. R., & Ngcoza, K. M. (2003). 'Hands-on', minds-on', 'words-on', practical activities in electrostatics: Towards conceptual understanding. In D. Fisher & T. Marsh (Eds.), *Proceedings of the Third International Conference on Science, Mathematics and Technology Education* (pp. 649-659). Rhodes University, East London Campus, South Africa.

McMillan, J.H. & Schumacher, S. (1993). Research in Education: A Conceptual introduction. New York:

McMillan, J.H. (1992). Educational Research: Fundamentals for the Consumer. USA: Harper Collins Publishers.

Millar, R., & Osborne, J. (1998). (Eds.) Beyond 2000: Science education for the future. The report of a seminar series funded by the Nuffield Foundation.

Mills, C.R (1959). The social imagination. New York: Oxford University Press.

Mortimer, E. F. (1995). Conceptual change or conceptual profile change. *Journal of Science Education*, 4, 267-285.

Mortimer, E. F. (1995). Conceptual change or conceptual profile change. *Journal of Science Education*, 4, 267-285.

Mqotsi, L. (2002). Science, Magic and Religion as Trajectories of the Psychology of Projection. The Indigenous Knowledge and the Integration of Knowledge Systems. Hoppers.

Naidoo, P. (2003). Why Some Schools Perform Well in Physical Science in South Africa? *Proceedings of the 11th Annual SAARMSTE Conference 11-15 January 2003* Swaziland.

Nanghonga.O. (2012). An investigation on how grade 8 learners make meaning of static electricity through exploring their cultural beliefs and experiences about lightning: A case study. A Master thesis (science education), Rhodes University.

Needo, N., Peires, M., and Morar, T. (2002). Code switching revisited: the use of language in primary school science and mathematics classrooms. In: C. Malcolm, and C. Lubisi (Eds.): *Proceedings of the 10th SAARMSTE Conference*. University of Natal, Durban, South Africa. Part III, pp. 308-312.

Newton, P. Driver, R., and Osborne, J. (1999). The place of argumentation in the pedagogy of School Science. *International Journal of Science Education*, 21(5), 553 – 576.

Nkopane. F.L.(2006) *Identifying and Finding the Impact of Grade 8 Learners' Alternative Conceptions of Lightning*. A master thesis. University of the Witwatersrand.

Norris, S.P. & Korpan, C.A. (2000). Pluralistic Science Education. In *Improving Science Education: The contribution of research*. Millar, R., Leach, J. and Osborne, J. (Eds.). Buckingham: Open University Press.

Nzita, R., & Niwampa, M. (1997). Peoples and Cultures of Uganda. Kampala: Foundation Publishers.Harper Collins College Publisher.

Ocholla, D. & Onyacha, O.B. (2005). The marginalised knowledge: an informetric analysis of indigenous knowledge publication. *South African Journal of Libraries and Information Science*. 71(3), 274-258.

Odora-Hoppers, C. A. (2005). Culture, Indigenous Knowledge and Development: The Role of University. Centre for Education Policy Development, Occasional Paper No. 5.

Odora-Hoppers, C.A. (2002). *Indigenous Knowledge and the Integration of Knowledge Systems*. South Africa: New African Education

Odubunmi, O. & Liphoto, N. (1999). An investigation into the junior teaching in some schools and implications for quality and equity. *Proceedings: Conference on MST Education in the next Millennium*. Maseru Lesotho

Ogawa, M. (1995). Science Education in a multi-science perspective. *Science Education*, *79,583-593*

Ogunniyi M.B. & Hewson M.G (2008). Effect of an Argumentation-Based Course on Teachers' Disposition towards a Science-Indigenous Knowledge Curriculum. *International Journal of Environmental & Science Education*. Vol. 3, No. 4, October 2008, 159-177.

Ogunniyi, M. B. (1988). Adapting western science to African traditional culture. *International Journal of Science Education***,** 10, 1-10.

Ogunniyi, M. B. (2004). The challenge of preparing and equipping science teachers in higher education to integrate scientific and indigenous knowledge systems for learners. *South Africa Journal of Higher Education*, 18(3), 289-304.

Ogunniyi, M. B. (2005). Relative effects of a history, philosophy and sociology of science course on teachers' understanding of the nature of science and instructional practice. *South African Journal of Higher Education,* Special issue: 1464-1472.

Ogunniyi, M. B. (2007). Teachers' Stances and Practical Arguments Regarding a Science-Indigenous Knowledge Curriculum: Part 1. *International Journal of Science Education,* 29(8), 963 - 986.

Ogunniyi, M. B. (2008). An argumentation-based package on the nature of science and indigenous knowledge systems, Book 1. Developed through the Science and indigenous Knowledge Systems Project (SIKSP), University of the Western Cape.

Ogunniyi, M.B. (2005). Teachers' perceptions of science/indigenous knowledge course. Paper presented at the *Joint Conference of the South African Association for Research and Development in Higher Education and the Productive Learning Cultures Project* (University of Bergen). Norway, August 30 – September 2, 2005.

Ogunniyi, M.B. (2007a). Teachers' stances and practical regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education* 29, (8): 1189-1200.

Ogunniyi, M.B. (2007b). Teachers' stance and practical regarding a science-indigenous knowledge curriculum: Part 2. *International Journal of Science Education*, 29 (10): 963-986.

Ogunniyi, M.B. (2011a). Exploring science educators' cosmological worldviews through the binoculars of an argumentation framework. *South African Journal of Higher Education*, 25(3), 542-542.

Ogunniyi, M.B. (2011b). The context of training teachers to implement a socially relevant science education in Africa. *African Journal of Research in Mathematics, Science and Technology Education,* 15(3), 98-121.

Okebukola, PA. (1985). The relative effectiveness of co-operative and competitive interaction techniques in strengthening student's performance in science classes. *Journal of Science Education,* 69(4), 501-509

Oloruntegbe, O. K., & Ikpe, A. (2011). Ecocultural factors in students' ability to relate science concepts learned at school and experienced at home: Implications for chemistry education. *Journal of Chemical Education,* 88(3), 266-271.

Osborne, J. (1999). Promoting rhetoric and argument in the science classroom. Paper presented in the ESERA conference. Kiel.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school Science . *Journal Of Research In Science Teaching, 41*(10), 994 –1020.

Osborne, J.F. (1996): Beyond Constructivism. *Science Education* 80(1): 53-82.

Pabale, M. F. (2006). Exploring the integration of indigenous beliefs in teaching and learning of school science. Unpublished master's thesis, University of Limpopo.

Pallant, J. (2001). A step by step guide to data analysis using SPSS. Berkshire, Open University Press.

Pera, M. (1994). The discourse of science. London. University of Chicago Press.Ltd.

Phelan, P., Davidson, A., & Cao, H. (1991). Students' Multiple Worlds: Negotiating the Boundaries of Family, Peer and School Culture. *Anthropology and Education Quarterly*. 22 (3): 224-250

Philander.R.(2012). The effect of an argumentation-based instructional approach on Grade 3 learners' understanding of river pollution. A master thesis. University of the Western Cape.

Proctor, K. (1993). Tutors professional knowledge of supervision and implications for supervision practice in conceptualising reflection in teacher development. London. Palmer Press.

Quinn, N. (1997). A cognitive theory of cultural meaning. Cambridge University Press.

Raseroka, H. (2002). From Africa to the world- the globalisation of Indigenous Knowledge Systems. 'setting the scene' *SCECSAL* 2002, 15-19 April pp 1-12. South Africa.

Riffel, A. D. (2013). Grade 9 learners' views on intergrating Indigenous Knowledge Systems into Meteorological Education in Geography. A master thesis. University of the Western Cape.

Roeder, M. (2007). Pernicious Lightning Myths. International Conference on Lightning and Static Electricity 2007. 28-31 August 2007.5pp.

Roeder, W. P. (2008a). Recent changes in lightning safety. 3rd conference on Meteorological Applications of Lightning Data, 19-23 Jan 2008. Paper p2 14.5pp.

Roeder, W.P. (2008b). Recent updates in lightning safety. 20th International Lightning Detection conference, 21-22 April 2008. 6pp.

Roeder,W. P. (2001). Post communism ad theory of democracy. Princeton, NJ. Princeton University Press.

Rollnick, M. & Rutherford, M. (1996). The use of mother tongue and English in learning and expression of science concepts: a classroom-based study. *International Journal of Science Education*, vol. 18 (1), 91-103.

Rollnick, M. & Rutherford, M. (1996). The use of mother tongue and English in learning and expression of science concepts: a classroom-based study. *International Journal of Science Education*, vol. 18 (1), 91-103.

Rollnick, M. (1998) The Influence of language on the second language teaching and learning of science. In W. Cobern (Ed) . Socio-cultural perspectives on science education: an international dialogue, Dordrecht:Kluwer, 121-138.

Rollnick, M. (1998). Current issues and perspectives on second language learning of science. *Studies in science education.* 35, 93-122.

Roschelle, T. (1995). Learning in interactive environments: Prior knowledge and new experiences. Retrieved, April 13, 2014, from the World Wide Web http://www.exploratorium.edu/ifi/r.

Sanders, M. & Mokuku, T. (2004). How valid is face validity? In proceedings of the *2nd annual meeting of the Southern African Association for Research in Mathematics and Science Education*, Durban, South, (Ed.) M. J Glencross: 479-489.

Scholtz, Z., Braund, M., Hodges, M., Koopman, R., & Lubben, F. (2008). South African teachers' ability to argue: The emergence of inclusive argumentation. *International Journal of Educational Development*, 28(1), 21-34.

Schunk, D. (1991). Learning theories: An educational perspective. New York: Macmillan.

Schurink, W.J. (1998). Qualitative Research in Management and organisational studies with reference to recent SA research. SA Journal of Human Resource Management 2003. 1(3), 2-14.

Seifert, T. & Wheeler, P. (1994). Enhancing motivation: a classroom application of self-instruction strategy training. *Journal of Research in Education*, 51, 1-10.

Shilongo, T. N. (2007). The transition from Oshikwanyama to English as a medium of instruction: A case study of rural Namibian School. Unpublished master's thesis, Education Department, Rhodes University, South Africa.

Shiva, V. (1989). Staying Alive. Women, Ecology, and Development. Zed Books, London.

Shizha, E. (2005). Indigenizing science education in Zimbambe. Palgrave. Mcmillan.

Siegel, H. (1989). The rationality of science, critical thinking and science education. Synthese, 80(1), 9-41.

Siegel, H. (1995). Why should educators care about argumentation? Informal Logic, *17(2), 159–176*.

Simon, S., Erduran, S. and Osborne, J. (2006). Learning to Teach Argumentation: Research and development in the science classroom. *International Journal of Science Education*, *28*(2-3), 235 – 260.

Simons, P. R. J. (1992). Constructive learning: The role of the learner. In: Corte de, E. (Ed.), Computer based learning environments and problem solving. *Journal of Research in Science Teaching, 33*(4), 393-406.

Siseho, C. S. & Ogunniyi, M. B. (2010).Using an argumentation-based instructional model to enhance teachers' ability to co-construct scientific concepts. In V. Mudaly (Ed.) *Proceedings of the eighteenth annual meeting of the Southern African Association for Research in Mathematics, Science and Technology Education* , UKZN: SAARMSTE.

Siseho.C.S. (2013), The Effect of an Argumentation Instructional Model on Pre-Service Teachers‟ Ability to Implement a Science-IK Curriculum. A doctoral thesis. University of the Western Cape.

Skoumios, M., & Hatzinikita, V. (2009).Learning and justification during a science teaching sequence. *The International Journal of Learning*, *16*(4), 327-341.

Slotta, J.D., Chi, M. T.H., & Joram, E . (1995). Assessing students' miscalculations of physics concepts: An ontolological basis for conceptual change. *Cognition and Instruction*, *13*(3), pp. 373-400.

Sluijs, M.A. (2001). IGNIS E COELO fire from heaven. http://www.mytholopedia.info/ignis-e-coelo.htm

Snively, G. and Corsiglia, J. (2001). Discovering Indegenous Science. Implications for Science Education. *Journal of Science Education,* 85: 6 – 34.

Stake, R. E. (2000). Case Studies in Handbook of Qualitative Research; Sage Publications; California.

Stears, M., Malcolm, C., & Kowlas, L. (2003). Making use of everyday knowledge in the science classroom. *African Journal of Research in SMT Education*, *7*, 109-118.

Stoffels, N. T. (2005). Exploring teacher decision making during complex curriculum change. *International Journal of Educational Development.* Vol 25 issue 5. Pp 531-546.

The Harold Newspaper. 5 January 2011, page 10.

Toulmin, S. (1958). The uses of argument. Cambridge, UK: Cambridge University Press.

Treagust, D.F., & Duit, R. (2008). Conceptual change: A discussion of theoretical, methodological and practical challenges for science education. *Cultural Studies of Science Education*, 3, 297–328.

Tuckman, B. (1994). Conducting educational research. Harcourt Brace. Jovanovich.

UNICEF (2004). School readiness: A conceptual framework. United Nations children's fund. New York.

Van der Linde, P., Ogunniyi, M.B., & Langehoven, K.R. (2012). The effect of an argumentation-based instruction on grade 11 learners' understanding of chemical reactions used in extracting gold. In D. Nampota & M. Kazima (Eds.), *Proceedings of the 20th annual meeting of the Southern African association for research in mathematics, science and technology education,* University of Malawi, 16th -19th Jan. 2012, (pp. 495-515). Lilongwe: SAARMSTE

Van Wyk, J. A. (2002). Indigenous knowledge systems: Implication for natural science and technology teaching and learning. *South African Journal of Education, 22*(4), 305-312.

Vygotsky, L. (1978). Mind in society. Cambridge, M.A: Havard University Press.

Waldrip, G.P. & Taylor .P. (1999) Students worldviews and school views, *International Journal of Science education*, 17:695-704.

Waldrip, B. (2000). Teacher –Student Interactions in Primary science: Validity andApplication of a questionnaire. *Proceedings of the second international Conference on Science, Mathematics and Technology Education* (pp.467-476). Perth: Curtin University of Technology.

Wasagu ,M.A, (1999). The relationship between science students' cultural beliefs and their academic achievement at the secondary school level in Sokoto State. Journal of Science Teachers Association. Nigeria. 12: 18-23.

APPENDICES

APPENDIX A: Letter of permission to collect data at experimental group school in 2010

64 Joepat Street
New Orleans
Paarl
7646
18 May 2011

The Principal
Winelands Secondary School
Diva Street
Winelands
7640

Dear Sir,

RE: APPLICATION TO COLLECT DATA FOR MASTERS IN SCIENCE EDUCATION THESIS

I am currently studying for my Masters in Science Education at the University of the Western Cape. I hereby wish to request permission to use the Grade 10 Physical Science class as the experimental group in data gathering exercise for my thesis. The title of my thesis is **"Effects of a dialogical argumentation instructional model on grade10 learners' conceptions of lightning"**. The driving force behind this study is to unpack the conflict and possible resolution to the infusion of science and IKS as required by the new curriculum, using argumentation as an instructional method. Since I am teaching at the school, the data gathering will take place during normal school hours and will not affect the school's timetable in any way.

As previously discussed, the information gathered in the study shall be used for research purposes only. The name of the school and learners involved will not be disclosed to anyone. A summary report of my findings will be given to the school once the research is completed.

Yours sincerely

Noluthando Hlazo

APPENDIX B: Conceptions on Lightning Questionnaire

LEARNER'S CONCEPTIONS ON LIGHTNING (INTEGRATION OF SCIENCE AND IKS)

This questionnaire is about your ideas on lightning. There are no right or wrong answers, feel free to express your views. The information you provide will solely be used for research purposes and will not be disclosed to anyone.

SECTION A: PERSONAL INFORMATION

NAME:..

GRADE 10.........

GENDER: BOY ☐ GIRL ☐

AGE: (make a cross (X) in an appropriate box)

15 YEARS	16 YEARS	17 YEARS	18 YEARS	19 YEARS

HOME LANGUAGE :(make a cross(X) in an appropriate box)

XHOSA	ZULU	SOTHO	OTHER: (PLEASE SPECIFY)

OTHER LANGUAGES SPOKEN:..

PROVINCE ORIGINALLY FROM:..

NAME OF TOWN IN THAT PROVINCE:...

WHOM DO YOU LIVE WITH AT HOME?

MOTHER	FATHER	GRAND FATHER	GRAND MOTHER

EDUCATIONAL BACKGROUND OF PARENTS:

NEVER ATTENDED SCHOOL	PRIMARY LEVEL	SECONDARY LEVEL	DIPLOMA	DEGREE

HOW MANY TIMES DO YOU READ BOOKS OTHER THAN YOUR SCHOOL BOOKS?

ONCE A WEEK	ONCE A MONTH	ONCE A YEAR	NEVER

SECTION B: Personal views (izimvo zakho) about science

Please indicate by a cross(X) your feelings about science. Give reasons for each answer you give.

1. Science is interesting.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

2. Using my indigenous knowledge to learn science helps me to understand science better.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

3. I can use what I learn in a science class at home.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

4. I believe more in my indigenous knowledge than science.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

5. I'm only interested in science to pass my exams.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

6. There is a relationship between lightning and electricity.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

7. Lightning is caused by witches and traditional doctors.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

8. It is not necessary to protect yourself from lightning because it cannot kill you.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

9. Science explains formation of lightning better.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

10. When lightning strikes we should cover our mirrors.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

APPENDIX C: Science Achievement Test on Lightning

SCIENCE ACHIEVEMENT TEST ON LIGHTNING

NAME:..

GRADE 10:..........

Question 1

Read the stories below and indicate which statement you agree with by making a cross(X) on the boxes provided. Also indicate your source of information.

1.1 Lightning is...............

(a) Caused by witches. ☐

(b) Fire ☐

(c) A large spark ☐

(d) A natural phenomenon ☐

Reason for your answer:

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....

1.2 To protect your house from lightning you must............

(a) Use a lightning conductor. ☐

(b) Ask a priest (umfundisi) to pray for your house. ☐

(c) Consult a traditional doctor (igqirha) to give you muthi to protect you. ☐

(d) Put a motorcar tyre on the roof of the house. ☐

Reason for your answer:

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....

1.3 Chitibhunga, a famous traditional doctor while performing a ritual pointed his spear(umkhonto) in all directions while there was a lightning storm. He was struck by lightning and was badly injured. After that incident people were saying that..........

(a) He was bewitched by other traditional doctors. ☐

(b) He was not a qualified traditional doctor. ☐

(c) His spear conducted charges through him. ☐

(d) The ancestors (abaphantsi) were angry with him. ☐

Reason for your answer:

....

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....

....

1.4 Gogo told her grandson not to stand under the tree umnga when there is a lightning storm. The explanation for that could be....

(a) Impundulu (lightning bird) lays its eggs on the umnga tree. ☐

(b) Tall trees attract lightning. ☐

(c) A willow tree attracts lightning. ☐

(d) Witches use the tree to hide their muthi. ☐

Reason for your answer:

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1.5 When there is a lightning storm, people are advised not to handle water. This is because..........

(a) Lightning bird (impundulu) lives in water. ☐

(b) Lightning likes water. ☐

(c) Water is a good conductor of lightning. ☐

(d) Water is pure. ☐

1.6 During a football match in the FNB stadium between Moroka Swallows and Celtic there was a lightning strike and many players were injured and one was killed. The player had huge wounds all over his body.

Doctors who saw the wounds explained that.....

(a) Lightning kills people in a strange way. ☐

(b) The other team members bewitched him as he was the highest goal scorer. ☐

(c) Tokoloshe beat him with a sjambok. ☐

(d) Impundulu scratched him with its long hard nails. ☐

Reason for your answer:

....

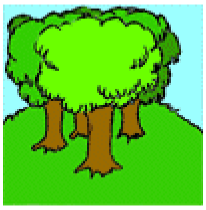
....

....

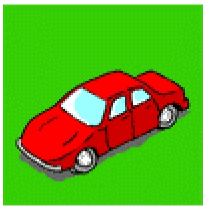
....

1.7 Bob has been caught outdoors when a thunderstorm suddenly forms overhead. He needs to find a safe place for protection from lightning.

In the picture below, where will Bob be the safest?

(a)  ☐

(b)  ☐

(c)  ☐

(d) 

☐

Reason for your answer:

....

....

....

....

QUESTION 2

2.1 Zuko rubbed a plastic ruler on the sleeves of his jersey. He then brought the rubbed ruler close to small pieces of paper.

2.1.1 What will happen to the pieces of paper?

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....

....

2.1.2 Explain why this happens.

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2.1.3 Explain what happened to the ruler during rubbing?

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2.2 Two freely hanging strips which carry different charges are brought close to each other.

2.2.1 What will happen to the strips?

....

....

....

....

2.2.2 Explain your answer.

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2.3 A positively charged metal strip is brought near another positively charged metal strip.

2.3.1 What will happen to the charged strips?

....

....

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....

2.3.2 Explain your answer.

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....

....

2.4 Two balloons are brought close to each other. One balloon is positively charged and the other one is not charged.

2.4.1 What charge will be induced on the uncharged balloon?

....

....

2.4.2 Explain your answer.

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....

2.5 What happens when you take a jersey off in a dark room?

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....

....

2.5.1 Explain why that happens.

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....

2.6 During a thunderstorm, there are huge sparks followed by thunder. What is the cause of..

2.6.1 The sparks?

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....

....

2.6.2 The thunder?

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2.6.3 Why is the thunder heard long after you have seen the sparks? Explain.

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2.7 Explain how a cloud becomes charged.

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2.8 Explain how lightning is formed.

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2.9 Church buildings have a strip of copper fixed to the side of the church. This strip extends high to the church spike.

2.9.1 What is the purpose of the copper strip?

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2.10 What are the things that you must avoid during a thunderstorm? Give reasons.

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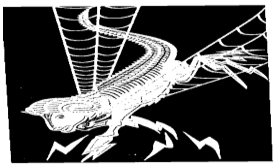
Question 3

Read the following article and evaluate the different views on lightning. On a table, separate the scientific and indigenous explanations and write down your conclusions.

All cultures have their deep seated, fixed belief system surrounding lightning. There have been many attempts to explain lightning, resulting in a collection of lightning explanations. According to the Xhosa people, the *impundulu* or lightning bird  is about the size of a man, white or black in colour with a large hooked beak, long legs and red feet. *Impundulu* is frequently employed by witches as it cannot resist a woman and is easily influenced by their cunning tricks. The power of the *impundulu* is immense. It flaps its wings and thunder roars, it spits and forked lightning flashes. Where *impundulu* strikes, the ground is burnt and here it lays its eggs. These eggs are about the size of a hen's once laid, the egg sets about tunneling through the ground to the nearest stream or river where it lies in the water. There it swells until it bursts and releases a new, full-grown impundulu. The Sotho's call it *tladi.* The people of Congo call it the lightning dog *nzazi.* They say the nzazi barks as it comes down to earth and again when it returns to the sky. Some stories say the Zulu *izinyanga* try to attract the lightning bird by placing a large bowl of amasi (sour milk) mixed with muthi where they want it to strike. The ancient Greeks believed that the mythical god Zeus marked his presence as the ruler of the heavens by lightning, thunder and rain.

No matter what your belief, the power of lightning cannot be disputed. A lightning bolt can deliver enough energy to boil seven thousand litres of water. It is not difficult to understand why people try to protect themselves from lightning in different ways. Some people put tyres on their roofs as a form of insulation while others cut down trees around their houses, cover mirrors and stay away from water during a storm. Unfortunately many of these actions offer very little protection. We cannot predict where lightning will strike and the thin insulation offered by tyres on a roof offers no protection. However it is safe to be in a car because you are inside a metal shell. If the car is struck, the charge stays in the metal until it is discharged to the earth instead of passing through the people inside. Mirrors do not attract lightning and only water in contact with pipes that can be struck is dangerous during a storm. The chance of a house being struck by lightning increases if the trees surrounding it are cut down.

INDIGENOUS EXPLANATION	**SCIENTIFIC EXPLANATION**
1.	
2.	
3.	
4.	
5.	
6	
7.	
8.	

Your conclusions:

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APPENDIX D: Investigation task on lightning

Investigation task (learners work individually at home)

Ask at least 3 people at home (relatives) or people in your community about how they feel and what they believe about lightning. Use the questions in this table to help you with this activity.

Questions	**Your own ideas**	**People interviewed**
What is lightning?		1. 2.

		3.
What do you think causes it?		1. 2. 3.
Is there any link between electricity and		1.

lightning? Please explain why or why not.		 2. 3.

Report from

Investigation task (learner-centred class discussion)

1. What did the people at home tell you about lightning?

……

……

……

……

……

……

……

………

2. Which of these ideas do you think are not true? Please give reasons.

……

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………
………
………

APPENDIX E: Interview Questions

INTERVIEW QUESTIONS

1. What were your views about lightning before the science lesson? *(ubusazi ntoni ngombane phambi kokuba ufunde ngawo?*

2. What are your views now? / have your views changed*? (lukhona na utshintsho kwinto ubukholelwa kuyo ngombane?*

3. Has arguing about the topic with other learners had any influence or impact on your views? *(ingaba ukuxoxa nabanye abafundi kube negalelo na kwindlela ocinga ngayo ngoku?*

4. If yes how? (*ukuba kunjalo cacisa.)*

5. Will arguing about science topics make you understand them better? How? *(ingaba ukuxoxa nabanye abafundi ngezinto kukwenza uqonde lula? Kanjani?)*

6. Do you think traditional knowledge should be infused in science lessons? Why? *(ingaba inkolela zethu zingadityaniswa na xa sifunda ngezenzululwazi?*

APPENDIX F: Lesson Plans

Lesson Plans

Teacher: Miss N. Hlazo	Grade: 10			School: Winelands Sec
	Term	1 2	**Week**	14- 19 July 21-25 11-16
Focus Learning Outcomes	**LO1:** AS 2,4 **LO2:** AS 2,3 **LO3:** AS1			
Assessment Standards	Interpret data to draw conclusions: seek patterns and trends in the information collected and link it to existing scientific knowledge to help draw conclusions. Communicate and present information and scientific arguments: communicate information and conclusions with clarity and precision. Explain relationships: express and explain prescribed scientific theories and models by indicating some of the relationships of different facts and concepts with each other. Applying scientific knowledge: apply scientific knowledge in familiar, simple contexts. Evaluate knowledge and claims: discuss knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge.			
Learning Outcomes and Assessment	**LO 1: Scientific enquiry and problem solving skills:** The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts.			

Standards	**LO 2: Constructing and applying scientific knowledge**: The learner is able to state, explain, interpret and evaluate scientific and technological knowledge and can apply it to everyday contexts. **LO 3: The nature of science and its relationships to technology, society and the environment:** The learner is able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio- economic, environmental and human development.
Integrated Learning Outcomes from other subjects	Languages Life Sciences (effects of lightning) Technology (uses of static electricity in industry; uses of static electricity in everyday life) History
Knowledge are	Matter and Material
Theme/ Content	Electrostatics/ Static electricity
Concepts	Electrical charges; anode; cathode; attractive and repulsive forces; conductors; insulators
Prior beliefs	The concepts of: negative electron and positive proton; electrostatic attraction in everyday life, e.g. hair and comb; lightning; Sparks seen when taking off a jersey.

Teacher activities	Learner activities	Resources	Assessment methods and Lesson Outcomes	Time
Revise static electricity concepts. Prepare and demonstrate the learner activities on electrostatics. Explain separation of charges. List conductors and insulators. Discuss lightning and its effects. Facilitate the group discussions.	List examples of static electricity in everyday life. Summarize observations of teacher demonstration. Complete the activities. Discuss in groups what happens during lightning. Discuss the safety rules Identify the dangers of superstitions and ignorance when dealing with lightning.	Plastic ruler, woolen cloth, pieces of paper, string, two balloons for each group, electroscope, polythene strip, van der Graaff generator, Books	Assessment will be based on learner's ability to: Make and interpret observations. Read through text and respond appropriately. Communicate scientific information. Describe the forces between charges. Identify conductors and insulators. Explain how lightning occurs. State that static electricity is created when materials are rubbed together. State that charges are separated when certain materials are rubbed against one another. State that like	50 minutes per period

Ask questions relating to lightning. (What is lightning? How does it occur? Preventative measures against lightning? Beliefs about lightning etc.)			charges repel and unlike charges attract each other.	

Expanded opportunities: allow learners to discuss using their home language so that everyone participates	**Enrichment and Extension:** uses of static electricity in industry; effects of lightning on the human body

Rubric to be used to assess the learner activities.

Criterion	3 marks	2 marks	1 mark	O mark	Score
Making observations: **Ruler and balloons**	Complete and accurate observations	Some inaccuracies in observations	Observations incomplete	Poor attempt/ no observations made	

Interpreting observations: Neutral electroscope	Observations complete and accurate; interpretations and drawing show insight	Appropriate observations, but interpretations or drawing show lack of insight	Some observations, interpretations or drawing incomplete or incorrect	Poor attempt/ no interpretations or drawing present	
Interpreting observations: Charged electroscope	Observations complete and accurate; interpretations and drawing show insight	Appropriate observations, but interpretations or drawing show lack of insight	Some observations, interpretations or drawing incomplete or incorrect	Poor attempt/ no interpretations or drawing present	
Interpreting observations: Van de Graaff generator		Observation and interpretation complete and accurate	Observation or interpretation incomplete or incorrect	Poor attempt/ no observation or interpretation present	
Responding to text on lightning	Answers complete and accurate; interpretations show insight	Appropriate answers, but interpretations show lack of insight	Some answers incomplete or incorrect	Most answers incomplete or incorrect	
Opinion on traditional beliefs			Unprejudiced opinion given	Opinion prejudiced or not present	

Total: 15 marks

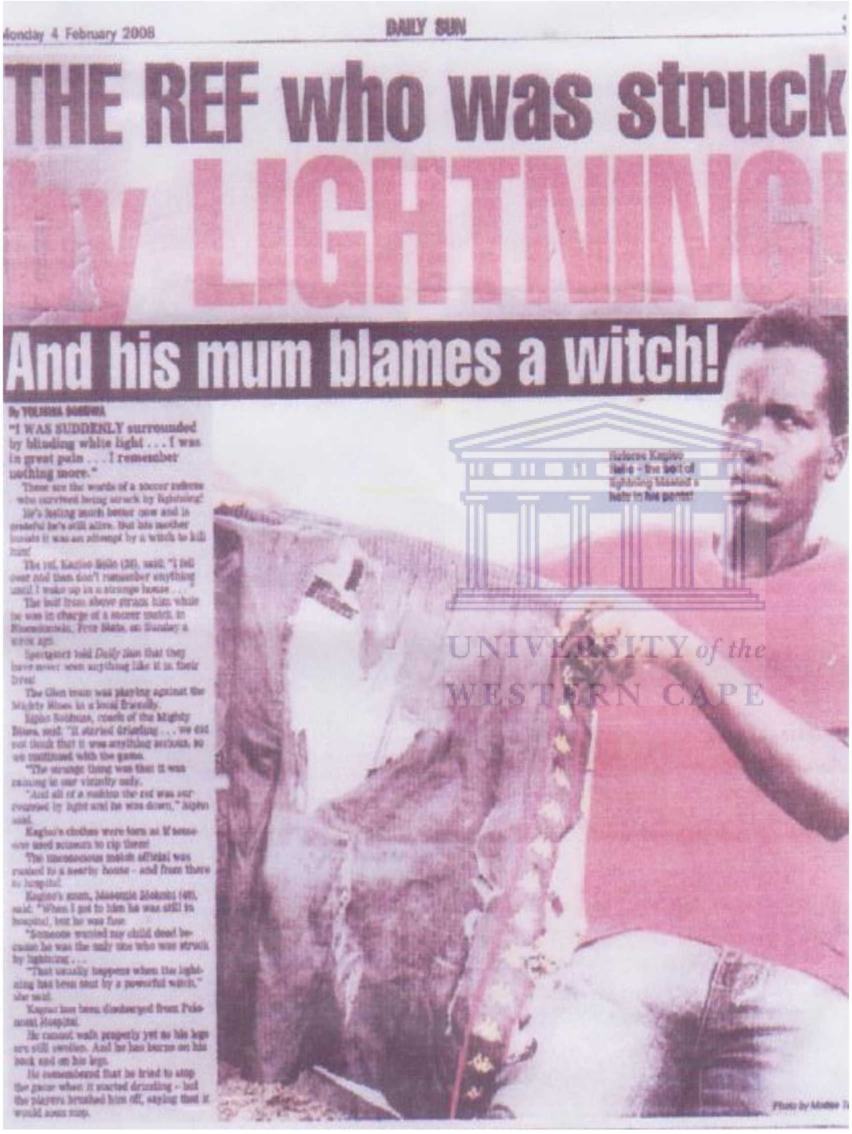
Table to be used to convert marks to the seven- point rating scale:

Rating code	Description of competence	Percentage	Mark achieved
7	Outstanding achievement	80 – 100%	12 – 15
6	Meritorious achievement	70 – 79%	11
5	Substantial achievement	60 – 69%	9 – 10
4	Adequate achievement	50 – 59%	8
3	Moderate achievement	40 – 49%	6 – 7
2	Elementary achievement	30 – 39%	5
1	Not achieved	0 – 29%	0 – 4

APPENDIX G: Argumentation Worksheets

Activity 1: Beliefs about Lightning using TAP

Read the newspaper report about an unusual lightning incident that occurred during a thunderstorm in Johannesburg on 4 February 2008 and answer the questions that follow.



Monday 4 February 2008 DAILY SUN

THE REF who was struck by LIGHTNING!

And his mum blames a witch!

By [illegible]

"I WAS SUDDENLY surrounded by blinding white light . . . I was in great pain . . . I remember nothing more."

These are the words of a soccer referee who survived being struck by lightning!

He's feeling much better now and is grateful he's still alive. But his mother insists it was an attempt by a witch to kill him!

The ref, [illegible] (26), said: "I fell over and then don't remember anything until I woke up in a strange house . . ."

The bolt from above struck him while he was in charge of a soccer match in [illegible], Free State, on Sunday a week ago.

Spectators told *Daily Sun* that they have never seen anything like it in their lives!

The [illegible] team was playing against the Mighty [illegible] in a local friendly.

[illegible], coach of the Mighty [illegible], said: "It started drizzling . . . we did not think that it was anything serious, so we continued with the game.

"The strange thing was that it was raining in our vicinity only.

"And all of a sudden the ref was surrounded by light and he was down," [illegible] said.

[illegible]'s clothes were torn as if someone used scissors to rip them!

The unconscious match official was rushed to a nearby house – and from there to hospital!

[illegible]'s mum, Masentle [illegible] (49), said: "When I got to him he was still in hospital, but he was fine.

"Someone wanted my child dead because he was the only one who was struck by lightning . . .

"That usually happens when the lightning has been sent by a powerful witch," she said.

[illegible] has been discharged from [illegible] Hospital.

He cannot walk properly yet as his legs are still swollen. And he has burns on his back and on his legs.

He remembered that he tried to stop the game when it started drizzling – but the players brushed him off, saying that it would soon stop.

1.1 What or whom did Masentle blame when her son was struck by lightning. What did she believe was the cause of the accident? State your answer as a **claim.**

……

……………………………………………………………………………………

1.2 What **evidence** or reasons did Masentle use to support her claim?

……

……………………………………………………………………………………

1.3 What assumptions does she refer to as a warrant to support her data? State your answer as a **warrant**.

……

……………………………………………………………………………………

1.4 What does Kagiso remember about what happened to him when he was struck by lightning?

……

…………………………………………………………………………………...

1.5 What effect did the lightning have on Kagiso's body ad on his clothes?

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……………………………………………………………………………………

1.6 Based on Kagiso's account and type of injuries that he sustained, what scientific explanation would you propose? State your answer as **rebuttal** to Masentle's claim with reasons to support your evidence.

……

……………………………………………………………………………………

Activity 2: Investigating Lightning using TAP

Individual task

- Fill in the TAP framework below by writing down your personal narrative experiences, cultural beliefs and scientific explanations about the cause and effect of lightning.

CLAIM (opinion)	**REASONS/GROUNDS (support your claim)**

Activity 3: Small group discussion

- In your groups, share your claims and grounds and record the most interesting explanations, beliefs and stories about the cause and effect of lightning.

Name of group member/ code	**Claim**	**Reasons/Grounds (to support the claim)**	**Counter claims and Rebuttals**
1.			
2.			
3.			
4.			

Activity 4: Whole class discussion

- Group leaders present the groups' explanations, stories and beliefs about lightning to the whole class.

Group No/Name	**Claims**	**Reasons/ Grounds ((supporting the claim)**	**Counter Claims/ Rebuttals**
1.			
2.			
3.			
4.			