Chapter 1

Introduction

> This study does not aim to eradicate the beliefs that learners have about lightning. However, when people's lives are in danger it is important that the beliefs be modified since the environment in which they are practiced is constantly changing… what makes this modification even more necessary and urgent is the killings and persecutions that the ordinary people are being subjected to, because they are believed to be responsible for lightning strikes (Mahapa, 2002).

1.1 Introduction to the chapter

This study explores the possible role of indigenous beliefs in the teaching and learning of school science and how learners deal with possible conflicts that may occur during the teaching and learning process. The focus was on the beliefs that learners have about lightning. These beliefs were incorporated in the teaching of electrostatics with the aim of promoting conceptual understanding in electrostatics, in particular, an understanding of the scientific view of lightning.

In this chapter, I will discuss the background of this study, its rationale and purpose, and the research questions.

1.2 Background of the study

The people of Limpopo Province in South Africa (S.A.) have a view of lightning that differs from the scientific view. In many rural areas, lightning deaths are seen as a result of witchcraft. As a result the province is experiencing many killings and persecutions of people in various villages, which were sparked by accusations of witchcraft and beliefs that human beings are capable of conducting lightning strikes (Mahapa, 2002:1). For example, in the area where I teach there are serious problems (allegations and accusations), which are the result of some of the beliefs about lightning. Most of the community members believe that a person can cause lightning to strike other people or houses out of jealousy or hatred. Some of them believe that people can use lightning to steal other people's properties/belongings like a bag of maize meal or food. Such people do not perceive lightning as a natural phenomenon, and obviously, they do not know the link between lightning and electrostatics. Therefore, there is a need for scientific literacy as far as electrostatics is concerned. One may hope that if people develop a scientific understanding of lightning the social tensions associated with the phenomenon will be reduced.

1.3 Rationale and purpose of the study

South Africa comes from a past in which the poor quality or lack of education resulted in limited access to scientific knowledge. Furthermore, South Africa consists of diverse cultural groups with diverse cultural backgrounds. Hence, the adoption of the Constitution of the Republic of South Africa (Act 108 of 1996) provides a basis for curriculum transformation and development, which aims to heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights (DoE, National Curriculum Statement (NCS) Grades 10-12, General, Physical sciences, 2003:1). Some of the principles guiding our development are, according to the NCS (2003)

- Social Transformation, which aims to redress the educational imbalances (p.2).
- Human rights, inclusivity, and social justice, which aims to address the intellectual, social, emotional, spiritual and physical needs of learners through the design and development of appropriate Learning Programmes and through the use of appropriate assessment instruments (p.4).
- Valuing Indigenous Knowledge Systems, which states that different perspectives have been included in the Subject Statements to assist problem solving in all fields (p.4).

These principles imply that educators need to make scientific knowledge accessible to all South Africans in order to address the educational imbalances. For example the people of Limpopo in rural areas deserve to know the scientific view of lightning. This can be done through the design and development of appropriate Learning Programmes in which Indigenous Beliefs about lightning can be given the attention they deserve. I found these principles very important to me as an educator and also as the researcher. As an educator I need to design teaching and learning materials that address these principles, and as the researcher I need to investigate the impact that these principles have on the learning of school science.

Another aspect of the NCS, which caught my attention, is Learning Outcome 3 (LO3): *The Nature of Science and its Relationship to Technology, Society and the Environment.* This learning outcome expects learners to be 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 (p.28). Its first Assessment Standard (AS) is:

Evaluating Knowledge Claims; and it expects learners to be able to discuss knowledge claims by indicating the link between indigenous systems and scientific knowledge (p.28). The attainment of this assessment standard is evident when the learner, for example, uses scientific knowledge to explain why certain traditional practices are important (p.28). As a result, the learner emerging from Further Education and Training (FET) must be able to transfer skills between more and less familiar situations, i.e. from one context to another. For this learning outcome to be achieved educators need to be able to integrate the IKS/Beliefs with science topics. These are some of the challenges that educators are faced with.

The above-mentioned aspects of the NCS raise a number of questions, which lead to the formulation of this research topic. For example: Are teachers aware of integration of IKS as expected by the NCS? Some IKS enthusiasts like Ntuli (2002), claim that, “there is no attempt at any level to explain the indigenous knowledge systems’ awareness of the essential interrelatedness and interdependence of all phenomena: physical, biological, social and culture” (p.65). For teachers to be aware of the integration of IKS, they must be in possession of the NCS, unfortunately, most teachers do not have this document, and in my District there was no other form of dissemination about the integration of IKS. As a result, it will be very difficult for teachers in this District to implement Learning Outcome 3, as expected by the curriculum developers. Another question is, whether the few teachers who are aware of the integration of IKS, can provide indigenous examples that can be incorporated into the school science curriculum. Since the NCS suggests that, “all subjects that form part of the NCS have integrated elements of indigenous knowledge”, can teachers identify such elements? Where can they find these, and how can these elements be integrated in the teaching of science? I soon realised that teachers out there will need assistance with the integration of IKS.

As a science teacher, I too, am expected to integrate IKS into my science teaching. In fact, teachers are recognized as the central determining factor in successful implementation of reform in science education. The success of intended reform depends on teacher’s ability to integrate the philosophy and practices of the current curriculum.

As an agent of change, I decided to embark on an exploratory investigation of the impact of Indigenous Beliefs on the learning of school science, especially on lightning. The allegations and accusations that people can cause lightning to strike make this study to be more relevant to the participants of this study, the people of Limpopo Province, and to any one who still practices traditional methods of protection against lightning. Even though absolute protection is not possible, people need to be informed about the safest ways of protecting themselves against lightning. Learners' beliefs about lightning were integrated in the teaching of electrostatics with the hope that a better understanding of electrostatics will make my learners aware of these safest ways of protecting themselves against lightning. Another aim of this study is to make learners aware that in certain instances science conceptions are much more fruitful than their alternative conceptions. Learners deserve to know the different perspectives from which to understand and make sense of the natural phenomena. However, the decision of whether to apply the scientific knowledge or not is entirely theirs.

1.4 Research questions

My general (main) research question is:

What indigenous beliefs do learners bring to science classrooms, and how can these beliefs be given a function in the learning of science?

As clarified above the context of lightning as an electrostatic phenomenon was chosen as a relevant context for exploring this question. In order to address this question, it was important to have a full understanding of the indigenous beliefs which my learners have with respect to lightning, and the role that these beliefs can play in the learning process. This led to the formulation of what Plomp (2004:11) calls "*key questions*" (which emerge from the main research question) and "*operational research questions*" (sub-questions phrased as practical researchable questions).

The research question contains two main parts, the first part being: "*What indigenous beliefs do learners bring to science classrooms?*" This study investigates the beliefs that learners have about lightning, in order to integrate these beliefs with the teaching of electrostatics. In the preceding sections I highlighted the problems that are caused by some of the beliefs about lightning and why scientific literacy is needed in as far as lightning is concerned. This key question was addressed by the baseline study.

The second part of my general research question is: "*How can these beliefs be given a function in the learning of science?* Learners in rural areas are constantly exposed to situations in which people are accused of being able to use lightning to kill other people or to destroy other people's properties. The integration of the beliefs about lightning in this study that sometimes lead to such situations aims to promote conceptual understanding in electrostatics to help learners make informed choices on issues related to lightning. The design and implementation process addressed this key question.

The general research question can be broken down into five operational research questions.

1. What are the main cultural and traditional beliefs about lightning that exist in the social context of learners in Limpopo Province?
2. To which of these beliefs do the learners adhere?
3. Is it possible to design on the basis of contemporary views in science education, a teaching sequence in which indigenous beliefs about lightning are effectively integrated with the teaching of the science topic of electrostatics? What do learners learn from an effective integration of this kind?
4. Specifically, in what way can a design of this kind provide teachers and learners with opportunities to explore conflicts between scientific and indigenous ways of understanding the phenomenon?
5. How does this teaching sequence on electrostatics in which indigenous beliefs on lightning have been integrated affect the way learners take decisions on relevant daily issues?

Chapter 2

Literature Review

2.1 Introduction

Research has shown that learning proceeds primarily from prior knowledge, and only secondarily from the presented materials. This is in accordance with the Constructivist Learning Theory and the Worldview Theory. But some of the findings have shown that prior knowledge can sometimes be at odds with the presented materials, and as a result learners may become confused. Some of the researchers suggest that getting African students to relate with indigenous beliefs is a task that raises more problems than it solves.

This chapter will focus on specific aspects of contemporary issues in science education. I will start with a short summary on lightning, thereafter I will discuss the theories that deal with learners' prior knowledge, followed by the link between these theories, and a discussion of IKS. One of the most important elements of this research is the integration of learners' prior knowledge with a science topic; a number of suggestions that emerge from the research literature will be discussed, thus outlining the theoretical framework of this study.

2.2 Lightning

According to science lightning is one of the natural phenomena that result from electrostatic forces. However, learners have their own ideas of what lightning is, while the community members played a major role in the development of these ideas.

2.2.1 The scientific view of lightning

According to the National Curriculum Statement Grades 10-12 (2003:50), Grade 10 learners are expected to be able to recognise lightning as electric/capacitative discharge. The NCS suggests that this core concept can be used by learners to attain Assessment Standards of Learning Outcome 3. This study aims to find out if the integration of beliefs on lightning with this core concept and other concepts in electrostatics can help learners to understand the scientific view of lightning.

Some scientists like Uman (1986:44, 93, 114, 123), distinguish different kinds of lightning according to their formation, shape, and behaviour, for example: *hot lightning* is a lightning flash that contains continuing current, causes fire; *cold lightning* is a lightning flash that does not contain continuing current, does not cause fire; *stepped leader* is a downward-travelling spark, from cloud to ground; *return stroke* is an upward-travelling spark, from tall buildings/ground to cloud; *heat lightning* is an illumination of distant clouds, occurs on hot nights); *sheet lightning* refers to intracloud discharges which light up a large area simultaneously, giving the impression of a sheet of light; *ball lightning* is a mobile luminous sphere, about size of an orange; *ribbon lightning* is an optical illusion, that occurs when cloud-to-ground flash moves sideways; and *bead or chain lightning* refers to a lightning channel to ground that appears to break up into luminous fragments, and causes a series of ball lightnings.

2.2.2 The cultural view of lightning

Mahapa's (2002:53) findings indicate that according to the cultural view of lightning there are two types of lightning: the lightning event that is considered to be of the natural cause, and the one that is not considered to be of the natural cause, namely *Tladi* (p.53). Three types of *tladi* were identified as (i) *tladi ya nonyana (*lightning strike caused by a bird); (ii) *tladi mothwana* (lightning strike conducted by people); and (iii) *tladi ya mollo* (lightning strike associated with fire).

This cultural view of lightning makes people develop non-scientific ideas about lightning that may lead to the persecutions and killings of innocent people. Some of the ideas or beliefs about lightning are: (i) shiny objects attract lightning. (ii) bright colours (especially red) attract lightning. (iii) a bird called *tladi* conducts lightning. (iv) suitable location to hide for lightning strikes: avoiding trees, open space, water, etc. (v) lightning is attracted by tallest objects. (vi) lightning is mysterious, it does things that are hard to explain. (vii) people can use lightning to achieve their objectives (Mahapa:62-62). Maselwa's (2004:40-41) findings also indicate that according to the cultural view of lightning there are four categories of the things that parents told their children not to do during a lightning storm: *first category* (deals with electrical appliances); learners should not watch TV, play radios, touch electricity wires, and use telephones. *Second category* (deals with consumption); learners were not allowed to drink water, drink milk, eat eggs eat meat, and eat *umphokoqo* (African salad, that is, cooked maize meal with sour milk). *Third category* (deals with social issues); learners should not play in the field, wear red clothes, sit close to one another, sleep while others are not sleeping, and stand on the thresholds of a building. *Fourth category* (deals with general issues); parents warned learners to cover mirrors, not to handle metals or shiny objects, not to handle or carry water, not to throw soapy water through the door, not to stand under a tree, and to put a motor car tyre on the roof.

This study will determine the kind of indigenous beliefs about lightning that are held by the community members in the area where I teach and those that my learners adhere to, in attempt to answer the first two operational research questions.

2.2.3 Protection against lightning

Many researchers that are investigating awareness and protection on lightning and electrostatics hold the view that lightning's behaviour is random and unpredictable; as a result preparedness and quick response are the best defences towards the lightning hazard. Prevention and education are the keys to lightning safety. However, it was also found that lightning protection systems provide limited protection (National Lightning Safety Institute, 1998). Uman (1986) also argues that no lightning rod, however tall, can offer absolute protection … lightning does not respect token levels of insulation (p.10). Kithil (2000) adds by saying, "lightning protection in an absolute sense, is essentially impossible, lightning can overcome any defence man can conceive (p.6). He continues to say; "Absolute protection from lightning may exist in a thick-walled and fully enclosed Faraday Cage; however, this is impractical in most cases"(p.9).

The above views make this study to be more relevant to the participants of this study, the people of Limpopo Province, and any one who still practices traditional methods of protection against lightning. Even though absolute protection is not possible, people need to be informed about the safest ways of protecting themselves against lightning. The following Protection methods are recommended by different researchers on Safety and Awareness as far as lightning and electrostatics are concerned.

Uman (186:21) suggests that:

- *if out-of-doors; do not make a lightning rod of yourself, and do not stand beneath a lightning rod.*
- *if in urban area; seek shelter in a building or car*
- *if in wide-open-space; crouch or lie down, find a ravine, valley*
- *if in a wooden area; seek shelter in dense woods, thick growth of small trees.*

National Lightning Safety Institute (1997:31) provides the following tips for Personal Conduct during Lightning Activity:

- *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 and temporary shelters.*
- *avoid the following locations; hilltops, top of buildings, open sports fields, parking lots, swimming pools/lakes/seashores, wires (fence, clotheslines, railroad tracts, etc.), electrical appliances, telephone.*
- *don't ride in open boats tractors, bicycles, scooters, etc.*
- *seek depressed areas; avoid mountaintops, hilltops, and other high places.*

This study will explore how indigenous beliefs and these knowledge claims can be taught, in an integrated whole that enables learners to make informed decisions in relevant situations. The fifth operational research question seeks to find out how an intervention of this kind affects the way learners take decisions in situations that involve lightning.

2.3 Theoretical Framework

In order to address integration of social or cultural issues such as indigenous beliefs about lightning with a science topic, this study drew on theories associated with prior knowledge of learners such as Constructivist Theory and the Worldview Theory that were applied through participatory action research. Also, an understanding of Indigenous Knowledge Systems from the perspectives of these theories was developed.

The constructivist view of learning supports the idea that learning outcomes do not depend solely on what the educator presents; rather they are an interactive result of what information is encountered and how the student processes it based on perceived notions and existing personal knowledge (Yager, 1995:37). The constructivist theory is learner-centred and suggests that connecting the science content being learnt to the learner's experiences and prior knowledge maximises learner involvement and learning. On the other hand, the Worldview Theory also provides a non-rational foundation for thought, emotion, and behaviour; it provides a person with presuppositions (Cobern, 1996:585). The Worldview Theory underpins Jegede's (1997) border crossings from the sub-cultures associated with the learner's socio-cultural environment into the sub-cultures of science. The integration of Indigenous Knowledge Systems or Indigenous Beliefs were based on Aikenhead's (1994) sequence for STS science teaching model, and Snively's (1995) five-step process for producing a Traditional Ecological Knowledge (TEK) unit in cross-cultural science teaching. Sections 2.3 to2.5 below provide detailed information about the above-mentioned systems.

2.4 Constructivism, Worldview Theory, and Nature of Science (NOS)

The most conspicuous psychological influence on curriculum thinking in science since 1980 has been the constructivist view of learning (Fensham, in Matthews, 1998:165). Most recent reforms like C2005 are based on constructivism. Constructivism is generally viewed as a way of thinking about learning (Yager, 1995:35); it is a theory about knowledge and learning (Haney and McArthur, 1996:283). In constructivism, knowledge is not considered an absolute; knowledge is the result of the social, cultural, and historical milieu (Matson and Parsons, 198:224). This implies that knowledge is constructed individually based upon a person's socio-cultural background. Since learning is about making meaning within a cultural milieu, multiculturalists ask the following important questions: within a cultural milieu of a particular student, what knowledge is important? What knowledge is meaningful? How does knowledge relate to a student's cultural milieu? For example, according to the Worldview Theory, a person sitting in a science classroom is not just a science student, he or she is a thinking human being who sees the world in terms of a variety of other contexts influenced by gender, ethnicity, religion, etc. (Shipman et al, 2002:528). Knowledge is viewed as depending on a reasonably large number of different concepts, each refined through use, example, and experiences. Thus, the intellectual picture of the world inside learner's heads includes prior conceptions or beliefs about the natural world. Constructivism suggests that the concepts knowledge and belief are not strictly separable.

The Worldview Theory sees a person as having presuppositions about what the world is really like and what constitutes valid and important knowledge about the world (Cobern, 1996:584). These presuppositions are the views that a person holds about natural phenomena, which also include: commonsense, alternative frameworks, indigenous beliefs, misconceptions, and/or valid science. Lewis (1947, in Cobern 1996:585) once wrote; *"it is simply no use to see through first principles… If you see through everything, then everything is transparent. But a wholly transparent world is an invisible world. To see through all things is the same as not to see"* (p.91). Lewis wanted to indicate that the basic or primary beliefs of a worldview cannot and should not be tested against those of other views. It is true that scientists and educators are interested in how people see the world, and in most cases they expect people to use the scientific worldview. This is exactly what the conceptual change teaching and learning is all about: how learners change their vision of the world from a traditional worldview to incorporate the scientific worldview as well.

Developing a scientific worldview is a major goal for *science education*. Indeed, curriculum statements for science education such as the NCS show that *scientific literacy* is the main goal for science education. Scientific literacy stands for what the general public ought to know about science; it also implies an appreciation of the nature, aims, and general limitations of science, coupled with some understanding of the more important scientific ideas. The NCS describes what scientific literate students should know and be able to do after FET. For example, a scientifically literate person should be able to understand the interrelationships between science and technology (Pella, in Bybee, 1997:52), the nature of science, and use processes of science in solving problems, making decisions and furthering his own understanding of the universe (Showalter, in Laugksch, 2000:76).

In simple terms, a scientifically literate person must be able to read, write and converse coherently about scientific issues. For example, he\she must be able to evaluate scientific evidence used in advertising, or be equipped to take decisions about matters that affect his\her personal or economic well-being such as diet, safety, energy usage, etc. One of the reasons why we should promote scientific literacy is that the isolation of science from the general public may result in the public failing to understand science properly, and as a consequence citizens may respond to science with a mixture of feelings. For example, in South Africa, especially in rural areas, scientifically literate citizens will have a working understanding of some of the natural phenomena in the world around them such as lightning, echoes, eclipse, rainbow, etc., as a result they are likely to find everyday life less terrifying and mystifying.

Constructivism is based on the premise that knowledge is not something that can be transferred from one person to another, but instead must be built by the individual. A constructivist classroom is one in which learners are active participants in the meaning-making process; because one can only know what one has constructed oneself in a social context. Constructivist ways of teaching and learning, and scientific literacy underpin the notion of the Nature of Science (NOS). According to Zeidler (2002:345), the Nature of Science refers to one's understanding of the social practices and organization of science.

Holding an explicit understanding of the enterprise of science is considered to be the linchpin of scientific literacy, because people who understand how scientific knowledge evolves can thoughtfully evaluate claims, rather than reject or accept them uncritically (Hogan, 2000:52). This view is supported by Lederman (1999:916) when he says, an understanding of the NOS will enable students and the general public to be more informed consumers of science, which will empower them to make more informed decisions when scientific claims and data are involved. NOS as an essential component of scientific literacy and therefore of the public understanding of science, includes the cultural significance of scientific achievement as a primary argument (Driver et al. 1996, in Irwin, 2000:9). Zeidler et al. (2002) add by saying, “if indeed, our goal in science education is to develop a scientifically literate population capable of making informed decisions in a democracy, then including moral and ethical issues as a defining component of the NOS is highly desirable” (p.345). Irwin (2000:7), suggests that a scientifically and technologically literate person should understand that the NOS and technology are products of cultures within which they develop.

As with any curriculum reform, the success of the current efforts in S.A. will be contingent upon teachers internalising the importance of the stated goals of the reform and their ability to transform these goals into classroom practice.

The above-mentioned theories are relevant to this study in that they highlight the value of cultural and social components of meaning making or making sense of the natural world. These theories suggest that educators need to utilise and take into account the ideas that learners bring to science classrooms. Therefore operational research question 1 of this study is meant to establish what knowledge about lightning, exists in the social and cultural setting, while operational research question 2 is meant to determine whether learners share this knowledge. The remaining operational research questions should allow us to express how this knowledge can be integrated in the teaching of electrostatics, and what the consequences of this integration are.

2.5 Indigenous Knowledge Systems (IKS)

According to literature indigenous knowledge is not a uniform concept across all indigenous peoples, it is a diverse knowledge that is spread throughout different peoples in many layers (Onwu and Mosimege, 2004:2). For the purpose of IKS incorporation into the curriculum, Onwu and Mosimege (2004:2) regard Indigenous Knowledge as an inclusive knowledge that covers technologies and practices that have been and are still used by indigenous and local people for existence, survival, and adaptation in a variety of environments. IKS in the South African context refers to a body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years (NCS Grades 10-12 General, Physical Sciences, 2003:4). Dlamini (2003:589) also defines Indigenous Knowledge Systems as the knowledge society has about certain phenomena, activities and events. It is important to note that Indigenous Knowledge Systems are local, community-based systems of knowledge which are unique to a given culture or society, hence indigenous knowledge is part of the community or the individual. Related to IKS are*:*

Indigenous Science, which refers to a culture-dependent collective rational perceiving of reality, where collective means are held in sufficiently similar form by many persons to allow effective communication, but independent of any particular mind or set of minds (Ogawa 1995: 588, in Snively and Corsiglia, 2001:10); *Traditional Ecological Knowledge* (TEK), which generally represents experience acquired over thousands of years of direct human contact with the environment (Snively and Corsiglia, 2001:11); and *Indigenous Knowledge,* that is considered to be various beliefs and practices (traditions, myths, rituals, etc.) that can be found in any society; and have been handed down from forefathers (Mbiti, 1969\1983 in Lillejørd and Søreide, 2003:93).

The above definitions encompass Indigenous Beliefs about the natural world, which have been developed many years ago by different cultural groups. South African researchers should take it upon themselves to explore beliefs and conceptions in the South African context. Emereole et al, in Emereole and Maripe (2003:568) believe that most of the so-called African superstitious beliefs have rational bases. Onwu and Mosimege (2004:7) indicate that such beliefs may have been designed to serve a particular purpose with respect to society. Mqotsi (2002) agrees that beliefs have social and psychological functions, for example they enforce morality; they constitute a manner of adapting to the environment; they act as anxiety-relieving mechanisms (p.168-169). Moreover, they are a reality in their own right and have logic of their own which provides those who espouse them with a philosophy of life and a theory of psychology (Evans-Pritchard, 1951:98-102, in Mqotsi 2002:169). Hence, the cultural context of the beliefs is very important as it provides a basis for further understanding of why certain beliefs are held and regarded as important. The cultural context also, provides the basis for a deeper understanding of how a particular community, tribe or clan operates the way it does, even in instances where their operation is seen as strange by those who are not part of that community.

It is an objective of this study to find out the kind of cultural beliefs about lightning of both learners and their parents who are the community members, to obtain a better understanding of the cultural context of these beliefs and rituals that are practiced in the village. It is in this learner-context that the scientific view is to be developed.

2.6 Integration of IKS and Indigenous Beliefs with a science topic.

Obviously all learners come into the classroom with a broad range of ideas, experiences, presuppositions, beliefs, values, etc. Unfortunately, most science educators have long assumed that only the scientific worldview represents “true” knowledge. It is also obvious that these experiences are different from one learner to another, because they are largely informed by what these learners have gone through in their own environment at home, at school, and in their own individual circumstances. Learners, who live in communities where IKS is strong, will tend to interpret their experiences through an IKS-based that are largely world-view. The question is, to what extend do their views reinforce or undermine what the teacher is trying to achieve in the science classroom? In the case of indigenous beliefs or claims that contradict science knowledge, how should a science teacher handle that kind of situation in the classroom? Much has been said on integration of Indigenous Knowledge Systems, and recently, efforts have been made to investigate the inclusion of Indigenous Beliefs sometimes referred to as *"relevant"* Indigenous Beliefs into the school science curriculum. However, the burning questions are still: What Indigenous Knowledge or Indigenous Beliefs should be included in the school science curriculum? How do we identify these IKS/beliefs, in other words, which model (s) are there for valuing these IKS/beliefs? When and how should these IKS/beliefs be incorporated? These questions need immediate attention if we want to see this integration of IKS being implemented, while only few educators will be able to implement this integration of IKS with a science topic on their own. This study explores the integration of indigenous beliefs about lightning with the teaching of electrostatics with the intention to provide an exemplary case that may serve as a model, and facilitate similar efforts attempted by other educators.

A review of the Further Education and Training (FET) Physical Science textbooks indicates that these textbooks do not provide the integration of IKS and/or indigenous beliefs. Inspection of six of the ten textbooks that were sent to schools by the publishers in collaboration with the Department of Education revealed that there is no integration of IKS at all. Some authors do mention some of the IK related to some of the topics. For example in one textbook the issues (beliefs) about lightning are mentioned and there is an activity in which learners are required to do an investigation on the beliefs held by the community members. However, identifying and cataloguing is not the same as integrating. Integration goes much deeper than that: it is not just about acknowledging learners' prior knowledge; but it is about doing something about learners' prior knowledge. The integration of learners' prior knowledge implies that there should be some sort of comparison or juxtaposition. Some of the textbooks do raise questions related to IK but do not attempt any form of integration with science. This I believe is taking for granted that creative educators will create conducive learning environment in which these issues will be discussed.

Onwu and Mosimege (2004) state that, "what is now needed in the current science education reform agenda is a mechanism for integrating IKS into our school science curriculum in a mutually supportive and inclusive way, so that both forms of knowledge systems can begin to provide the engaging tension among our learners" (p.2). These authors argue that there are a variety of possibilities for the inclusion of IKS into the curriculum. They suggest that, (1) at school level, learners may be asked to do small-scale investigations about how their parents or grandparents tend to use IKS, in which ever form, for their livelihood and subsistence. (2) one of the more obvious curriculum initiatives for IKS\ science interface, would entail the constructivist strategy of using learner's previous experience or prior learning as a point of departure in providing relevant science learning experiences that engage and build on existing knowledge, (3) another form of IKS\ science engagement would be to use science to evaluate IKS and vice versa. In this study operational research questions 1 and 2 relate directly to the first suggestion, while 3 relates to the second, and 4 and 5 to the third suggestion.

Snively (1995, in Snively and Corsiglia, 2001:27), outlines a five-step process for producing a Traditional Ecological Knowledge (TEK) unit in cross-cultural science teaching. The author claims that this approach provides a general framework for exploring the two perspectives (Western science and indigenous science) while teaching about one concept or topic of interest. The process includes:

"Step 1: Choose a Science Concept or Topic of Interest.
Step 2: Identify Personal Knowledge.

- *Discuss the importance of respecting the beliefs of others*
- *Brainstorm what they know about the concept or topic*
- *Brainstorm questions about the concept or topic*
- *Identify personal ideas, beliefs, opinions*

Step 3: Research the Various Perspectives.

- *Research the Western modern science perspective*
- *Research the various indigenous perspective and, if possible, the local TEK perspective*
- *Organize\process the information*
- *Identify similarities and differences between the two perspectives*
- *Ensure that authentic explanations from the perspectives are presented*

Step 4: Reflect

- *Consider the consequences of each perspective*
- *Consider the concept or issue from a synthesis of perspectives*
- *Consider the consequences of a synthesis*
- *Consider the concept or issue in view of values, ethics, wisdom*
- *If appropriate, consider the concept or issue from a historical perspective*
- *Consider the possibility of allowing for the existence of different viewpoints*
- *Consider the possibility of a shared vision*
- *Ensure that students compare their previous perspectives with their present perspective*
- *Build consensus*

Step 5: Evaluate the process.

- *Evaluate the decision making process*
- *Evaluate the effects of personal or group actions*
- *Evaluate possibilities in terms of future inquiries and considerations*
- *How did this process make each person feel?"*

Sniveley (*ibid.*) agues that although the two perspectives may interpret the world differently, students should also see that the two overlap and can reinforce one another, and suggests that discussion should stress similarities as well as differences, areas where IK helps fill the gap where knowledge in Western Modern Science (WMS) is lacking and vice versa. Odora-Hoppers (2002) supports this view by saying: " it cannot be said enough that rural people's knowledge and modern scientific knowledge are complementary in their strengths and weakness, combined they can achieve what neither would" (p.16). Stanley and Brickhouse (2001:47) suggest an alternative to this approach. They argue that, rather than merely showing students that IK and TEK are different from WMS and possibly suggesting they were inferior, their approach would be to show students how these different views of science are firmly rooted in certain cultural assumptions that influence how students go about formulating and solving problems of significance.

Snively's five-step process outlines the most important decisions to make when designing the teaching and learning materials. He guides the educator about the important issues to consider before and during the teaching and learning process. These steps were therefore used during the design of the teaching and learning materials in this study, to ensure adequate integration of the indigenous beliefs about lightning with the teaching of electrostatics. Informative assessment methods were used to evaluate the process of integrating learners' beliefs about lightning with electrostatics.

According to Jegede (1997:14-15), Africa's saviour from lack or limited scientific knowledge will be the appropriate science-technology-society (STS) education with a tailored pedagogy, which will explore how science can be integrated into the cultural traditions and practices of Africa. This author suggests that embracing STS appears to be the most attractive viable option for Africa's educational system; and claims that STS education

- *Brings sciences, science educators, and all groups of people to think of the scientific enterprise as human enterprise;*
- *Relates what is taught in science classes to our day-to day living;*
- *Is cognitively accessible at different levels to the major of those who enjoy science studies, who want a science-based career, or who need it for matriculation or certification purposes;*
- *Uses local resources for the understanding of concepts, and;*
- *Demonstrates in concrete terms that science and technology are major factors that will influence the future of the whole world.*

Jegede (*1997:16*) proposes that the best way to achieve the desired results is to use what he calls a *conceptual ecocultural paradigm,* which consists of:

- *Generating information about environment to explain natural phenomena;*

- *Identifying and using indigenous scientific and technological principles, theories, and concepts within the African society; and*
- *Teaching the values of the typical African human feelings in relation to, and the practice of, technology as a human enterprise.*

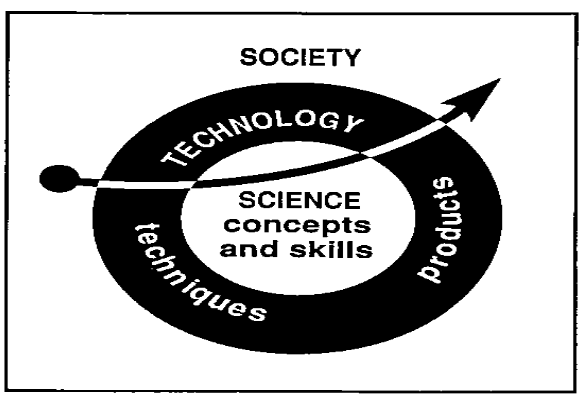
He claims that the paradigm addresses two major, interrelated, educational issues that have emerged recently, namely the issue of *constructivism,* in which the learner constructs his or her own knowledge from new experiences in terms of an existing conceptual framework, and the issue of the *worldview* that learners in traditional societies take into the science classroom.

STS science teaching aims to help students make sense out of their everyday experience. Teaching science through STS refers to teaching about natural phenomena in a manner that embeds science in the technological and social environments of the student (Aikenhead, 1994:48). Therefore in STS science curriculum the science content is connected and integrated with the students' everyday worlds, in a manner that mirrors students' natural efforts at making sense out of those worlds. So, STS science teaching is expected to

- *Increase general interest in and public understanding of science,*
- *Fill a critical void in the traditional curriculum (the social responsibility in collective decision making on issues related to science and technology).*

The following sequence for STS science teaching is suggested by Aikenhead (1994:54-58).

Fig.1: A Sequence for STS Science Teaching



The arrow indicates that the STS instruction begins in the domain of the society, where a key question (societal issue/problem related to science or technology) is posed. The key question creates the need to know certain technological knowledge. Aikenhead argues that societal issues are almost always related to technology, and that students are affected far more by their technological world than by their scientific world (p.57). Both the societal problem/issue and technological knowledge create the need to know some science content. The arrow ends in the domain of society, where students often address the original question or social problem and then make a decision. This sequence suggests that variation in lessons can be achieved by starting the instruction in the technology domain with an interesting technology; alternatively by beginning with an intriguing bit of science content.

Aikenhead (1994:53-56) proposes a descriptive scheme, which he calls “Categories of STS Science”. This scheme delineates the diversity in STS science in terms of the degree and manner in which STS content is integrated with traditional science content. The proposed scheme characterized STS science in terms of:

- *Content structure* - *the proportion of STS content compared with traditional science content, and the way the two are combined.*
- *Student evaluation* - *the relative emphasis given to STS versus traditional content.*
- *Concrete examples of STS science* - *titles of published teaching materials for schools, with the names of their publishers.*

The sequence can be realised in many different ways. It distinguishes 8 different categories (see Appendix B).

I found the sixth category most suitable for my intervention: *Science along with STS Content;* in which STS content is the focus of instruction while relevant science content enriches the learning. The strength of this category is that students are assessed approximately equally on both the STS and pure science content. The teaching and learning materials that were designed in this study made use of this category while categories 1 to 4 assess more science content (suggesting that scientific worldview is more important than the traditional worldview) and categories 7 to 8 that assess more STS content (suggesting that the traditional worldview is more important than the scientific worldview), this category does not regard one worldview as more important than the other and regards none of the worldviews as inferior. In this study the societal issue consists of the problem(s) related to beliefs about lightning, which created the need to understand the reasons for those particular beliefs. The beliefs and the reasons behind them created the need to know some science concepts in electrostatics.

Chapter 3

Research design

3.1 Introduction

The goals of this study were to investigate both elders' and learners' beliefs about lightning, and to incorporate these beliefs in the teaching of electrostatics to explore whether this integration promotes the scientific view as suggested by the Pre- and Post- Assessment task. See also my operational research question 3. Also whether this integration helps learners to take decisions on relevant daily issues that are related to lightning.

In this chapter, I will discuss the paradigm informing my research study, research participants, and appropriate techniques for data collection and data analysis. Furthermore, the two phases of this study will be described.

3.2 Philosophy underlying the research methodology

This was an exploratory qualitative study. The researcher was informed and guided by the post-modernist paradigm. In post-modernism, emphasis is on the collection of qualitative data, whose rationale is to bring about change on the human beings involved. According to literature, post-moderm research does not accept the view of a stable, coherent, uniform world. It argues that meaning is situated in a particular perspective or context, and, since different people and groups often have different perspectives and contexts, there are many different meanings in the world, none of which is necessarily more valid or true than another. According to Kuiper (1997) this paradigm adds that human behaviour is not predictable or generalizable: each research context brings its own "truth" with it. According to Lillejord and Søreide (2003), "in constructivistic perspective, the reach for an "objective" truth will be futile… it is therefore more fruitful to look for and try to understand expressed meaning than to search for the "true story" (p.92). This paradigm helps the researcher to have a deeper understanding of why people behave (act) as they do. I hoped that this paradigm would help me to have a better understanding of the beliefs that my learners have about lightning and how these beliefs can be used productively in the teaching and learning of Electrostatics.

3.3 Participatory Action Research

Teacher research is defined as "a self-reflective, experiential mode of inquiry that involves the use of various interpretive methods to resolve problems specific to the context of individual teachers and their students" (Briscoe and Wells, 2002:418). In other words, as teachers become more knowledgeable through their own research, they gain autonomy of practice that empowers them to continue critically examining the learning experiences they provide for the children they teach. Action research helps teachers to examine their existing beliefs about teaching and learning outcomes. According to Childs and Woolnough (2002:51), self-evaluating professionals will continually consider their own practice, evaluate it and modify their practice accordingly. These authors believe that the concept of the teacher as a self-evaluating professional "provides research insights which are focused onto real students learning real science with real teachers at real schools" (p.51). These ideas motivated me to design this participatory investigation.

The purpose of an action research is to design/develop new skills or new approaches and to solve problems with direct application for example to the classroom situation. However it lacks scientific rigor (Isaac and Michael, 1997), because (i) its internal and external validity are weak, (ii) its objective is situational, and (iii) its sample is restricted and unrepresentative (p.59).

3.4 Why a Case Study?

Case studies are in-depth investigations of a given social unit resulting in a complete, well-organized picture of that unit (Isaac and Michael, 1997:53). According to these authors, the purpose of a case study is to study the background, current status, and environmental interactions of a given social unit; for example an individual, group, institution, or community. Case studies usually examine a small number of units across a large number of variables and conditions. The beauty of case studies is that they are intensive, and bring to light the important variables, processes, and interactions that deserve more extensive attention. However, because of their narrow focus on a few units, case studies are limited in their representativeness. For example, they do not allow valid generalizations; and they are vulnerable to subjective biases.

3.5 Research participants

Regarding sampling, in post-modernism, there is a move away from approaches that concentrate on producing large data sets which can be analysed statistically and to a great precision, towards an approach where the actions, ideas, thoughts, priorities, problems and so on of people in education are described in a predominately qualitative way. For this to happen a reasonably small sample is required so that the researcher can be able to spend some time with each of the respondents. In view of this, I conducted this research at my school with my Grade 10 learners (with the permission of my principal). There are eleven learners in this class. One of the advantages of using my own class was that the research process would not deviate from my normal teaching programme; another reason is that I could expect maximum cooperation from my learners. I also involved one elder per learner (in the Baseline Study), who is actually influencing the learner's cultural background (parent, grand-parent, relative). This means that the sample consists of eleven learners (boys and girls) and nine elders (men and women).

3.6 Design

The research process took place in two phases. The intention was to use data collected during the first phase to design the Learning Programme (teaching and learning activities) in the second phase.

3.6.1 Phase 1

This phase involved a **Baseline Study** that aimed at determining both elders' and learners' cultural beliefs about lightning and learners' prior knowledge on electrostatics, in order to answer operational research questions 1 and 2.

3.6.1.1 Elders' interview schedule

This instrument is used to answer operational research question 1. The interview schedule (see Appendix B) consists of 10 open-ended questions that allowed me to make some follow up questions in order to have a better understanding of why these elders hold particular views about lightning. The questions were translated to *Sepedi* with the help of the *Sepedi* educator at my school. The interviews were conducted in *Sepedi* since not all the elders understand English.

Prior to the administration of this instrument, a pilot study was conducted in 2004 to collect data on the beliefs that elders have about lightning. Nine elders (parents/relatives of my 2004 Grade 10 learners) were interviewed and the results indicated that the questions were well understood. It was also administered in 2005 to the parents/relatives of Grade 10 learners at three different schools by three Physical Science educators in my district. These educators also agreed that the interview questions were clear, hence all the questions were retained as reflected in Appendix B.

Lillejord and Søreide (2003:93), point out that a qualitative research interview in indigenous settings is a collection of stories or narratives, and through them researchers gain new perspectives on a culture or cultural phenomenon; and that it is also notably important to take the time necessary to clarify the aim of the research. Hence, eleven elders were visited, clarified about the aim of the research, and interviewed. The interviews were audio taped and recorded with the permission of the respondents.

3.6.1.2 Learners' questionnaire

This instrument is designed to answer operational research question 2. The questionnaire aimed at determining learners' cultural/indigenous beliefs about lightning, and what they already knew about Electricity, therefore it was administered before the Teaching and Learning Process. It consists of nine open-ended questions (see Appendix C) that required learners to explain and to clarify their answers. The last question (question 9) in the questionnaire required learners to investigate cultural beliefs about lightning from other people (community members). The objective of this small-scale investigation was to help learners to explore other cultural beliefs in their community. The questions were translated to Sepedi with the help of my colleague (*Sepedi* educator). The purpose was to help learners to understand these questions so that they could provide relevant information. Learners were also allowed to respond in *Sepedi* so that they could provide as much information as possible.

This instrument was also piloted during the 2004 with my Grade 10 learners, and administered in 2005 with Grade 10 learners of three different schools in my district. The results from the pilot study and the three schools indicated that the questions in this questionnaire were clear to all the learners; hence there were no changes.

The questions in both elders' interview schedule and learners' questionnaire were constructed by the researcher, using her own background knowledge on cultural beliefs about lightning, and information from related studies of similar cultural groups like Mahapa's (2002) and Maselwa's (2004) studies.

3.6.1.3 Pre- and Post- Assessment

The same set of questions was used before and after the Teaching and Learning Process. The objective of this assessment was to determine whether learners would have a better understanding of the scientific view of lightning after the Teaching and Learning Process, in which their beliefs or conceptions were incorporated (see also operational research questions 3-5).

This assessment task consists of five questions (see Appendix D). The first two questions ask for the definitions of lightning and electricity, while the third question explores the link\relationship between lightning and electricity. The fourth question asks learners about the best method of protection of houses from lightning, and the last (fifth) question asks whether *tladi* should be discussed during science lessons about electricity or not.

3.6.2 Phase 2

Phase 2 involved the **Teaching and Learning Process,** that unfolded in three stages; *Planning, Implementation, and Evaluation.* The objective of this phase was to collect data that would contribute to answering operational research questions 3-5.

3.6.2.1 Stage 1: Planning (designing learning programme, assessment methods, tools, and techniques)

A Learning Programme for a series of four lessons was designed together with four worksheets (see Appendix E). This learning programme was designed to answer operational research question 3. I was guided by the sixth category of Aikenhead's (1994) sequence for STS science teaching model, and Snively's (1995) five-step process for producing a TEK unit as explained in the literature (see section 2.5) which suggest that we need to probe for and incorporate prior beliefs of learners. The Learning programme was designed in accordance with figure 1 (section2.5). The societal issue on the beliefs about lightning was the starting point as the arrow in the figure suggests. Since these beliefs created the need for my learners to know some science concepts, I used Snively's and Aikenhead's suggestions to incorporate these beliefs in the teaching of electrostatics with the hope that learners' understanding of electrostatics would make them to go back in the society as suggested by the arrow to take decisions on issues related to lightning. Hence in each lesson there are activities that require learners to use their understanding of some of the concepts in electrostatics to evaluate some of the beliefs that they have about lightning. The key questions that determine the structure of these lessons are presented in section 3.7.2. The activities were designed in such a way that learners would work in groups (three to four learners) most of the time; so that they could help one another in the execution of instructions, making predictions, explanations and decision-making.

3.6.2.2 Stage 2: Implementation (classroom practice)

In Stage 2 data were collected on four consecutive days for an hour per day using the following techniques: worksheets, learner-centred class discussions, group/individual interviews, and all the lessons were audio taped and videotaped. Data collected in this stage were aimed at answering operational research questions 4 and 5.

(i) Worksheets

The pilot study in 2004 suggested a need for major changes in the teaching materials. The structure of the lessons was changed to strengthen the incorporation of indigenous beliefs about lightning in the teaching of electrostatics. In the revised worksheets (see Appendix E) learners are required to observe, predict, describe, and provide explanations. In each worksheet, learning outcomes are clearly stated in accordance with the new teaching approach, Outcomes-Based Education (OBE). The focus in these worksheets is on the identification of key concepts that learners construct, and the attainment of the stated learning outcomes. These worksheets were also meant to answer operational research questions 3-5.

(ii) L*earner-centred class discussions*

In addition to the worksheets, learner-centred class discussions were conducted that supplemented the information provided in the worksheets in order to have clear answers to research questions 3-5. Each lesson was designed in such a way that after learners have completed their worksheets, there should be learner-centred class discussions in which groups would share their experiences, observations, interpretations and explanations. These learner-centred class discussions were audiotaped and video taped for in-depth analysis of learners’ participation and contribution.

(iii) G*roup/individual interviews*

In attempt to answer operational research questions 3-5, group/individual interviews were also conducted. After each lesson I read learners' answers on the worksheets and assessment sheets, in which I wrote some remarks, comments and questions. These guided me in conducting group/individual interviews a week after the Teaching and Learning Process. The focus was on finding clarity and reasons behind learners' answers. Also, semi-structured interviews were conducted after the Teaching and Learning Process, which were based on learners' responses in the Post-Assessment. These interviews were structured in such a way that learners would clarify their answers and give reasons for the choices of the science concepts used in their answers to the Post- Assessment task. During these interviews learners were allowed to respond in *Sepedi* so that they could express themselves better. The purpose of these semi-structured interviews was to determine the level of learners' understanding of the scientific view of lightning.

3.7 Data Analysis

3.7.1 Analysing elders' interviews and learners' questionnaires

The purpose was to find the common indigenous beliefs about lightning amongst the elders. Audiotapes were transcribed and recorded. Since elders responded in *Sepedi* during the interviews, I translated their answers to English trying to preserve the original information. I studied their answers looking for shared or common beliefs about lightning. I then grouped similar statements into categories. These categories provided me with the kind of beliefs held by these elders.

Learners' questionnaires were analysed in order to identify the common cultural beliefs about lightning held by learners. Some of the learners used *Sepedi* to answer the questions in the questionnaires. I translated such answers to English; thereafter I grouped similar statements into categories of beliefs about lightning. Both elders' and learners' beliefs about lightning did not differ from what I expected, nor from Mahapa's (2002) and Maselwa's (2004) findings.

Learners' beliefs about lightning were compared with those of elders. A further categorisation was made, in which similar beliefs about lightning were grouped together. Finally these categories of beliefs about lightning were presented in a table form (see Table 1, section 4.2), and used to answer operational research questions 1 and 2.

3.7.2 Analysing worksheets

Analysis of learners' answers in the worksheets provided answers to operational research questions 3-5. During the teaching and learning process worksheets were provided to learners. These worksheets informed me about learners' level of understanding of lightning and electrostatics as beliefs were incorporated into the lessons. For example, did the incorporation of learners' beliefs about lightning in electrostatics help them to understand the scientific view of lightning? The following questions oriented me to analyse the answers provided in the worksheets.

(i) In the first worksheet:

- Can learners relate lightning to electricity based on what they were taught about electrostatic forces?

(ii) In the second worksheet:

- Do learners understand the concept of electric discharge?
- Can they relate the spark produced by the Van de Graaff Generator to lightning?
- Do they recognise lightning as an electric discharge?
- Can they use their understanding of electric discharge to decide whether a person can really make his or her own lightning to kill other people?

(iii) In the third worksheet:

- Do learners understand the concept of induction?
- Can they use their understanding of induction to explain why
    A. The ground becomes positively charged during a lightning storm?
    B. A lightning rod is the most suitable method to protect buildings from lightning?

(iv) In the fourth worksheet:

- Are learners aware that there are several ways of explaining what happens around us, and that science is one of them?
- Can they identify the dangers of superstitions and ignorance when dealing with lightning?
- Are they prepared to take social responsibilities: informing and educating people about the scientific view of lightning?

3.7.3 Analysing audiotapes and videotapes

Audiotapes and videotapes were used to collect data during learner-centred class discussions. I watched and listened to these tapes every day after each lesson. Relevant sections were recorded for analysis. The videotapes helped me to analyse and interpret the involvement and body language of all the participants, including my involvement and my own body language. The video recordings also helped me to have a closer observation of the interaction between learners in the groups, and the execution of activities. All these observations were recorded so that they could be used during the interpretation of results in section 4.3. Findings from the audiotapes and videotapes supplemented those from the worksheets, and were used to answer operational research questions 4 and 5.

3.7.4 Analysing Pre- and Post- Assessment

The same set of questions was written before and after the teaching and learning process. The focus was on the comparison of the level of understanding of lightning and electricity before and after the teaching and learning process. Learners' responses were analysed in terms of what beliefs/pre-knowledge about lightning and electricity did they have before the teaching and learning process; and what knowledge do they have about lightning and electricity after the teaching and learning process. I then compared learners' answers before and after the teaching and learning process to determine whether the activities helped learners develop a better understanding of the scientific view of lightning and to see the link between lightning and electrostatics. This comparison was used to answer operational research questions 3-5.

3.7.5 Analysing interviews

The interviews were audio taped and transcribed for adequate analysis in order to provide adequate answers to operational research questions 3-5. In all the interviews I identified both the scientific and non-scientific concepts that were used by learners in their responses. The interviews helped me to determine whether learners had an understanding of the scientific view of lightning after the incorporation of their beliefs about lightning, and whether they were able to see the link between lightning and electricity. I also checked whether learners still maintained their original beliefs about lightning or not.

Chapter 4

Results

4.1 Introduction

This study aims to answer the following operational research questions:

1. What are the main cultural and traditional beliefs about lightning that exist in the social context of learners in Limpopo?
2. To which of these beliefs do the learners adhere?
3. Is it possible to design on the basis of contemporary views in science education, a teaching sequence in which indigenous beliefs about lightning are effectively integrated with the teaching of the science topic of electrostatics? What do learners learn from an effective integration of this kind?
4. Specifically, in what way can a design of this kind provide teachers and learners with opportunities to explore conflicts between scientific and indigenous ways of understanding?
5. How does this teaching sequence on electrostatics in which indigenous beliefs on lightning have been integrated affect the way learners take decisions on relevant daily issues?

In the previous chapter on research design, I discussed the research methodology of my case study. I also discussed a variety of techniques that I have used to collect data to answer the above-mentioned questions. The procedure for the execution of activities was also outlined. This chapter focuses on the presentation of the results that were obtained during the data-collecting sessions, and the interpretation of these results. In section 4.2 I will present the results that answer operational research questions 1 and 2. This section presents the kind of beliefs about lightning that are held by the respondents. In sections 4.3 and 4.4 I will present the results that answer operational research questions 3-5. The two sections explain how the beliefs about lightning were integrated with the teaching of electrostatics and how learners responded to the cultural view of lightning as well as the scientific view of lightning.

Since this exploratory study was an action research, in this chapter the symbols R and T stand for the Researcher/Teacher. Elders were given codes E1 up to E11 while learners were given codes L1 up to L11.

4.2 Beliefs about lightning

This section is meant to answer operational research questions 1 and 2; hence it will present findings from elders' interview schedule (Appendix B) and learners' questionnaire (Appendix C). Table 1 presents the main cultural and traditional beliefs about lightning that exist in the social context of learners in the area where I teach. Furthermore, it summarises some of the differences between *legadima* (lightning) and *tladi* as described by the respondents (both learners and elders). Analysis of data involved categorisation of beliefs about lightning held by elders in order to answer operational research question 1, and six categories (see Table 1) emerged from the responses. Learners' beliefs about lightning were also grouped into categories. Further analysis involved comparison of elders' beliefs and learners' beliefs about lightning in order to identify the beliefs that learners adhere to, this comparison answered operational research question 2.

Table 1: Beliefs about lightning – *Legadima* versus *Tladi*

Categories	LEGADIMA (LIGHTNING)	Frequency		TLADI	Frequency	
		Elders (n=11)	Learners (n=11)		Elders (n=11)	Learners (n=11)
1.Caused by	God or Nature	11	11	People/witches	10	9
2.Formation	Collision between hot air and cold air. Collision between two or more clouds. Collision between clouds and mountain or hill.	5 4 4	6 6 3	Witchcraft Magic Bird Lizard	10 9 8 10	9 7 7 9
3.Occurs when	It's raining There are clouds	11 6	11 4	Anytime In the presence of *legadima*	10 10	9 9
4.Self-protection	Prayer: pray or ask for priest's prayer. - Use water from church.	3 3	4 5	Traditional rituals. Consult traditional doctor or *sangoma*	10 10	9 9
5.House protection	Motorcar tyre. '*Gas*'/lightning conductor. Prayer. Water from church	9 4 3 3	8 5 4 5	Traditional rituals or practices: Consult traditional doctor or *sangoma*	10 10	9 9
6.Strikes people or houses	No	11	11	Yes	10	9

Responses from elders' interviews and learners' questionnaires during the Baseline Study (Phase 1), revealed that most of the respondents have common understandings and beliefs about lightning. For example, 10 (91%) elders and 9 (82%) learners believed that there are two types of lightning: natural lightning known as *legadima* in Sepedi (from God) and *tladi* (caused by people/bird/lizard), while 1 (9%) elder and 2 (18%) learners believed that there is only one form of lightning: the natural lightning.

Respondents who believed in the existence of *tladi* agreed on what causes *tladi,* and how to protect themselves and their houses from *tladi*. They agreed on the following traditional rituals or practices: use of traditional medicines; use of "*patla ya motse"* (stick put on the wall/roof inside the house to prevent witches from entering the house); sprinkling salt (in crystal form) on the roof of the house; putting some small branches/leaves of trees *(mosehla tree or mosunkwane shrub)* on the roof of the house; and wearing *metlamo* (ropes from churches or traditional doctors) around their waists.

All the respondents mentioned the following precautionary measures to be taken during a lightning storm:

- never play outside the house, in the field, under the tree
- don't touch water/bath, porridge, books, windows, mirrors, fence/wire metallic objects.
- don't switch on lights, music, radio, TV, electrical appliances.
- don't wear red clothes, ride a bicycle without rubbers on the handles, read books, and that sick people should not drink/apply medicines.

They also believed that *legadima/*lightning is conducted by trees (especially tall ones), and all shiny or white objects such as water, fence/metals, mirrors, maize meal, and white paper.

A close examination of the frequencies (see Table 1) regarding *legadima*/lightning and *tladi* reveals that learners do hold the same cultural beliefs about *legadima* and *tladi* as are held by their parents and/or community members. This observation answers operational research question 2.The table also shows that some of the respondents did not have much to say about the beliefs about *legadima,* because most of the frequencies are lower than those of beliefs about *tladi*.

Regarding the methods of protection of houses against *legadima*, 9 (82%) elders and 8 (89%) learners recommended the use of motorcar tyres on the roof of the house; while 4 (36%) elders and 5 (45%) learners mentioned the use of *gas* (referring to a lightning conductor). The word *gas* is also commonly used to refer to electrical materials such as electrical conductors and electric stoves. However, elders' interviews and learners' questionnaires indicated that they did not know how this *gas* works. The four elders said: *gas belongs to the Whites and obviously it will not protect houses from tladi*, while the five learners said: *it (gas) will protect the house by repelling the natural lightning (legadima), but it will not protect the house from tladi.*

When responding to the question of whether issues about *legadima/*lightning should be taught or mentioned in schools, 6 (54%) elders said no, because they do not want their children to learn witchcraft, and that issues about *tladi* should not be discussed in public because one could be labelled as a witch and hence be accused of causing lightning to strike people or houses. Five (46%) elders believed that these issues should be taught, because:

> E2: children should know that tladi is there, and it is dangerous.
>
> E3: if something bad can happen to one of the children, others should know what to do.
>
> E6: children should know how to protect themselves against lightning.
>
> E8: children should know about its (*tladi's*) dangers, and how it is formed; if they don't know they might get into trouble.
>
> E11: children should know these issues, and they should educate others!

Learners' questionnaires indicated that learners did not know the scientific view of lightning. This was indicated by the kind of answers that learners provided when responding to the question: *In your own view, what is lightning?* This is how six learners attempted to answer this question.

> L1: Lightning is fire that is caused by people when they want to burn other people's houses because of jealousy.
>
> L3: It is tladi which comes during thunder.
>
> L4: Is "tladi" that is formed by different methods.
>
> L6: It is something that is caused by witches.
>
> L8: Lightning is tladi that strikes people in the field.
>
> L11:When lightning strikes, it is called tladi.

It was not surprising to find that these learners did not know the link between lightning and electricity, because they did not know the scientific view of lightning. The three learners, who believed that there is a link between lightning and electricity, mentioned that both: "don't want water", "can choke" (referring to electrical shock), and "are fire".

Regarding the issue of whether a person can cause lightning to strike other people or houses, 7 (64%) learners believed that it was possible because:

L2: he/ she will be using his/her medicines, and lightning that strikes people or houses is called “tladi”.

L3: there are people who are able to “ratha tladi” (use tladi to strke) because they are witches or traditional doctors.

L4: there are such people, in my village such people were found immediately after striking.

L5: of witchcraft and jealousy.

L6: of witchcraft, if a person is a witch and jealous of you because you are rich.

L8: some people are not trustworthy, they are witches, they can do that.

L11:when a person is struck by lightning, one of his/her organs will not be found, who would have taken it besides a witch?.

These kinds of explanations indicate that these learners hold strong cultural beliefs about lightning that developed through learners’ interaction with their community members. These findings indicate the importance of this study, that indeed these ideas that learners bring to science classrooms need to be addressed through appropriate learning programmes.

4.3 Incorporating cultural beliefs about lightning

The preceding section (4.2) has verified that learners come into the science classrooms with a lot of ideas and experiences. The question is: To what extent do these experiences reinforce or undermine what we educators are trying to achieve in the science classrooms? This is what operational research questions 3-5 of this study were trying to find out. Appropriate lesson plans were designed as explained in the methodology (section 3.6.2.1, see also section 2.5 figure 1) that incorporated these indigenous beliefs about lightning in the teaching and learning of electrostatics.

The following cultural beliefs about lightning were incorporated during the design of the teaching and learning materials in trying to answer operational research questions 3-5.

I. The belief that a person can cause lightning to strike other people was integrated with the concept of electric discharge (see Appendix E, Worksheet No.2, activity 3.2). The misconceptions (see Table 1, category 2) about the formation of lightning were also addressed during the explanation of the concept of electric discharge

II. The issue of whether a motorcar tyre can protect houses from lightning was integrated with the concept of induction (see Appendix E, Worksheet No.3, activity 3.4). The action of a lightning conductor was also explained to allow learners to compare the two methods of protection against lightning (Worksheet No.3, activity 3.5).

III. The remaining issues related to protection against lightning were addressed in the fourth worksheet in which learners were required to use their understanding of static electricity to evaluate the given statements about lightning and electricity (see Appendix E, Worksheet No. 4).

4.3.1 Classroom experiences: obstacles and opportunities related to implementation

The following findings emerged from the worksheets, learner-centred class discussions, audiotapes and videotapes. These four instruments supplemented each other during data collection. Learner-centred class discussions were used for clarification of learners' answers in the worksheets, audiotapes and videotapes were used to verify learners' involvement during learner-centred class discussions and for closer observation of what took place during the data-collecting sessions.

4.3.1.1 Legadima (lightning) versus tladi

During the first lesson learners were taught about electrostatic forces, electrostatic charges, insulators, and electrical conductors. The understanding of these concepts would help learners to see the link between lightning (*legadima*) and electricity. Hence, in the first worksheet (see Worksheet No. 1, activity 5) learners were given an investigation task that required them to find out people's ideas about lightning (*legadima*), and to ask them whether there is a link between electricity and lightning (*legadima*). This task also required them to provide their own ideas about *legadima* after being taught about electrostatic forces.

Learner-centred class discussion on the report from an investigation task (Worksheet No 2, activity 1) indicated that almost all learners distinguished *tlad*i from *legadima* on the basis of causing damage or trouble; for example they said they talk about *tladi* whenever lightning has struck a person/house and that *legadima* does not strike people/houses. The idea that *legadima* (lightning) does not strike people or houses, is one of the cultural beliefs that contradict science. Section 2.2.3 has indicated that lightning is dangerous as a result prevention and education are the keys to lightning safety. This activity provided us (myself and learners) with the opportunity to explore this conflict. At this stage it was obvious that my learners held a very strong belief that *tladi* is more dangerous than lightning. One of the objectives of this study was to make learners aware that lightning (*legadima*) is very dangerous.

I was faced with the following challenge: How do I address the belief that *legadima* (lightning) does not strike people or houses? This is where the videotape clearly revealed my frustration. As learners supplied reasons why *tladi* is more dangerous than *legadima* one after the other, I kept on saying “OK! …” (and nodding). As the researcher I had to collect data without influencing the results, especially that there were still other concepts to be taught that could help learners to have a better understanding of the scientific view of lightning such as electric discharge, voltage, and induction. It was clear that the concepts which learners learned in the first lesson such as electrostatic charges and electrostatic forces did not help them to relate lightning to electricity, because they continued to use their indigenous ways of explaining this phenomenon.

During the introduction of the concepts of electric discharge and voltage in the second lesson, learners were taught about what actually happens between the thundercloud and the ground. In trying to address the above-mentioned challenge, learners were made aware of the amount of the current (up to 50 000A) and voltage (millions of volts) that could be produced during a thunderstorm. At this point the videotape revealed that learners were indeed puzzled and a bit frightened at the thought of the possibility of such a large amount of current passing through their bodies or houses. They immediately realized that *legadima* (lightning) is very dangerous, in other words they learned that lightning is related to electricity in terms of the current and voltage produced during lightning.

This learner-centred class discussion provided learners with the opportunity to explore the cultural view of lightning and the scientific view of lightning regarding the issue of danger and damage that could be caused by lightning (*legadima*). Indeed, learners became aware that *legadima* is dangerous because it can cause electric shock that may result in death, and that it can burn houses. Not only did this activity provide learners with the opportunity to explore both ways of knowing, but it also helped learners with conceptual development. For example, after this learner-centred class discussion learners knew the difference between the two concepts: *electric shock* and *choke.* After this activity almost all learners started to talk about electric shock instead of *choking*.

Inclusion of learners’ cultural beliefs about lightning in the teaching of electrostatics in this study confirmed that the integration of IKS’s in science classrooms maximises learner-involvement and motivation. Almost all learners wanted to share their views willingly, some of them requested to share their views in Sepedi during the second lesson (activity 1), that was on the report from the investigation task in which learners were requested to ask people in their community about the meanings of lightning and electricity, and whether there is any link/relationship between them. The participation was excellent! It was exciting to listen to learners' points of view and how much they knew about lightning: I still remember one of them saying to me, *" do you understand mam?"* He was trying to convince me that people could manipulate natural lightning to strike/kill other people or houses. This is the kind of motivation and active participation by learners I was referring to earlier on.

This was due to the fact that learners were talking about the things that they are familiar with. This active participation proves that indeed including learners' prior knowledge, experiences, and beliefs makes learners to be active participants in the learning process. I'm saying this because in the activities that required my learners to use science concepts, most learners did not respond willingly, I had to call them by names randomly before they could respond; some would not respond even if I switched to Sepedi.

In the second lesson I could clearly see the transition from activity 1, in which learners were sharing their beliefs about lightning, to activity 2 in which learners were expected to observe, predict, and give scientific explanations.

4.3.1.2 Manipulation of lightning and electric discharge

The concept of electric discharge provided learners with information on how lightning is produced and how it travels through the air towards the ground.

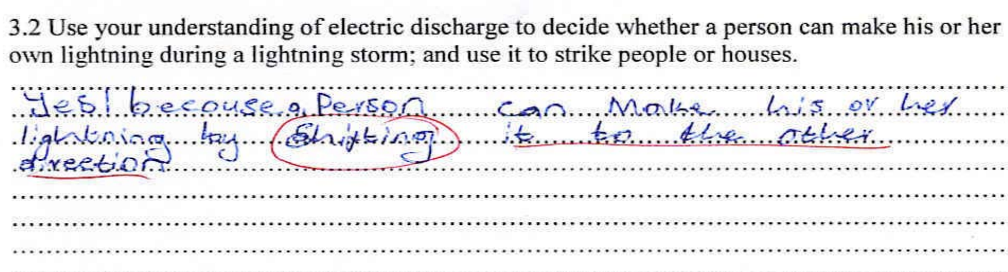
After the introduction of the concept of "electric discharge" and the demonstration of the production of the "spark" by the van de Graaff Generator, learners were filled with mixed feelings. It was not easy for most of them to relate the "small" spark to lightning. Most of them said: "but mam this is not the same as lightning, lightning is like a flash light" (L4); "this spark is the same as the one produced by two stones" (L2); "yes, and like the one from fire" (L5). These learners' answers indicated that they could not differentiate the kind of spark that is produced by the van de Graaff Generator and the ones that are called *dithlase* in Sepedi, that are actually small pieces of those materials. After a long discussion learners recognised lightning as a large spark, and that the difference between the small sparks produced by the van de Graaf Generator and the large spark called lightning is the amount of voltage. One of the factors that contributed to the size of the spark produced by "our" van de Graaff Generator is that the rubber that turns the handle broke; so, I had to improvise by using a piece of ladies' stockings, and it worked better because learners were able to see the spark. This learner-centred discussion revealed that inclusion of learners' prior knowledge promotes conceptual development, because after this discussion learners realised that the sparks (*dithlase*) they know of within the context of the *Pedi Culture*, are not the same as the sparks produced by electrostatic forces.

However, responses in the worksheets indicated that eventually all learners were able to recognise lightning as an electric discharge. They also explained lightning as a large spark.

When learners were required to use their understanding of the concept of "electric discharge" to decide whether a person can really make lightning to strike people or houses, 8 (73%) learners said it was not possible because *lightning is an electric discharge, hence people cannot "control charges"*, but 3 (27%) learners insisted that *people can redirect lightning with their own "conductors or medicines"*, they still believed that somehow people are able to manipulate lightning through supernatural powers to achieve their own goals. I soon realised that I was faced with another challenge: the challenge of modifying this belief or making learners aware that lightning cannot be directed by people. This shows that as an educator I was struggling with the implementation of the constructivist ways of teaching, because I did not know whether to tell learners that people could not redirect lightning or not. I hoped that learners would realise this on their own. It was obvious that learners continued to use their own opinions, as indicated in the following samples from the worksheets.

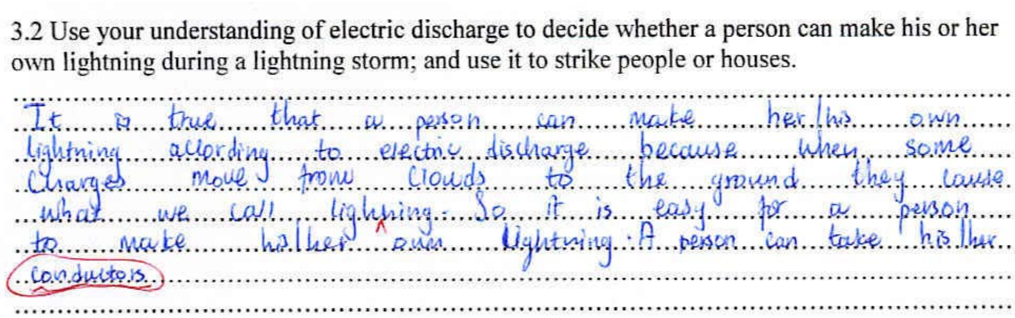
Fig. 2 : Samples from the Worksheets

L1


3.2 Use your understanding of electric discharge to decide whether a person can make his or her own lightning during a lightning storm; and use it to strike people or houses.

Yes! because a Person can Make his or her lightning by Shifting it to the other direction

L2


3.2 Use your understanding of electric discharge to decide whether a person can make his or her own lightning during a lightning storm; and use it to strike people or houses.

It is true that a person can make her/his own lightning according to electric discharge because when some charges move from clouds to the ground they cause what we call lighting. So it is easy for a person to make ha/her own lightning. A person can take his/her conductors.

L3

3.2 Use your understanding of electric discharge to decide whether a person can make his or her own lightning during a lightning storm; and use it to strike people or houses.

No, because the van de Graaff Generator is made by a person, so a person can make big van de Graaff Generator and It will ~~sta~~ strike people ~~when~~ but he/she cannot make the clouds

L4

3.2 Use your understanding of electric discharge to decide whether a person can make his or her own lightning during a lightning storm; and use it to strike people or houses.

A person can not make his or her own lightning during a lightning storm because lightning use charges to strike people but some time ower grandfather say people can causes it.

When learners were asked to clarify their answers, most of them could not go beyond what they wrote in the worksheets. This could be due to the fact that learners were struggling to use relevant science concepts. Here follows part of the learner-centred class discussion on the issue of whether a person can use lightning to strike other people or not.

> L1 : Yes, because a person can make his/her lightning by shifting it to the other direction.
>
> T : Shifting what, in which direction?
>
> L1 : Shifting electric discharge to cause trouble, to strike other people.
>
> L2 : I agree mam, he or she can connect her conductors to the place where she need to strike.
>
> T : What kind of conductors?
>
> L2 : Mam, they use their things, their medicines.
>
> L4 : No, I don't agree, because lightning use charges to strike, and people can't control charges.
>
> L7 : Yes, it is not true, according to electric discharge, it is not easy for a person to make his/her own lightning.

This learner-centred discussion shows how learners were exploring the conflict between scientific and indigenous ways of understanding the phenomenon of lightning (operational research 4). Their responses indicate how they were struggling to make sense of the concept of electric discharge. L3 seems to have understood that although a person can make his/her own lightning by using the van de Graaff Generator he/she cannot redirect lightning. However, even though learners were taught about electrostatic forces in the first lesson, they did not use them in their explanations. This may imply that learners did not understand how to link forces of attraction to the concept of electric discharge, alternatively, this may imply that when learners are faced with situations/problems that need to be resolved they tend to revert to their pre-existing ideas. This activity is one of the examples in which learners were expected to take decisions on issues related to lightning based on their understanding of the scientific view of lightning. Operational research question 5 asks how this kind of a teaching sequence in which indigenous beliefs on lightning have been integrated affect the way learners take decisions on relevant daily issues? It seems the indigenous beliefs on lightning of the 8 learners who decided that it was no longer possible for people to redirect lightning were modified by the concept of electric discharge. I hoped that this modification of beliefs about lightning could bring about reduction of accusations and persecutions of innocent people.

Although the inclusion of cultural beliefs about lightning motivated learners and helped them to develop the understanding of the scientific view of lightning, the belief that people can manipulate lightning is one of the beliefs that were not easy to modify. For example, during the individual interviews one of the learners (L11) said something that I didn't expect; he said: *since the van de Graaff Generator is made by a person this means that a person can make a very big van de Graaf Generator to form a very large spark to strike other people*. The idea that there are people who use lightning in different ways to strike other people is strongly held by these learners, even those who said they no longer believe in the existence of *tladi*. L4 is one of them, he said: *before these lessons I believed that there is what is called tladi, but after learning about the concept of electric discharge I don't believe in tladi anymore*. However during the interview he indicated that people who use lightning to strike other people are often found washing themselves in rivers immediately after striking.

4.3.1.3 The motorcar tyre and induction

In one of the activities, learners were required to use their understanding of induction to determine whether a motorcar tyre put on the roof of the house can protect that house from lightning or not. The worksheets indicated that nine (82%) learners thought that it was actually possible for the motorcar tyre to protect houses from lightning.

Three of the nine learners said it was possible because a motorcar tyre is an insulator. These are the answers from worksheets:

> L1: the tyre is an insulator, insulators don't allow charges to flow.

L2: the tyre is not a metal is a rubber, it cannot allows lightning to pass through it, the tyre can also decrease the speed of lightning.

L11: insulators don't conduct electricity.

Six of the nine learners thought that there would be a force of repulsion between the motorcar tyre and the house.

L3: it (tyre) will repel it (*lightning*), there will be force of repulsion between house and lightning.

L6: both have same charges, there will be force of repulsion between house and lightning.

L5: negative charges of tyre will repel negative charges of lightning.

L8: there will be forces of repulsion between the tyre and the house.

L9: the tyre will repel lightning.

L10: charges on the tyre will repel charges on lightning.

Obviously these nine learners did not understand the concept of induction, that is they did not understand when and how induction occurs. This implies that these learners did not relate what happened between the rubbed balloon and the wall (activity 1.1) to what happens between the motorcar tyre and the cloud during lightning. Neither did they relate what happens between the cloud and the ground (activity 1.2) during lightning to this situation. This indicates that their decisions were based on their pre-existing knowledge, for example L2 said the tyre would decrease the speed of lightning.

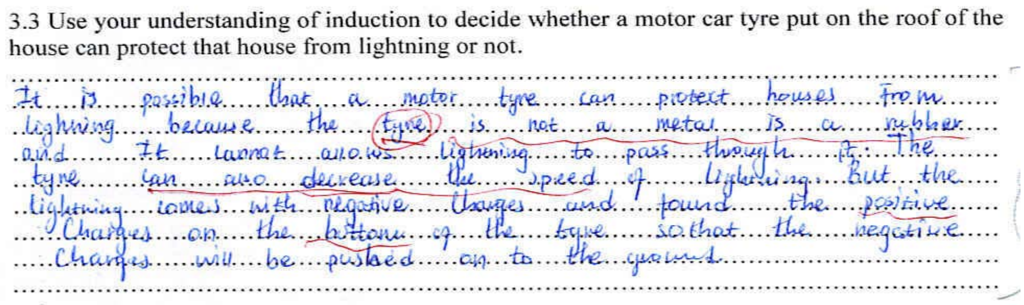
Only 2 (18%) learners had the idea that the separation of charges on the motorcar tyre would form a path for lightning through the house.

L4: charges will be separated, there will be a force of attraction between the house and lightning.

L7: charges on the tyre will be separated, and charges on the house will be separated, and charges will flow from lightning to the house.

The learner-centred class discussion below was based on L2's answer in the worksheet. He was asked to clarify what he wrote in the worksheet. This was because he seemed to be contradicting himself. The first statement indicates that he thinks that the tyre will prevent lightning to pass through the house because it is an insulator. The second statement suggests that the tyre will slow down lightning. The third statement suggests that charges will pass through the house. Other learners' opinions were also invited.

Fig. 3: L2's answer from the worksheet



3.3 Use your understanding of induction to decide whether a motor car tyre put on the roof of the house can protect that house from lightning or not.

It is possible that a motor tyre can protect houses from lightning because the (tyre) is not a metal is a rubber and It cannot allows lightning to pass through it. The tyre can also decrease the speed of lightning. But the lightning comes with negative charges and found the positive charges on the bottom of the tyre so that the negative charges will be pushed on to the ground.

This is part of the learner-centred class discussion that indicates how learners struggled to describe how the motorcar tyre could protect houses from lightning using the concept of induction:

L2 : It is possible that a motorcar tyre can protect houses from lightning because the tyre is not a metal, is a rubber, eh… rubber is an insulator it cannot allow lightning to pass through it.

T : How will it stop lightning?

L2 : Lightning comes with negative charges and found the positive charges on the bottom of the tyre, so the negative charges will be pushed on to the ground.

T : On to the ground, through the house?

L2 : No, lightning will not go through the house.

T : Why? (he did not respond). Any one please, yes L5, what do you think?

L5 : Because motorcar tyre is neutral and lightning is negative, so when lightning comes is attracted by the positive charges from the tyre and lightning can't strike that house.

T : What do others say? Yes L7.

L7: it is not true because charges on the tyre will be separated, and charges on the house will be separated, and charges will flow from lightning to the house.

Learners struggled to relate the concepts such as insulators, forces of attraction and repulsion to the concept of induction in trying to decide whether a motorcar tyre would protect houses from lightning or not. The explanations provided in the worksheets and during class discussion indicated that learners did not understand the concept of induction. For example they did not understand why forces of attraction were greater than forces of repulsion during induction. That is why the six learners thought that the separation of charges on the tyre would cause a force of repulsion between the tyre and lightning. The three learners decided to use their pre-existing knowledge about insulators. However, they did learn that during induction charges are separated, and that there are forces of attraction and repulsion. These examples indicate that learners needed more examples and extra time in order to develop a better understanding of the concept of induction.

4.3.1.4 Precautionary measures against lightning

Lesson 4 was mainly about issues on lightning, and as already mentioned in section 4.2, this is where the remaining beliefs about lightning were addressed. In Worksheet No. 4 (activities 1.3 and 2) learners were required to use their understanding of static electricity to explain why their parents told them not to do certain things during a lightning storm. Table 2 below summarises learners' responses from the worksheets.

Table 2: Precautionary measures against lightning

Statements about precautionary measures during lightning storm	**Responses in the Questionnaires**	**n = 11**	**Responses in Worksheet No. 4**	**n = 11**
You must not play outside the house.	You'll be struck by lightning You'll be struck by *tladi*.	2 9	Lightning strikes tallest objects, people might be targets.	11
You must not touch electrical appliances, metals, and water.	They will *choke* you.	11	They are conductors or good conductors of electricity/lightning.	11
You must not ride bicycle without rubbers on the handles.	It will *choke* you.	11	Handles are metals (good conductors), you might get electric shock.	11
You must not sit under the trees especially tall ones.	Birds/lizards/*kgokgolotala* cause *tladi.*	8	Tall trees are the first objects to be struck by lightning.	9
	Tall trees conduct lightning.	3	*Kgokgolotala*(lizard) on the tree attracts lightning because it has different colours.	2
Lightning usually strikes huts known as *merale* (kitchens), especially in rural areas.	People want to steal food or bag of mealie-meal.	7	*Merale* are higher than main houses.	7
	It is easy for witches to get into *morale* than into main house.	4	*Merale* have more metals(saucepans, pots, stoves) that are good conductors.	2
			Merale don't have lightning conductors.	1
			Sparks from lightning will attract sparks from fire.	1
You must not touch white objects such as maize meal, paper, porridge.	White objects attract lightning	8	This is just a superstition.	10
	Bright objects attract bright light of lightning.	3	Lightning is a bright light, it will attract white objects.	1
You must cover mirrors and windows.	Mirrors conduct lightning. Glass conducts lightning. Mirrors reflect lightning.	7 2 2	There will be induction that could cause lightning to strike the house.	7
			Reflection of lightning by glass could cause blindness.	3
			Mirror will attract the bright light of lightning.	1
You must not wear red clothes.	Red colour attracts lightning.	6	This is just a superstition.	10
	Red clothes conduct lightning.	5	Red col. of lightning attracts red col. of cloth.	1

Table 2 shows an observable change in learners' responses in these activities from the ones provided in the questionnaires (during the Baseline Study). For example on the issue of why lightning strikes tall trees, many learners (9) used the knowledge of the effect of the height of an object during a lightning storm rather than *kgokgolotala* (lizard), and none of them mentioned the bird. Another observable change is about the issue of red clothes and white objects. Almost all learners regarded these statements as superstitions. This is a sign that the activities during the teaching and learning process helped learners to gain information on the scientific view of lightning.

On the question why lightning usually strikes houses or huts known as *merale* (kitchens) in which we cook, especially in rural areas, learners provided different answers but said nothing about the smoke which conducts electricity very well (even better than air). During the demonstration of the spark produced by the van de Graaff Generator learners were told that the spark travels through the air, and smoke was also given as an examples of a medium that provides path for movement of electrostatic charges. In rural areas most people use wood and coal to make fire, for cooking and other things; and a lot of smoke is produced.

The preceding paragraphs indicate that learners understood that lightning would strike the tallest object, but failed to use the effect of electrostatic forces. For example why forces of attraction are strongest between the thundercloud and the tallest tree or any tall object. This clearly indicates that although learners were taught about forces of attraction and repulsion they were not able to apply this knowledge to other situations. The two learners who said lightning would strike tall trees because of the presence of *kgokgolotala (lizard)* show that although learners were taught science concepts some of them (learners) continued to use their prior knowledge to resolve issues. Generally, responses from this worksheet indicate that at this stage learners tried to use the information from the previous lessons in making decisions on why their parents told them not to do certain things during a lightning storm.

These activities provided learners with opportunities to explore conflicts between scientific and indigenous ways of understanding the phenomenon of lightning, at the same time these activities indicated how this teaching sequence enhanced the way learners take decisions on relevant daily issues.

4.3.2 Findings from the Pre- and Post Assessment

The objective of this assessment task was to determine whether learners would have a better understanding of the scientific view of lightning after the Teaching and Learning Process, in which their beliefs or conceptions were incorporated. This was done in order to address operational research questions 3-5. Generally, learners' responses in the Post-assessment task were different from those in the Pre-assessment task because learners provided scientific explanations. Table 3 below, presents the comparison of learners' responses before and after the Teaching and Learning Process.

Table 3: Learners' responses during the Pre- and Post- Assessment

Question	Pre-Assessment	n=11	Post-Assessment	n=11
1. What is lightning and what do you think causes it?	**Heat/fire**, caused by friction or attraction between clouds. Flash of **light**, caused by interference or disturbance of clouds.	7 4	Large/big **spark**, caused by forces of attraction between cloud and ground. **Electric discharge**, caused by induction.	3 8
2. What is electricity and what causes it?	**Fire/light**, caused by coal. **Energy/power**, caused by water. ***Gas (****electric current****)***, caused by conductors.	4 3 4	**Flow of electric charge**, caused by induction.	11
3. Is there any relationship between lightning and electricity?	**Yes**, both … are **fire** can ***choke (****electric shock****)/*****kill.** **No** (reason not provided)	 6 3 2	**Yes,** both … work with electric **charges**. have high **voltage** and can cause **electric shock** can **burn** or **kill** **No**	 3 4 3 1
4. From the following methods of protection against lightning: Motorcar tyre, Traditional medicines, *Patla ya motse*, and Lightning conductor, Which one would you advice your community members to use?	**Motorcar tyre**, is the best and the cheapest method. **Traditional medicines or *patla ya motse***, people who use lightning to strike use traditional medicines, and most people in the village use *patla ya motse.* **Lightning conductor**, decrease speed of lightning.	4 **3** 4	**lightning conductor**, makes charges to flow down into the ground. **traditional medicines or *patla ya motse***, people who use lightning to strike use traditional medicines.	9 2
5. Do you think tladi should be discussed in science lessons about electricity? Please explain why or why not.	**Yes,** learners should know how people use it (*tladi*). **No,** other people will know how to make *tladi*.	7 4	**Yes,** because people do not know what's going on during lightning. **No,** learners do not know what causes *tladi* and how it is formed.	7 4

Table 3 reveals that before the Teaching and Learning Process, learners did not understand the scientific view of lightning, because during the Pre- assessment task, almost all learners did not use relevant science concepts in their explanations. The table also reveals that after the Teaching and Learning Process most learners used relevant science concepts in their explanations. For example, 8 learners explained lightning in terms of electric discharge and 3 learners used both electric discharge and large spark to explain lightning. Regarding the method of protection 9 learners recommended the use of a lightning conductor. Regarding the relationship between lightning and electricity all learners used science concepts to identify this relationship and none of them used the word "*choke*", they were comfortable with *electric shock*.

4.3.3 Findings from Interviews

The interviews were based on learners' responses from the worksheets and Pre- and Post-Assessment as explained in section 3.7.5. These interviews were meant to determine what learners learned from this kind of a teaching sequence (operational research question 3), and how this teaching sequence affected the way learners take decisions on relevant daily issues (operational research question 5). After careful study of learners' responses, questions were designed for individual learners. In this way, I had the opportunity to understand why learners thought they have learned certain concepts or achieved certain learning outcomes.

The interviews revealed that some of the learners like L2, L4, and L5 have an idea of what electric discharge and induction are all about. For complete interviews with these learners please see Appendix K. However, all learners were interviewed individually, these learners' individual interviews (L2, L4, L5) were selected as samples because they were not shy during the interviews. They were free and open to talk about their experiences and to share their ideas about their prior-knowledge about lightning. Other learners were free to share their ideas during the learner-centred class discussions, but said very little or kept quite during the individual interviews.

L2 is one of the learners who continued to believe that lightning (*legadima*) is a natural phenomenon, whereas *tladi* is caused by people. This is part of the interview with L2:

> L2: Eh, in my culture there is another form of lightning called *tladi*, they say it is caused by people, and before the lessons that's what I thought.
>
> T : What do you think now?
>
> L2: I still agree, but now I know more about lightning, about natural lightning.

L4 believes that after the teaching and learning process, he understands that lightning is neither caused by people nor birds; he also believes that he now has the responsibility to educate his community members about lightning, when asked what kind of responsibility, this is how he responded:

> L4: Eh, is, is the responsibility to tell my community about lightning; to tell them how to protect themselves against lightning…I will tell them to put lightning conductors on their houses, not motorcar tyres.
>
> T : If your community members can tell you that here is a person, he has just struck another person's house, and they found him washing in the river. What will you do or say?
>
> L4: Well, they usually find them.
>
> T : Is that true?
>
> L4: Yes!
>
> T : So, what will you say to them?
>
> L4: Actually there is no *tladi*, is just what people believe.

L5 believes that lightning (*legadima*) and *tladi* is one and the same thing; he believes that *tladi* is just another name (traditional or cultural name) for *legadima*. This is what he said during the interview:

> L5: Before the lessons, I thought *legadima* is *tladi*, but now I think I know that *legadima* is not *tladi*. *Tladi* is traditional, is a traditional name of lightning (*legadima*), is a cultural name.

These interviews are more informative than the answers that were provided in the Pre- and Post-Assessment. They reveal that learners did learn something from this teaching sequence though in different ways. For example, L2 indicated that he learned more about the scientific view of lightning, and he boldly added that this does not affect the way he feels about *tladi*. This implies that from now on the two concepts (*legadima* and *tladi*) will co-exist in this learner's mind, when and how to use them will depend on the prevailing situation. The interviews indicated that there were two other learners who held the same view as L2 (L6 and L11), while L4, L5 and other six learners (L1, L3, L7, L8, L9, L10) changed their original ideas about the two types of lightning, they think that the scientific view of lightning helped them to realize that *tladi* is just another name for *legadima* (in other words they do not believe in the existence of *tladi* anymore). L4 and three other learners mentioned that it is important for other learners and community members to know about the scientific view of lightning. However, the interview with L4 above indicated that when learners are confronted with real life situations they tend to accommodate or rely on their indigenous ways of understanding the phenomenon of lightning. This shows that one intervention cannot make a big difference in the way people make sense of the things that happen around them.

This chapter has the kind of the results that were obtained during the execution of different data-collecting techniques. There were a few challenges that I was faced with. However, as the process unfolded; that is, as learners were introduced to more science concepts in electrostatics, they gradually gained more knowledge and a better understanding of the scientific view of lightning. Some of the learners' cultural beliefs about lightning were modified. It was however, not easy to modify these cultural beliefs, especially the belief that people can manipulate lightning. Some (3) of the learners who achieved most of the learning outcomes, and developde a better understanding of the scientific view of lightning, continued to believe that there are people out there who have some supernatural powers that are beyond their comprehension. This observation suggests that indigenous beliefs about lightning did not prevent learners from understanding the scientific view of lightning, instead this motivated learners to want to know more about the scientific view of lightning.

The activities mentioned in this chapter are some of the activities that provided learners with opportunities to explore conflicts between scientific and indigenous ways of understanding the phenomenon of lightning, and this led to the modification of other learners' beliefs on lightning. During the interviews four learners indicated that they have already shared what they learned about lightning (scientific view of lightning) with their relatives and other learners, which I hope will promote scientific literacy in as far as lightning is concerned in this society.

Chapter 5

Discussion

5.1 Introduction

This study aimed to explore the impact of the activities that incorporated indigenous beliefs about lightning in the teaching and learning of the science topic of electrostatics. To achieve this, I had to identify the cultural beliefs about lightning held by my learners; secondly, I had to incorporate these beliefs in the teaching and learning of electrostatics. Findings from the Baseline Study and the Pre-Assessment task verified that indeed learners come to the classrooms with a broad range of ideas, experiences, presuppositions, beliefs, values, etc. These findings answered operational research questions 1 and 2. Findings from the Teaching and Learning Process and the Post-Assessment task answered operational research questions 3-5. The finding indicated that learners learned new concepts in electrostatics that improved their understanding of the scientific view of lightning. They also indicated that this kind of teaching promotes scientific literacy as well as conceptual development; it also encourages learners to take decisions on relevant daily issues. In this chapter I will provide the discussion of the results of this research study as well as limitations of the study..

5.2 Inclusion of cultural beliefs about lightning

Luft (1998:109) suggests that lack of cultural examples in science may result in students holding views that they cannot participate in science or in their perceptions, who should participate in science. The examples of learners' active participation in the results section suggest that incorporation of cultural examples could be one way to draw learners into an active attitude to the learning of science topics, and that an exploration of the integration of indigenous knowledge into the teaching of science could be beneficial well beyond the aims of acknowledging the learners' culture and contextualising the topics.

Findings from this study indicated how difficult it is to modify cultural beliefs that are strongly held by learners. What science teachers need to do, is to refine learners' prior knowledge, and not attempt to replace learners' understandings with their own. The findings have also highlighted some of the challenges that educators may face when trying to incorporate learners' prior knowledge into the teaching and learning of science, especially 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 opportunities to explore conflicts between scientific and cultural ways of understanding natural phenomena. This exploration may enhance conceptual development on the part of learners, while on the part of teachers it might help them to improve their teaching strategies as well as the design of teaching and learning materials.

5.3 When does real learning occur?

Research has indicated that the conceptual change model is based on the constructivist notion that all learning is a process of personal construction that requires the new concept to be found more intelligible, plausible, and fruitful. In other words, if the new concept is found to be "useful" or "more powerful" it will replace the old concept. In simple terms this implies that if for example a learner believed that lightning is "*tlad*i"; after he/she was taught that lightning is an "electric discharge", and finds this concept of "electric discharge" more intelligible than "*tladi*", then "*tladi*" will be replaced by electric discharge in the mind of the learner. Findings from this study confirmed that total conceptual change is not always possible. The individual interviews in this study have indicated that learners kept both scientific and cultural views of lightning. The question is when does real learning occur?

According to Cobern (1996), most students 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 students 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 students' worldview or simply deteriorate for lack of significance" (p.588).

What does this mean to the learner who found the concept of "electric discharge" more intelligible than *tladi*? Does it mean that this learner will only use the concept of "electric discharge" in an assessment task or when his/her science teacher asks him? The results of this study indicated that most learners like L4 and L5 seemed to have decided that they were wrong to say lightning is *tladi*; they said after these lessons they no longer believe in the existence of *tladi*. Did they achieve what constructivists call "conceptual change" or did they practice what Cobern calls "cognitive apartheid"?

Waldrip's (2000:9) findings also suggest that in science classrooms traditional beliefs exist in parallel but are dominated by school knowledge. This creates a serious dilemma. The question in this case, where dual beliefs are held, is whether meaningful learning has occurred or not. Science education needs to investigate further what really happens in the mind of the learner during the teaching and learning process.

The results from the interviews indicated that most learners like L2 developed some understanding of the following science concepts: *electrostatic forces*, *electric discharge* and *induction*. The discussion above also indicated that L2 still believes in the existence of *tladi*. In figures A and B below, long parallel arrows depict the orientation of a worldview in which concepts depicted by arrowheads are embedded. According to Cobern, the three arrowsheads (in figure A) that are going against the existing orientation of L2's worldview represent the three science concepts that L2 has learned. Figure B indicates how L2 has dealt with them; he created a special place for them: *the compartment wall*, so that these science concepts must not interfere with his normal way of meaning making! Indeed, the results from Lesson 4 (Worksheet No. 4) indicated that although L2 has realized that some of the ideas he had about lightning were wrong, he also personally admitted that he still believes in the existence of *tladi*. This implies that the science concepts will be used whenever required like when asked by the science teacher or in the examination.

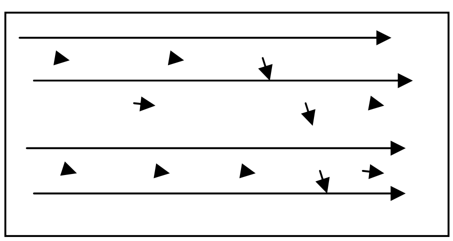


Figure A: Three new science concepts

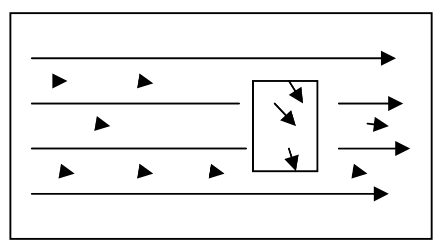


Figure B: Compartment wall

The objective of the activities in this study was to accomplish Jegede's (1995) third level of collateral learning: dependent collateral learning, where students use ideas from one worldview to challenge or understand the views from another. This kind of integration also is meant to accomplish Jegede's fourth level of collateral learning: secured collateral learning, where students resolve conflict, by using both the scientific and indigenous ways of knowing.

In this study, all learners fall into Jegede's first level of parallel collateral learning; because during the interviews follow-up questions revealed that although these learners think that they no longer believe in superstitions about lightning, their responses indicated otherwise. Waldrip (2000:9) argues that, if the students, after formal science learning, still continue to hold such traditional beliefs, then this means that the elders in the village community (with a large percentage being illiterate) still have power and authority over these beliefs in the communities in which the students belong.

5.4 Inclusion of cultural beliefs and social conflicts

After the second lesson that included electric discharge, some of the learners like L5 started to share the scientific view of lightning with their community members and fellow learners. During the interview he said: "*Yes, I just told them yesterday that there is nothing like tladi. They did not agree, they tell me that when I was small I knew there is tladi. I told them that in the past there was no education. Now I learned about lightning and I know what to do when there is lightning*". Discussions and arguments on the issue of lightning were exchanged between parents and learners, and between learners themselves. According to L5 this turned into a hot debate in which he was reminded about his roots. This is another example of the challenges that both teachers and learners may encounter in trying to incorporate learners' cultural beliefs. Learners may find themselves in serious troubles. Although one of the objectives of this study was to achieve *scientific literacy* in as far as lightning is concerned, it was not supposed to be at the expense of learners. In future learners may not participate in science activities because of such incidents.

People should know about the scientific view of lightning, so that they can use proper methods of protection against lightning, and reduce persecutions of people wrongly believed to cause lightning to strike other people/houses. I know that this was just a drop in the ocean, but I believe that if this study could be replicated in similar cultures more people will be aware and hopefully will practice the correct methods.

5.5 Language as a barrier towards real learning

Most studies that dealt with cultural issues and/or indigenous knowledge, highlighted the problem experienced by African learners, in understanding science or mathematics concepts. The results of this study also revealed that learners experienced some difficulties in expressing themselves in English. During the learner-centred 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 Sepedi. The use of the words *choke* and *gas* by learners are some of the examples that indicate that English as the medium of instruction can be a learning barrier.

Fatnowna and Pickett (2002) argue that, if you control the learning and use of language you control the way in which people see and relate to the world around them. This explains why some of African learners fail to understand some science concepts even if they were introduced to them in the previous grades or sections. In most cases learners just memorise science concepts, laws, principles without having a glue of what those concepts mean. For example, the learner-centred class discussion in the first lesson indicated that learners knew about the law of attraction and repulsion from previous grades; but did they understand it? No, because they could not use it to decide why scientists believe that there are two types of charges.

Other researchers believe that *"Code- Switching"* (the use of more than one language in discourse) in mathematics and science teaching can improve teaching and learning. According to Needo et al. (2002:312), code switching allows learners to think, to argue, and to classify their thoughts; it is a tool to understanding. For example in their research study they reported that when learners are grappling to understand a concept they use Xhosa and that, in fact, having to use English would be a barrier to grasping the concept (p.311). I agree with these authors that indeed educators should be allowed to code-switch if they find it necessary, to ensure that learners understand what is expected of them to learn; especially in rural areas. In this study I frequently switched to Sepedi in order to help my learners to understand the science concepts and also to encourage them to be actively involved during learner-centred class discussions.

The language issue as a problem was also mentioned by Maselwa (2004:34), in his Master's thesis in which he was investigating the effect of prior knowledge about lightning in the teaching of electrostatics. He argues that, some learners could be reluctant to give views because of lack of proficiency in English, which is the medium of instruction. Mahapa (2002) also highlighted the problem of English as the language of communication in schools. He suggests 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). In this study I managed to translate questions in both elders' interview schedule and learners' questionnaire into Sepedi (see Appendices B and C). Respondents were also encouraged to respond in Sepedi. However, during the design of the teaching and learning materials I found it very difficult to do the same, due to lack of relevant concepts in Sepedi.

5.6 Limitations of the study

According to literature, case studies and action research are very useful within the practical dimensions of the situation; I personally found them very helpful, because I was able to evaluate my own teaching practice. However, their findings do not directly contribute to the general body of education knowledge due to their limiting nature (Isaac and Michael, 1997). The weaknesses of both the case study and an action research apply in this study.

Looking at the nature of my case study, I cannot claim that the findings of this research can be generalised. Firstly, the fact that data was collected from a very small group of learners suggests that I cannot generalise my findings. Secondly, these findings were derived from data that were obtained from a deprived rural area, hence I cannot claim that they will hold true for wealthy metropolitan areas, however, they can benefit learners and teachers from the same cultural background. Thirdly, in a case study the researcher may try to avoid subjective interpretation of data, of which in most cases is very difficult; however, I tried to be as more objective as I could. The data-collecting instruments that were used in this study helped me to present the kind of findings that answered the research questions.

The fact that I was using my own learners may have affected the results in the sense that my learners might have provided the kind of answers that they thought their science teacher wanted to hear. The use of more than one instrument helped me to determine the kind of understanding that was developed by the learners.

The time factor is a problem that might cause a lot of anxiety on the part of the educator/researcher. For example, two lessons (1 and 3) did exceed the prescribed time, and this made me to be impatient, speeding up the execution of activities, not giving learners enough time to think about the remaining questions. The responses in those activities may not reveal the actual understanding of learners.

Chapter 6

Conclusion

6.1 Introduction

This chapter summarises findings from all the research activities, and provides the implications or recommendations for further research.

6.2 Overview of research findings

While on the one hand assumptions and findings by several science educators indicate that inclusion of indigenous ways of knowing would enhance learners' understanding and hence performance in science (Ashriff, 1998 and Ratsie, 2001 in Emereole and Maripe, 2003; Fatnowna and Pickett, 2002; Mahapa, 2002; Maselwa, 2004); on the other hand, findings by Emereole and Maripe (2003:568) suggest that getting African students to relate science with indigenous beliefs is a task that raises more problems than it solves.

Findings from this study indicate that inclusion of indigenous ways of knowing could indeed maximise or reinforce the learning of science, because it promotes conceptual development, scientific literacy, and active participation. Carefully designed materials that integrate learners' prior knowledge with a science topic can indeed provide learners with opportunities to explore conflicts between scientific and indigenous ways of knowing.

The design of my lessons was in accordance with Aikenhead's (1994:54-58) sequence for STS science teaching (see Figure 1). The instruments that were designed to collect data from this kind of a teaching sequence provided relevant answers to operational research questions 3-5. The activities that were designed in this teaching sequence helped learners to develop an understanding of the scientific view of lightning.

The study has indicated that the explanations of the concepts of electric discharge and induction did help learners to see the link between lightning and electrostatics. Most learners were able to relate what happens during a lightning storm to these concepts, mostly in terms of the movement of charge. The comparison between the spark produced by the Van de Graaff Generator and the one produced by the thundercloud also helped learners to realise that the voltage between the thundercloud and the ground is millions of volts, indicating how dangerous lightning really is.

During the execution of activities, the researcher was faced with challenges such as *"tladi is more dangerous than lightning"* and "*people are able to manipulate lightning*". It has been mentioned in the preceding sections that the aim of science instruction is not to replace learners' prior knowledge but to modify them. Follow-up questions (probing) during both learner-centred class discussions and individual interviews helped learners to realize in so many ways that some of the ideas they had about lightning needed some modification, and that in most cases science conceptions are more fruitful than their own conceptions. However some of the learners continued to believe that people could manipulate lightning. The most important thing is that even though these learners continued to believe in the existence of *tladi*, they developed an understanding of the scientific view of lightning. In the traditional way of teaching, I could have told them to believe the scientific view of lightning, or I might have not included these beliefs in my lessons at all. Thanks to the contemporary views in science education, and the new teaching method in South Africa (OBE), and the work that has been done by researchers on multiculturalism and Indigenous Knowledge Systems.

Does the integration of indigenous beliefs with a science topic help learners to solve relevant daily problems? This was a small-scale study that focused on the integration of beliefs about lightning with electrostatics. The kind of problems identified here were protection against lightning; what to do and not to do during a lightning storm based on what learners have learned about static electricity. Based on the discussions above and on learners' responses during the interviews, the kind of the activities that were designed did help learners to solve relevant daily problems. For example learners realised that cutting trees around houses to avoid birds and lizards that can allegedly cause lightning to strike, creates a high possibility of those houses to be struck by lightning. Other decisions involved the choice of lightning conductors over traditional practices and the motorcar tyre; and why they should be inside the house rather than being outside or in the field during a lightning storm.

6.3 Implications

The results from this study indicate that integration of IKS should be an ongoing process, because it maximises learners' active involvement during the Teaching and Learning Process. This suggests that teachers should integrate IKS/Indigenous Beliefs with a science topic frequently.

This study revealed that researchers engaged in integrating learners' prior knowledge need to be equipped with a variety of skills such as designing relevant teaching and learning materials, questioning and/or probing, and analysing data. This suggests that there is a need for professional development in as far as the incorporation of learners' prior knowledge is concerned; because some educators might think that "awareness" on IKS is enough; no, the effect of these cultural examples need to be assessed.

Taking into account the reluctance of people to relinquish their culture, and the long history behind the cultural beliefs existing within the participants, it becomes obvious that changing these beliefs will require some well-planned long-term strategies to counteract the existing belief structures (Mahapa, 2002:186). It is not the intension of this study to make people to give up their culture, but to help them to consider scientific alternatives as far as lightning is concerned. This implies that there is a need for replication of this study in similar cultures and/or longitudinal study to investigate the impact of the incorporation of beliefs about lightning with the teaching of electrostatics. In fact, I took a step further by involving three teachers in the District where I teach. They used the same Teaching and Learning Materials that were used in this study to teach their learners about Electrostatics; however, when I started with the writing and interpretation of results they were not yet through with their teaching. This shows that this study could benefit other learners and educators from the same cultural background.

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APPENDICES

Appendix A: Categories of STS Science

CATEGORY	CONTENT STRUCTURE	STUDENT EVALUATION
1. .Motivation by STS content	Traditional school science, plus a mention of STS content	No Assessment on the STS content
2. Casual Infusion of STS Content	Traditional school science, plus a short study of STS content attached onto the science topic	Assessment mostly on pure science content and only superficially on the STS content (5% STS, 95% science)
3. Purposeful Infusion of STS Content	Traditional school science, plus a series of short studies of STS content integrated into science topic	Assessment to some degree on understanding of STS content (10%STS, 90% science)
4. Singular Discipline Through STS Content.	STS content serves as an organizer for the science content and its sequence	Assessment on the understanding of the STS content (20%STS, 80%science)
5. Science through STS Content.	STS content as an organizer, science topics selected from traditional science	Assessment on understanding of STS content, not as extensively as on science (30%STS, 70%science)
6. Science along with STS Content	STS content is the focus of instruction, relevant science enriches the learning	Assessment equally on STS and pure science (50%STS, 50% science)
7. Infusion of Science into STS Content.	STS content focus of instruction. Relevant science content mentioned, but not systematically taught	Assessment primarily on the STS content, and only partially on science content (80%STS, 20% science)
8. STS Content	A major technology or social issue is studied	Assessment not on pure science

Appendix B: Interview Schedule for Elders

BASELINE STUDY

INTERVIEW SCHEDULE FOR ELDERS

1. Could you please explain what lightning is? (*Naa o ka hlalosa gore legadima ke eng, hle?)*

2. When does it occur? (*Le ba gona neng?)*

3. How is it formed? (*Le hlolega bjang?)*

4. In your own view can a person cause lightning to strike, e.g. a house, a person, an animal, etc.? (*Go ya ka kgopolo ya gago, motho a ka kgona go dira gore legadima le bethe ntlo, motho, phoofolo, bjalo bjalo?)*

5. Is lightning dangerous? Please explain. (*Naa legadima le kotsi? Hlalosa hle*).

6. What must one "do" or "not do" during a thunderstorm? (*Ke eng seo motho a swanetsego go se dira goba go se se dire ge go na le magadima?)*

7. How do you protect your house from lightning? Please explain. (*Naa o tshireletsa ntlo(motse) wa gago bjang, kgahlanong le legadima?)*

8. What other things can you tell me about lightning? (*Ke dife tse dingwe tseo o ka mpotsago tsona ka ga legadima?)*

9. Do you think that these issues(views or ideas) should be taught at schools? Why, or why not? (*Naa o nagana gore dinthla tse di swane go rutwa kua dikolong? Ke ka lebaka la eng o realo, goba o gana?)*

10. Are you willing to share your views about lightning with my learners? If No, why not? (*Naa o ka abelana dinthla tse tsa gago le barutwana ba ka? Ge o re aowa, ke ka lebaka la eng?*)

THANK YOU

KE A LEBOGA

Appendix C: Learners' Questionnaire

BASELINE STUDY

LEARNERS' QUESTIONNAIRE

NB: PLEASE FEEL FREE TO ANSWER THESE QUESTIONS IN YOUR OWN MOTHER TONGUE, IF YOU WANT.

1. In your own view, what is lightning? (*Go ya ka kgopolo ya gago, legadima ke eng?)*

____
____
____

2. What is it made of? (*Le bopilwe ke eng?)*

____
____
____

3. What does it look like? (*Le lebellega bjang?)*

____
____
____

4. What happens during lightning? (*Go direga eng ge go na le legadima?)*

____
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5. When a person is struck by lightning, (*Ge motho a rathilwe ke legadima,*

5.1 how does he/she look like? (*o lebellega bjang?*)

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5.2 what happens to the clothes he/she was wearing? (*go direga eng ka diaparo tseoa bego a di apere?)*

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5.3 what about the hair, does it also burn? (*meriri yona, le yona e ya swa?)*

6. What kind of houses can be struck by lightning? Why? (*Ke mohuta ofe wa dintlo wo o ka rathago ke legadima? Ka lebaka la eng?)*

7. Is it possible for a tree to be struck by lightning? Explain. (*Go a kgonega gore mohlare o rathwe ke legadima?Ka lebaka la eng?)*

8. Can a person cause lightning to strike other people or houses? Please explain. (*Naa motho a ka kgona go dira gore legadima le rathe batho goba dintlo? Hlalosa hle.)*

9. Go and ask your parents, relatives or community members; to tell you everything they know about lightning.

For example, ask them (*Eya go kgopela batswadi, meloko goba batho ba mo motseng; gore ba o botse dilo ka moka tseo ba di tsebago ka legadima. Mohlala, ba botsise*

- The things which you must do, or must not do during lightning and **why? (***Dilo tseo o swanetsego go di dira goba o sa swanelago go di dira ge go na le legadima, le gore* ***ka lebaka la eng?****)*
- How they protect themselves from lightning and **why? (***Ba itshireletsa bjang legadimeng, le gore* ***ka lebaka la ebg?)***
- How they protect their houses from lightning and **why? (***Ba tshireletsa dintlo tsa bona bjang legadimeng, le gore* ***ka lebaka la eng?)***
- Other things and **why? (***Tse dingwe, le gore* ***ka lebaka la eng?)***

NB: If this page is not enough, feel free to use another page. (*Ge eba letlakala le ga la lekana, lokologa go somisa letlakala le lengwe).*

THANK YOU

KE A LEBOGA

Appendix D: Pre- and Post- Assessment

ELECTROSTATICS

GRADE 10

Name of learner: ___________________________ Date: _______

1. What is lightning, and what do you think causes it?

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2. What is electricity, and what do you think causes it?

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3. Is there any relationship between lightning and electricity? Please explain.

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4. There are different methods that different people believe can protect their houses from lightning, for example:

A. Putting motorcar tyres at the top of the roof.
B. Using traditional medicines and things like “patla ya motse”.
C. Using prayer and other things like Holly Water and pictures from their churches.
D. Using lightning conductors.

Which method would you advice your community members to use? Please explain why.

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5. Do you think “tladi” should be discussed in science lessons about electricity? Please explain why or why not.

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Appendix E: Teaching and Learning Materials

WORKSHEET No. 1

Name of learner: ________________________ Grade: ___ Date: _____

LESSON 1: ELECTROSTATIC FORCES AND CHARGES

At the end of this lesson, you should be able to

- ➢ Charge different objects through rubbing.
- ➢ Identify two types of charges.
- ➢ Identify the kind of substances that can be charged after rubbing.
- ➢ Explain how different charges interact.
- ➢ Identify examples of electrostatic forces.
- ➢ Understand why electrostatic forces are regarded as non-contact forces.
- ➢ Describe how electrons are transferred during rubbing.
- ➢ Identify insulators and conductors.

Activity 1: <u>Charging objects</u> (learners work in groups) **– 5 Minutes**

Work with a partner and do this simple experiment.

What you need: sellotape, pair of scissors or razor blade, and ruler.
What to do:

- cut three pieces of sellotape, about 20cm long, and label them: 1, 2, and 3.
- paste the third one on the table.
- put the sticky parts of the first and the second sellotapes together.
- now pull them apart and hang them on the edge of the table, about 30cm apart.
- remove the third piece from the table; bring it closer to the hanging sellotapes.
- write your observations, and report back to the class.

1.1 What did you observe?
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1.2 Scientists explain what you have observed as the result of forces electric charges exert on each other. They believe there are two kinds of electric charge. Using your observations, can you explain why they think so?
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Explanation:
This simple experiment shows us that these pieces of sellotapes are electrically charged. From what we have observed, we can conclude that there are two different kinds of electric charge; because when the third piece was brought closer to the first one it moved towards the third one; but when the third piece was brought closer to the second one it moved away.

An American scientist of the eighteenth century, Benjamin Franklin, called these electric charges positive (+) and negative (-). He defined the charge on a rubbed glass as positive and scientists *accepted his definition. According to science, like charges repel each other and unlike charges attract each other. This is called the* ***law of attraction and repulsion.***

Activity 2: <u>Testing the kind of charge on the charged sellotapes</u> (learners work in groups) **- 5 Minutes.**

What you need: the first two sellotapes used in Activity 1, glass rod, and silk cloth.
What to do:

- rub the glass rod with the silk cloth.
- bring the charged glass rod closer to the sellotapes, and observe.

2.1 Which of the sellotapes was positive and which was negative? Give reasons. (*The one that moved towards the glass rod was negative, and the one that moved away from the glass rod was positive: this is according to the law of attraction and repulsion).*
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Find out what charge other materials get when rubbed, by doing the following experiment.

Activity 3: <u>Testing the kind of charge on rubbed objects</u> (learners work in groups) **– 10 Minutes.**

What you need: plastic ruler, plastic straw, ebonite rod, balloon, flannel cloth, and woollen cloth.
What to do:

- rub plastic objects with flannel and wipe the balloon with woollen cloth (even your jersey or shirt)**.**
- bring them closer to the sellotapes, and write your observations.

3.1 After rubbings, which of the materials are positively charged, and which are negatively charged? Please give your reasons. *(Materials that are attracted by the negatively charged sellotape are positively charged, while those that are repelled by the negatively charged sellotape are negatively charged. Similarly, those that are attracted by the positively charged sellotape are negatively charged, while those that are repelled by the positively charged sellotape are positively charged).*
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Can we charge every object by rubbing? Well, the following experiment will help you to find out if you can charge every object by rubbing or not.

Activity 4: <u>Rubbing electrical conductors and insulators</u> (learners work in groups) **– 15 Minutes.**

Try to charge objects made of different materials such as plastic, glass, wood, and metal.

What you need: glass rod, plastic ruler, plastic straw, pen, plastic comb, ebonite rod, pencil, wooden ruler, nail, wire, metal rod, sellotape, and cloth materials made of cotton, flannel, silk, and wool.
What to do:

- charge different objects by rubbing them with a piece of cloth: *note that objects made of plastic work better after being rubbed with flannel, whereas objects made of glass work much better after being rubbed with silk.*
- for each object, test whether it is electrically charged by seeing if it attracts or repels the sellotape.

4.1 Record your observations in the second column of the table below.

The following steps will help you to identify the kind of materials that can or cannot be charged by rubbing.

- now, set up an electric circuit by connecting a cell, two electrical conductors (plastic coated wires) and a small light bulb: *if your circuit is connected correctly the light bulb will light up.*
- insert each object between one end of a wire attached to the bulb and the bulb itself, and observe.

4.2 Record your observations in the third and fourth columns of the table below.

Object rubbed	**Can the object be charged by rubbing?**	**Does the bulb light up or not? (**write: bulb lights up **or** bulb does not light up**)**	**Is this object an** electrical conductor **or an** insulator?
Glass rod			
Plastic ruler			
Plastic straw			
Pen			
Plastic comb			
Ebonite rod			
Wooden ruler			
Nail			
Wire			
Metal rod			

4.3 Which conclusion can you make from your observations? *(Insulators or non-conductors get charged but conductors don't. Note that the bulb lit up whenever charges flowed through it: i.e. whenever it was part of a complete circuit. Since the bulb lit up when metal objects were placed in the circuit, we know that metal allows charges to flow, and we say that metal is an **electrical conductor**. Since the bulb did not light up when glass and plastic objects were placed in the circuit, we know that glass and plastic do not allow charges to flow through them, and we call them **insulators** or **non-conductors.**)*

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4.4 A. Suppose an electric charge is placed on a conductor that you hold in your hand. What would happen to it?

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4.4 B. Suppose an electric charge is placed on an insulator that you hold in your hand. What would happen to it?

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4.4 C. Use your answers in A and B to explain that insulators can be charged by rubbing but conductors cannot. *(In electrical conductors charges are so free to move around that they won't just stay in place, whereas in insulators they can move slightly: in some insulators they are so fixed, they can't move around).*

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4.5 A. All solids are made up of molecules. All molecules are made up of atoms. What are atoms made of? Draw a diagram of an atom and label its parts. Describe how the ebonite rod in Activity 3 became negatively charged? Where did the extra negative charges come from? *(Electrons were rubbed off the flannel cloth onto the ebonite rod, increasing the number of negative charges on the ebonite rod. Note that, during rubbing* ***charges are neither created nor destroyed; they are merely separated.*** *This statement is called the* ***Law of Conservation of charge.*** *In other words the total charge remains the same before and after rubbing)*

4.5 B. On your diagram, indicate which parts have: negative (-) charge, positive (+) charge, and zero (o) charge.

4.5 C. It is very difficult to take "something" out of the nucleus of an atom. However. It is not difficult to add an electron to some atoms. Other atoms can easily loose an electron. Draw the atoms of a piece of glass before and after rubbing. Use the diagram to explain how the glass can become positively charged. Note that glass consists mainly of silicon (Si) atoms with: 14 protons; 14 neutrons; and 14 (2,8,4) electrons.

BEFORE RUBBING AFTER RUBBING

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5. Write few sentences about what you learned about electrostatic forces. The following words may help you to have much to say about electrostatic forces: *electrons and protons; like and unlike charges; charged objects; forces of attraction and repulsion.*

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Explanation:

*Everything is made of atoms, and charges are parts of atoms. Atoms are made of a **nucleus** and **negative charges** (**electrons**) that move around the nucleus. The nucleus has **positive charges** (**protons**) and neutral particles called **neutrons.***

*Most objects are **neutral** before rubbing – they have **equal** numbers of positive charges (**protons**) and negative charges (**electrons**).*

Benjamin Franklin believed that there was only one kind of charge that was either put on an object or taken off an object when it was rubbed with a cloth, namely, the negative charge (electron).

*When the glass rod was rubbed with silk, some of the electrons were rubbed off the glass rod onto the silk cloth: electrons were transferred from the rod to the cloth-the rod's atoms lost those electrons; leaving the rod with less negative charges and more positive charges, so the rod was **positively charged.** At the same time the silk cloth gained electrons from the glass rod and had more negative charges than positive charges, so it was **negatively charged.***

Explaining electrostatic forces:

*When electrically charged objects push each other, we say they **repel** each other and they exert a **force of repulsion**; and when one object pulls another object we say they **attract** each other, and they exert a **force of attraction**. These forces of attraction and repulsion between electrically charged objects are called **electrostatic forces.** Electrostatic forces do not need direct contact with other objects to cause them to move, in other words they act at a distance. Forces that exist between objects that interact without touching each other are called **non-contact forces.** Electrostatic forces are examples of non-contact forces.*

Activity 5: <u>Investigation task</u> (learners work individually at home)

Ask 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	**People's ideas**	**People interviewed**	**Your own ideas**
1. What is lightning?			
2. What do you think causes it?			
3. Is there any link between electricity and lightning? Please explain why or why not.			

WORKSHEET No. 2

Name of learner: ________________________ Grade: ____ Date: ________

LESSON 2: HOW CHARGES GET ENERGY TO MOVE – 60 Minutes

At the end of this lesson, you will be able to

- Describe some examples of electrostatic forces.
- Describe what electrical energy is.
- Relate energy between unlike charges to the energy that causes (is responsible for) lightning
- Recognise lightning as an electric discharge.

Activity 1: <u>Report from investigation task</u> (learner-centred class discussion) **– 5 Minutes.**

1.1 What did the people at home tell you about lightning?

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

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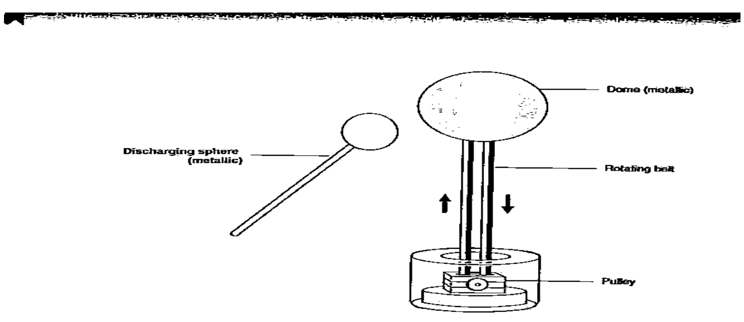
Can you make your own lightning? Now is the time to make your own lightning.

Activity 2: <u>Investigating the effect of static electricity using the Van de Graaff Generator</u> (learners work in groups) **– 10 Minutes.**

What you need: **the Van de Graaff Generator:**



Explanation: *Turning the handle of the Van de Graaff Generator makes the rubber belt to become negatively charged through friction. The rubber belt carries the negative charge to the dome. The dome collects the negative charge. When the charge on the dome becomes big enough a* ***discharge*** *takes place (i.e. electrons jump from the dome towards the discharging sphere). When negative charges move from one object to another, the process is called* ***electric discharge.*** *The dome can discharge in different ways, for example:*

- *electric sparks may jump from the dome to the discharging sphere.*

- *it can discharge continuously when a sharp-ended object like a nail is fixed on the dome (charge becomes so concentrated at the sharp end that a discharge takes place continuously into the air (the air becomes ionised): without sparking).*

What to do:

- charge the dome of the Van de Graaff Generator by turning its handle.
- bring the discharging sphere close to the dome.
- watch what happens at the gap between the dome and the discharging sphere.
- now, touch the electrically charged dome!

2.1 Describe what you saw in the gap. *(sparks, fire, light).*

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2.2 Describe what you heard. *(sound or crack sound)*

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2.3 Describe the feeling you experienced when you touched the dome. *(What you felt is **Static electricity,** sometimes it can also be felt when you pass next to the TV, sometimes during handshakes charges can move from one person to another**.** Static electricity is felt when an object that is positively charged or neutral comes close to an object that is negatively charged. During the interaction the positively charged or neutral object may "capture" some of the negative charges from the negatively charged object, i.e. some of the electrons will move from the negatively charged object to another, such as from the dome to your body).*

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Explanation of the occurrence of the spark:

- *charges that build up on the dome cause the air nearby to be ionised (note that ionised air is an electric conductor).*
- *charges from the dome move through the charged air to the discharging sphere: sometimes you may see a small burst of **light, spark** or hear a **"crack" sound.***
- *a spark is an example of **energy transformation**.*
- *charges on a charged object have **electrical potential energy.***
- *when there is a spark, this electrical potential energy is **transformed** or converted to **electrical kinetic energy (**current**)** that is usually called **electrical energy**.*
- *electrical charges colliding with air molecules result in transformation of electric energy into several forms of energy such as **light, sound** and **heat.***

Activity 3: <u>Sparks and lightning</u> (learners work individually) **– 10 Minutes**

Explanation of what actually happens between the thundercloud and the ground:
*There are strong winds inside a thundercloud that move water and ice particles up and down. This causes the cloud to be charged. The **bottom** of the cloud usually gets a **negative** charge and this **induces** a positive charge on the ground. The cloud can **discharge** in the form of a large spark called **lightning. Lightning is a spark just like that of the Van de Graaff Generator. However the amount of energy involved in one flash of lightning is billions of times larger than for the Van de Graaff Generator.***

Actually the thundercloud works like a big Van de Graaff Generator; and lightning is similar in some ways to the spark produced by the Van de Graaff Generator, because during a lightning storm:

- *Electric charges build up in the clouds.*
- *When enough charge has built up, the air near the cloud becomes charged too**.***

- *When the electrical potential energy is large enough there is a discharge via the charged air: this happens very fast and according to science the current can be 50 000 amperes. This current heats up the air, the air expands and then contracts due to cooling by the surrounding cold air. This happens so fast that a big sound wave is generated: we hear a clap of thunder.*
- *Electric energy of the charges is converted to sound, heat and light; just as you saw a spark produced by the Van de Graaff Generator, but in much large quantities: this makes lightning to be more dangerous!*
- *There is stored energy (**voltage**) between the cloud and the ground: the voltage can become millions of volts before lightning occurs.*

3.1 Use your imagination to draw a thundercloud above the ground. On your diagram show

- the charges on the cloud and on the ground.
- the lightning stroke between the cloud and the ground.

3.2 Use your understanding of electric discharge to decide whether a person can make his or her own lightning during a lightning storm; and use it to strike people or houses.

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Activity 4: <u>The effects of static electricity</u> (learners work in groups) **– 10 Minutes**

Lightning is one of the examples of natural phenomena that result from electrostatic charges in clouds and on earth. Can you think of other examples in which sparks are produced? (*When a jersey is pulled over one's head: the jersey and the hair become charged, small sparks are seen in the dark and soft crackles are heard. When one walks over certain carpets and touches a door knob: a small spark may occur as a result of one's body being charged through friction between the carpet and one's shoes. Sometimes static electricity on clothes causes itching)*

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WORKSHEET No 3

Name of learner: ________________________ Grade: ____ Date: _____

LESSON 3: FINDING OUT MORE ABOUT ELECTROSTATIC CHARGES – 60 Minutes

At the end of this lesson, you should be able to

- Describe the process of induction.
- Explain the use of an electroscope.
- Explain the effect of a positively charged object on the electroscope.
- Charge an electroscope positively or negatively.
- Explain how to detect an unknown charge with a charged electroscope.
- Explain how to charge conductors by induction.
- Make an electroscope.

Activity 1: <u>Charging objects by induction</u> (learners work in groups) **– 10 Minutes**

Explaining induction:
When a charged object causes the movement of charge in a neutral conducting object, it results in a force of attraction or repulsion between the two objects (the objects do not touch); the process is called ***induction.*** *During induction electric charges are separated, for example, the negatively charged dome of the Van de Graaff Generator caused the movement of charge in the discharging sphere that became positively charged.*

The following experiment will help you to have a better understanding of induction.

What you need: the balloon, and small pieces of paper.
What to do:

- rub the balloon on your jersey or shirt.
- put the balloon on the wall, leave it and observe.

1.1 Why does the balloon stick to the wall? *(This happened because when you rubbed the balloon, it obtained a positive charge and the wall was neutral. When the balloon was held close to the wall, the negative charges in the wall were attracted towards the positively charged balloon; a force of attraction existed between the balloon and the wall.)*
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1.2 Use your understanding of induction to describe how the ground obtains a positive charge during a lightning storm. *(Charges can flow from the negatively charged cloud through the air as lightning, because charged air conducts electricity. When lightning approaches the ground charges are separated: the negative charges are pushed downwards leaving the top of the ground positively charged. So, a force of attraction exists between the cloud and the ground because the negative charges from the cloud are attracted by the positive charges on the ground.)*
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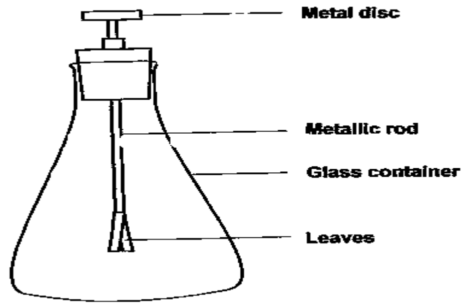
Activity 2: <u>Charging an electroscope negatively</u> (learners work in groups**) – 10 Minutes**.

The electroscope.



An electroscope is an instrument that is used to ***test*** *an electrical charge – to find out if an object is electrically charged. Electroscopes are made of different forms: an electroscope with one leaf made of either gold or aluminium; an electroscope with two leaves made of either gold or aluminium. Electroscopes usually use gold foil instead of aluminium foil, this is because the thin pieces of gold metal (called gold leaves) are soft and bend easily.*

What you need*:* An electroscope, an ebonite rod, and flannel cloth.

What to do*:*

- make sure that the electroscope is neutral by touching it with your finger.
- rub an ebonite rod with flannel cloth to make it positively charged.
- hold the negatively charged ebonite rod closer to the metal disc and observe what happens.

2.1 Use your understanding of induction to explain why the leaves moved away. *(the leaves moved apart, the electroscope gained some extra electrons from the ebonite rod, so, both leaves are negatively charged that's why they repel each other)*

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2.2 What do you think would have happened if you held a positively charged glass rod closer to the neutral electroscope? *(The positively charged glass rod would cause separation of charge on the electroscope. The negative charges would be attracted by the positively charged glass rod; there will be more negative charges on the disc and more positive charges on the leaves: both leaves would be positively charged, so, they would repel each other.)*

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Activity 3: <u>Detecting the effect of a positively charged object on a positively charged electroscope</u> (learners work in groups) – **10 Minutes**.

What you need: An electroscope, glass rod, and silk cloth.

What to do:

- Charge the electroscope positively by touching it with a positively charged glass rod (note that the leaves move away from each other).
- Touch the disc of the neutral electroscope with the negatively charged ebonite rod and observe.

3.1 Record what happens to the leaves, and explain why this happens. *(They move further apart or repel each other even more. More electrons are removed from the leaves, leaving them with more positive charge, so the force of repulsion between the leaves increases.)*

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3.2 What do you think will happen if a negatively charged object is brought closer to the metal disc of this positively charged electroscope? *(The leaves will fall or move towards each other, because electrons will move from the object onto the disc towards the leaves; positive charges in the leaves will attract the negative charges.)*

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3.3 Use your understanding of induction to decide whether a motor car tyre put on the roof of the house can protect that house from lightning or not.

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3.4 A lightning conductor is used to protect buildings from lightning. It consists of a metal rod taller than the building it is designed to protect, and reaching a meter or more into the earth. According to science, if lightning strikes, the conductor will be struck rather than the building. The charge will flow harmlessly through the rod into the ground.

Use your understanding of induction to describe the action of the lightning conductor.

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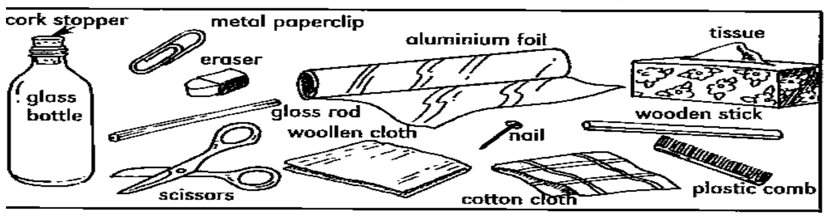
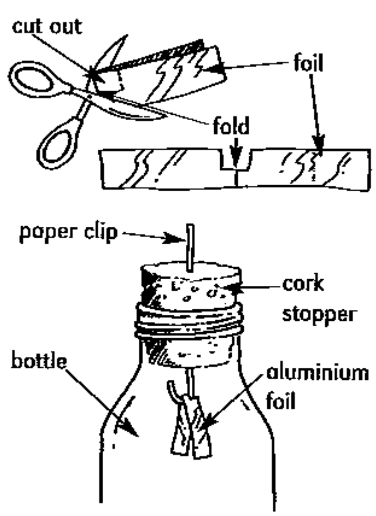
Activity 4: Designing and making your own electroscope **(Homework task – learners work individually)**

In this activity you are going to make your own electroscope. ***You will need*** the following equipment to design and make your own electroscope.



What to do:

- Cut a piece of thin aluminium foil about 20mm x 5mm. Then fold and cut the strip as shown in the diagram below.



- Straighten the metal paper clip and push the straight piece of wire through the cork stopper. You may use a nail to make a hole in the stopper.
- Make a small hook at the bottom end of the paper clip.
- Now you can make your electroscope. Use the diagram below to help you.
- Your electroscope should be tightly sealed.
- Use the remaining materials to see if your electroscope works, and report back to the class.

WORKSHEET No. 4

Name of learner: _______________________ Grade: ____ Date: ______

LESSON 4: ISSUES ABOUT LIGHTNING – 60 Minutes

At the end of this lesson, you should be able to:

- Identify safety measures against lightning
- Take informed decisions on everyday life situations that involve electrostatics.
- Take social responsibilities.
- Identify the dangers of superstitions and ignorance when dealing with lightning.
- Be aware that there are several ways of explaining what happens around us – science is one of them

Activity 1: Protection against lightning – 20 Minutes

1.1 Use your understanding of static electricity to explain why lightning is dangerous. *(Lightning is very dangerous, because during lightning a large amount of current is produced, and this current may cause fire that can burn houses or people. When lightning strikes a person, the charges from the cloud will flow through the person's body and this may cause an electric shock because our bodies are not used to conduct large currents. The electric shock may result in death!)*

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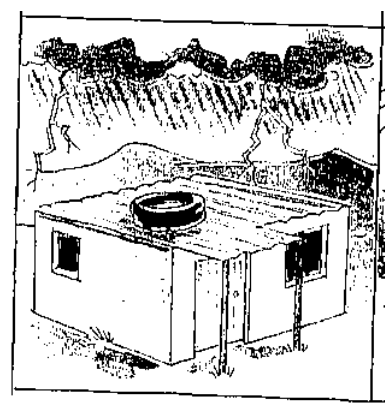
1.2 Look at the following pictures, and answer the questions that follow.



(a) What dangerous activities do you see in the pictures?

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(b) For each picture, explain why *what* is going on is dangerous; and suggest a safer alternative.

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1.3 Use your understanding of static electricity to explain why your parents told you not to
(a) Play outside the house during lightning storm. (*Outside the house there is air, and air is a conductor of electricity. Lightning needs a conducting path to travel along. So, it will travel through the air into your body and this could kill you!)*

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(b) Touch water, swimming or playing with water during lightning storm. (*Metals are good conductors of electricity, if you touch them during a lightning storm, large quantity of charge will pass through your body, and in this case you could even burn!)*

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© Touch metals or be near the fence during lightning storm. *(metals are good conductors of electricity, if you touch them during a lightning storm, large quantity of charge will pass through your body, and in this case you could even burn!)*

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(d) Use electrical appliances like TV or telephone during lightning storm*. (If lightning strikes a telephone cable and you are talking on the phone, it is possible for you to get an electric shock).*

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(e)Sit under the trees, especially tall ones during lightning storm. *(Electrostatic forces act at a distance, and these forces are greatest if the distance between the charged objects is smaller. The distance between the cloud and a tall tree is small, so, there is a high possibility of a tall tree to be struck by lightning. That is why some people believe that witches practice "tladi" by striking trees.)*

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4.Why does lightning usually strike houses or huts also known as "merale" in which we cook, especially in rural areas? *(Most of our people use wood to make fire, in most cases this wood makes a lot of smoke – smoke conducts electricity quite well: even better than air. Lightning can travel through smoke onto the house (usually called "morale") and the people inside the house may get electric shock. This is how many houses in rural areas are struck by lightning. So, it is better to put out fire, even cooking fire during a lightning storm.)*

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Activity 3: <u>Identifying beliefs about lightning</u> (**Learners work in groups)** – 20 Minutes

Use your understanding of static electricity to decide whether you agree with the following ideas about lightning or not. Please explain why you agree or why you don't agree. You may need an extra page for this question.

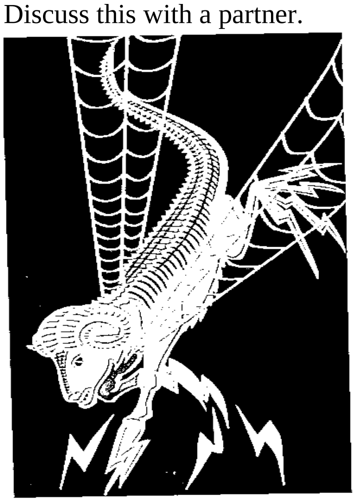
(a) Lightning is a large spark.
(b) Lightning is fire.
(c) Lightning is "tladi".
(d) Lightning is a natural phenomenon.
(e) Lightning comes from the sea.
(f) Lightning is caused by witches.
(g) Lightning is caused by the collision between clouds and mountains.
(h) Lightning occurs when it rains only.
(i) It is not necessary to protect yourself from a natural lightning, because a natural lightning cannot strike or kill a person.
(j) "Tladi' is more dangerous than a natural lightning.

(k) During a lightning storm you must not
    I. touch white objects like porridge and books.
    II. wear red clothes.
(l) To protect your house from lightning you must
    I. ask your priest to pray for your house or give you things like water, pictures, etc. to put into your house.
    II. consult a traditional doctor who will give you traditional medicine and things like "patla ya motse".
    III. use a lightning conductor.
    IV. put a motorcar tyre at the top of your roof.

Activity 3: <u>Lightning and Indigenous Knowledge</u> (learners work in groups). **15 Minutes**

*Some cultural groups have their own explanations for natural phenomena such as lightning. When this understanding and knowledge becomes part of a group's thinking and cultural practice, it is called **indigenous knowledge.***

3.1 Look at the picture that shows how the Lemba people in Africa explained lightning. Discuss this with a partner.



3.2 Read the following article. In groups, discuss and evaluate the different views on lightning. Separate the scientific and indigenous explanations on a table. Analyse the information and present your conclusion to the class.

There have been many attempts to explain lightning, resulting in a great collection of 'lightning explanations'. Xhosa people believed that the lightning bird, *impundulu,* laid an egg that brought bad luck. The people of the lower Congo call it the 'lightning dog', *Nzazi.* They say Nzazi barks as it comes down to earth, and again as it returns to the sky. There are stories which tell of Zulu **isinyanga,* trying to attract this 'heaven bird' by placing a bowl of **amasi,* mixed with medicines, where they want it to strike. Lightning also played a part in the beliefs of the Ancient Greeks. The *mythical god Zeus was believed to be the ruler of the heavens, and his powerful presence was marked by lightning, thunder and rain.

But, 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 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 in the way of protection. We cannot predict where lightning will strike, and the thin layer of insulation given by tyres on a roof offers no protection. However, it is safe to be in a car during a storm, 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. The same applies to metal houses, or those with metal roofs and metal drainpipes connected to the ground. 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.

***isinyanga:** traditional healers
***amasi:** sour milk
***mythical:** imaginary
***insulation:** something which prevents the flow of electric charge
***discharge:** the flow of electric charge out of a charged object
***indigenous:** belonging naturally

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Appendix F: Results from the Pre- and Post- Assessment

Question 1: What is lightning and what do you think causes it?

L1 : Flow of charges\ electrical discharge, caused by positive and negative charges that attract each other. (*Heat from sky, caused by friction of clouds and water).*
L2 : Electric discharge, caused by induction in clouds until charges are separated (*Light during rainy seasons, caused by disturbance of clouds when they meet)* .
L3 : Is a discharge or big spark, caused by ice particles or more voltage. *(Big fire from clouds formed when two clouds make interference).*
L4 : Large spark, caused by friction of ice particles during thunderclouds. *(Dangerous light from sky, caused by interference of rain clouds).*
L5 : Electric discharge, caused by charges and induction *(Light from sky, caused by sea water).*
L6 : Electric discharge, caused by induction of static electricity *(Something caused when two clouds interfer).*
L7 : Is charges, formed by two clouds.*(Is fire, caused by two clouds that are different).*
L8 : Electric discharge, caused by collision of clouds. *(Is the fire, caused by clouds when bitten).*
L9 : Big spark, caused by the conduction of electrons *(Big bright of a zick-zack light in the sky, caused by conduction of clouds).*
L10: Large spark, caused by positive and negative charges clouds *(Connection of electrons and protons, caused attraction of clouds).*
L11: Big spark, caused by forces of attraction between clouds and ground. *(Something like fire, caused by two clouds when they attract).*

Question 2: What is electricity, and what do you think causes it?

L1 : Term used to define current, caused by flow of charge, positive charge and negative charge.*(Is charges, caused by coals and water).*
L2 : Flow of charge, caused by induction that causes static electricity.*(Light and fire that people use to do many things and it moves in conductors, caused by many chemicals like coal, paraffin, etc.).*
L3 : Flow of electric charge, caused by induction of kinetic energy. *(Transfer of energy, caused by fire or coal).*
L4 : Flow of charge has positive and negative charges, made of current. *(Energy for many activities like light, cooking, etc.).*
L5 : Flow of current, caused by two charges which are connected. *(Power that come from Eskom, caused by burning coal in Eskom).*
L6 : Flow of charges, caused by induction of electricity. *(Is a charge of electric current, people use water to form it).*
L7 : Flow of charge, caused by negative and positive charges.*(Is gas which conduct together to form charge in the wire).*
L8 : General word which can be used by people to different scientific concepts, caused by electric charges. *(Is fire in the wires, caused when conductors are positive).*
L9 : Flow of charges, caused by positive charges and negative charges. *(Flow of current\ charges in wires, caused by conduction of protons and electrons).*
L10: Flow of electric charges, forms when positive charges and negative chares move. *(Flow of electric charges, caused by negative charges and positive charges).*
L11: Negative and positive charges which flow in electric wires, caused by the steam ofwater. *(Something like fire, caused by solar energy).*

Question 3 : Is there any difference between lightning and electricity? Please explain.

L1 : Yes, because they all work the same with charges. *(Yes, both will kill you, destroy you).*

L2 : Both have charges, they shock, and are very dangerous. *(Yes, both are usually fires because they have shocks).*
L3 : Yes, both have electric shock. *(Yes, both are fire).*
L4 : Yes, both have electrical charges, volt, and they can heat anything. *(Yes, lightning is just like electricity).*
L5 : Yes, both have charges, flow of electric charges and are dangerous. *(Yes, both have power).*
L6 : Yes, both are caused by induction of static electricity. *(Yes, they can choke you).*
L7 : Yes, they do the same work, they burn. *(No, they are different things).*
L8 : No, both have charges, but lightning is a natural phenomena and electricity is the general word. *(Yes, both have fire).*
L9 : Yes, both have volts, and they choke. *(Yes, both have electric charges).*
L10: Yes, both have charges and do the same work. *(Yes, both have positive and negative charges).*
L11: Yes, both have charges and burn. *(Yes, both are fire and they choke).*

Question 4 : There are different methods that different people believe they can protect their houses from lightning, for example:

A. *putting motorcar tyre at the top of the roof.*
B. *using traditional medicines and things like " patla ya motse".*
C. *Using prayer and other things like Holy Water and pictures from their churches.*
D. *Using lightning conductors.*
Which method would you advice your community members to use? Please explain.

L1 : Lightning conductors, because is the only thing that can attract with negative charges from the clouds. *(Motorcar tyre, because is simple method of all).*
L2 : Lightning conductors is the most safe one, because when lightning comes with negative charges it will attract positive charges on the top of lightning conductor and after attraction charges will flow deep into the earth. *(Lightning conductor, because it can decrease the speed of lightning).*
L3 : Lightning conductors, is the best thing, lightning will be attracted by lightning conductor. *(Traditional doctor).*
L4 : Lightning conductors, because current will move through conductor to the ground not your house. *(Traditional medicines, because many people in our village believe in traditional healing).*
L5 : Lightning conductors, because lightning conductor has charges and is very high. *(Traditional medicines, because the person that make lightning uses traditional medicines).*
L6 : Lightning conductor, because negative charges of lightning push negative charges of conductor down deep, your house will be safe. *("traditional medicines and things like patla ya motse", because many people use traditional medicines to form lightning).*
L7 : Lightning conductor, because it is taller than the house.*(Lightning conductor, because lightning is dangerous).*
L8 : Lightning conductor, because they have charges at top and down, and is taller than the house. *(Traditional medicines and " patla ya motse", because is used by all people who believe to ZCC).*
L9 : Lightning conductors, because at the point of conductor there are positive charges which are usually attracted by negative charges of lightning.*(Lightning conductors, because it takes lightning to the ground).*
L10: Lightning conductor, because is taller than house, lightning strikes taller objects before smaller ones. *(Lightning conductor, because is a good resource of lightning).*
L11: Lightning conductors, because is *longer* than houses and has positive charges. (*Traditional medicines, because people cause lightning to strike houses or people).*

Question 5 : Do you think " tladi" should be discussed in science lessons about electricity? Please explain why or why not.

L1 : Yes, because lot of people don't know a lot about lightning and what's going on during lightning. *(Yes, because we are not sure what exactly is lightning. I need to know what causes it and how people use it to destroy houses, people and animals).*
L2 : It can be discussed but for me I don't see a purpose, because it does not occur any time like lightning which can occur even when it is not rainy.*(Yes, because there is relationship between lightning and electricity).*
L3 : Yes, because some people come with ideas and we have an argument about lightning. *(Yes, because the member of science must know how to mix chemicals to make "tladi").*

L4 : Yes, because lightning is a form of electricity, we can also know what kind of electricity is lightning. *(Yes, because lightning is a form of electricity, and we need to know what causes lightning).*
L5 : No, because people say "tladi" is controlled by a person, and I know you can't control charges, and I don't believe that a person can strike someone. *(Yes, because "tladi" is something that has power, so we want to know about lightning).*
L6 : Yes, because we need to know the difference between lightning and electricity. *(No, because many people can know how to kill other people by using lightning and traditional medicine, because there are many killer in our village).*
L7 : No, because "tladi" is not a natural phenomenon it is caused by witches. *(Yes because is something that we can learn about).*
L8 : No, because "tladi" and electricity are differed.*(No, because there is difference between "tladi" and electricity).*
L9 : No, because we don't know what "tladi" is and how is caused\produced. *(No, because is something which is caused by a person especially blacks, and this is very dangerous than electricity, ("tladi" is used by witches only).*
L10: No, because in science lessons I will discuss lightning and I know what lightning is, and "tladi" is caused by people. *(Yes, because learners don't know difference between "tladi" and lightning; they think lightning is "tladi" and "tladi" is caused by people, lightning is natural resource).*
L11: No, because "tladi" and lightning is one thing. *(No, because the people who cause it know what they use, I believe they use traditional medicines, that's why my community members use that to protect lightning).*

Appendix G: Samples of Interviews with Learners (L2, L4, L5)

with L2

T : L2, on this programme evaluation form you rated yourself under level4 (pointing at statement no.13) ; i.e. now you can relate the energy between unlike charges to the energy between the cloud and the ground. What can you tell me about this energy?

L2: The energy between the thundercloud and the ground is like the energy between discharging sphere and the dome. Eh, that energy is electrical energy, is the energy between negative charge and positive charge, and we can get force of attraction or repulsion on that energy.

T : Ok, here (pointing at statement no.16) you have rated yourself under level 5, in other words you are confident that talking about cultural beliefs about lightning in the science classroom helped you to understand the scientific view of lightning.

L2: Yes.

T : Which cultural beliefs?

L2: Cultural beliefs?

T : Yes.

L2: I still remember that some of the lessons were talking about the Lemba people and that "picture". I think that is their cultural belief, that's how they explain lightning, but I don't agree, because on, on, eh, on the sky there is no animal there.

T : Are you sure?

L2: Yes, I'm sure.

T : Which scientific view do you understand?

L2: Scientific view?

T : Yes, of lightning.

L2: I now understand that lightning is an electric discharge.

T : What is an electric discharge?

L2: Electric discharge is where charges are able to move, if they are very many on one place they must move.

T : Can you give an example!

L2: Like if there are too many negative charges on the cloud they must move to the ground.

T : Ok, but you didn't tell me anything about your own cultural view of lightning.

L2: Eh, in my culture there is another form of lightning called "tladi", they say it is caused by people, and before the lessons that's what I thought.

T : What do you think now?

L2: I still agree, but now I know more about lightning, about natural lightning.

T : So you don't agree when the Lemba people say lightning looks like that animal, but you believe that "tladi" is caused by people?

L2: Yes.

T : Ok, thank you very much.

with L4

T : L4, in the lesson evaluation form for lesson 3 you wrote that you have learned more about induction. Now, what is induction?

L4: Yes. Eh, induction is when the, the, when the charges are selected.

T : Selected?

L4: When we can take, eh, a balloon which is positive and put it on a neutral object, you'll get induction, the positive charges will be pushed downwards, and you'll get negative charges on top of that object, is induction, is selection of charge, eish, separation of charge.

T : Ok, on the programme evaluation form here (pointing at statement no.15) you rated yourself under level 5. So do you think some of the ideas you had about lightning are not correct?

L4: Yes.

T : Can you give examples please?

L4: Eh, in my community they told me that there is a bird that can make lightning. So, in these lessons there is no lesson that talks about that bird.

T : Do you think they are wrong when told you so?

L4: Yes, I think they are wrong, there is no bird that can cause lightning to strike a, a tree. I don't think so.

T : What about "tladi", did you believe that there is "tladi"?

L4: Yes, but now I don't think so, because you taught us about lightning.

T : Ok, in this lesson evaluation (lesson 4) you say you have responsibility about lightning. What kind of responsibility?
L4: Eh, is, is the responsibility to tell my community about lightning; to tell them how to protect themselves against lightning.
T : How should they protect themselves?
L4: I'll tell them to put lightning conductor on their houses, not motorcar tyres, because is only method that can, is the best method that they can do to protect their houses.
T : Now, tell me, if your community members can tell you that, here is a person , he has just struck another person's house, we found him washing in the river. What will you say?
L4: Well, they usually find them.
T : Is that true?
L4: Yes.
T : So, what will you say to them?
L4: Actually there is no "tladi", is just what people believe.
T : But you have just told me that some people are usually found after striking!
L4: Yes, eish, I don't know.
T : So, you'll run away from your responsibility! Ok, thank you very much.

with L5
T : L5, how are you?
L5: I'm fine mam.
T : On this programme evaluation form for lesson 4 you rated yourself under level 5 (pointing at statement no.4). You say you had the opportunity to evaluate the cultural view of lightning.
L5: Yes, like before the lessons, I thought "legadima" is "tladi", but now I think I know that "legadima" is not "tladi". "Tladi" is cultural, is a cultural name of lightning, is a cultural name.
T : Can you tell your people that, hei people, there is no "tladi"!
L5: Yes, I was just told them yesterday that there is nothing like "tladi", no.
T : What did they say?
L5: They did not agree, they tell me that when I was small I knew there is "tladi". I told them that in the past there was no education. Now I learned about lightning, and I know what to do when there is lightning.
T : Do you think they are wrong if they say there is "tladi"?
L5: Yes, to me they are very wrong.
T : Oh, is this why you rated yourself under level 1 here (pointing at statement no.3)? You don't respect these people's view about lightning?
L5: Yes, they are wrong, I know how lightning is formed.
T : Ok, thank you very much.