THE EFFECT OF A CROSS-CULTURAL INSTRUCTIONAL APPROACH ON LEARNERS' CONCEPTIONS OF LIGHTNING AND ATTITUDES TOWARDS SCIENCE

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Education in the School of Science and Mathematics Education, University of the Western Cape

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Contiguity

Concept proliferation

Conceptual change

Conception

Collaborative learning

Multiculturalism

ABSTRACT

This study looks at the effect of a cross-cultural instructional approach on the learners' conceptions of lightning and attitude towards science. It explored Basotho conceptions of lightning and thunder under the following themes: nature of lightning, protection against lightning, animalistic/humanistic behaviour of lighting and nature of wounds inflicted by lightning. Fictitious stories were developed around these themes. It was important to develop stories around these themes because stories stimulate curiosity of learners particularly if they are situated within their everyday experiences. Using an instrument named My Ideas about Lightning and Thunder (MILT), the learners' conceptions about lightning and thunder were collected. The MILT was structured in such a manner that it allowed learners to read a story and then to express agreement or disagreement with one or more statements which reflect their views on the story. Furthermore, ample space was provided for the learners to write and express their own views and explanations of the incidence described in the story.

The study provides an overview of science education in Lesotho. In particular, it gives an outline of developments, apparent changes and dilemma experienced prior and after independence. It was against the background of curricular innovation and concomitant changes (Bishop, 1986) in Lesotho that the study was carried out.

Theoretical frameworks within multiculturalism were explored and were found to be appropriate to guide the study. These included contiguity theory, border-crossing, concept construction, collateral learning, collaborative learning, collateral learning and others. These frameworks were applied in the analysis of the data.

The learners were introduced to the scientific interpretation of lightning as presented in the Lesotho Junior Science curriculum using a cross-cultural instructional approach based on Jegede's (1995) cross-cultural pedagogical paradigm. The approach entails using a combination of knowledge about lightning prevailing in the learners' socio-cultural environment with school science. In other words, the science curriculum was situated in the context of learners' everyday experience through a cross-cultural instructional

approach that was sensitive to their socio-cultural environment. Specifically, the approach involves discussions, practical work, reading and lectures by the researcher and a traditional doctor.

To determine the effects of the treatment on the learners' conceptions and attitudes, a quasi-Solomon-3-Group design was adopted, where two of the three groups were exposed to the cross-cultural instructional approach. The learners' responses were qualitatively and quantitatively analysed in terms of a cognitive framework designed for the purpose. Based on the framework, it was found that:

1. Before being exposed to the cross-cultural instructional material, learners had both scientific and traditional conceptions of lightning and thunder. They believed among others in humanistic nature of lightning. Scientific conceptions held by the learners were those found at the interface between indigenous knowledge system (IKS) and scientific understanding about lightning and thunder.

2. Some learners' conceptions about lightning and thunder oscillated between the scientific and traditional worldviews depending on the theme and context governing their viewpoint. In one theme, some learners responded in traditional worldview terms while others responded using scientific worldview terms. The degree of the oscillation (the extent to which a response was scientific or traditional) depended on how learners found the interpretation to be intelligible, plausible and fruitful (Posner, et al, 1982). That was the case in all the three groups.

3. After the intervention, some learners from both the experimental and control groups accepted both the scientific and tradition explanations about how lightning occurs, i.e. an instance of simultaneous collateral learning (Jegede, 1995). In other words, the learners mobilized both scientific and traditional worldviews to explain the same phenomenon or demonstrated cognitive shifts in terms of Ogunniyi's (2007a) contiguity dominant, suppressed, emergent and equipollent categories.

4. The experimental and control group 2 (groups that received the cross-cultural instructional approach) were found to be more elaborate in their explanations of a scientific phenomenon than the group that was not exposed to the cross-cultural instructional approach.

5. All the groups were found to be positively inclined towards the scientific worldview. The learners attributed their perceptual shift and positive disposition towards science in terms of the empirical nature of science, while at the same time they argued that cultural practices were based on their cultural beliefs.

6. All the stakeholders (i.e. traditional doctors, learners, teachers, expert of Sesotho language, and chairperson of the National Science Panel) support the integration of the scientific and the traditional worldviews about lightning and thunder. However, they differ in the rationale and mode of integration. Some learners do not support the inclusion of witchcraft. They perceive it to be devious; the traditional doctor would like witchcraft and metaphysics to be included (to him inclusion of witchcraft would allow learners to know which diseases are associated with witchcraft); the Sesotho expert and teachers would like to see a holistic approach (excluding witchcraft) adopted during the integration; the chairperson of the panel argues for the inclusion of only those aspects of culture that could be explained using the scientific worldview. The study recommends that:

7. A systemic approach to integration should be adopted. All the stakeholders should deliberate on the rationale and mode of integration.

8. The implications of the integration on teacher training institutions' programmes as well as on teachers already in the field should be studied carefully.

DECLARATION

I declare that THE EFFECT OF A CROSS-CULTURAL INSTRUCTIONAL APPROACH ON THE LEARNERS' CONCEPTIONS OF LIGHTNING AND ATTITUDE TOWARDS SCIENCE, is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Neo Paul Lipotho August 2008

Signed: ______________________________

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List of Acronyms and Abbreviations used in the study

CG	=	Cloud Ground lightning
CIEMST	=	Centre for In-service Education for Science and Mathematics Teachers
Expt E	=	Experimental Group E
GRASSMATE	=	Graduate Studies in Science, Mathematics and Technology Education
IKS	=	Indigenous Knowledge System
LHDA	=	Lesotho Highlands Development Authority
LISP	=	Lesotho Integrated Science Project
MILT	=	My Ideas about Lightning and Thunder
MOE	=	Ministry of Education
NCC	=	National Curriculum Council
NCDC	=	National Curriculum Development Centre
NUL	=	National University of Lesotho
PAT	=	Physics Ability Test
ROSE	=	Relevance of Science Education
Sc	=	Science
SCASQ	=	Science and Culture Attitude Scale Questionnaire
SFSP	=	School Focused Support Project
SWV	=	Scientific Worldview
Trad	=	Traditional

Treat C2	=	Treatment Group C2
TWV	=	Traditional Worldview
Uncl	=	Unclear
VDG	=	Van de Graaf Generator
WSE	=	Worksheet for Static Electric

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KEYWORDS II

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CHAPTER 1: INTRODUCTION

1.1 Motivation for the study

Many African countries, including Lesotho have called for the integration of the Indigenous Knowledge Systems (IKS) with mainstream school science programme. In Lesotho, a new curriculum has been developed that propagates a form of science that allows learners to be able to identify and interpret relationship between science and Basotho ways of knowing. Literature abounds with claims made by researchers that traditional worldview and scientific worldview are incompatible and irreconcilable. Convergence of these two worldviews therefore, poses a big challenge for teachers who have been taught and trained to accept scientific worldview as the only rational form of knowledge. As in other countries, teachers in Lesotho have not been trained into how to go about integrating school science with IKS in their classrooms. The central concern of this study is to determine Basotho learners' ideas of lightning and thunder and the relative effect of an instructional approach in ameliorating conflicts which might arise in the minds of learners when exposed to school science. But, before delving into the study, it is appropriate to provide an overview of the Lesotho education system and the effect the integration is likely to have on it.

1.2 Lesotho Education System

Education in Lesotho is a joint venture between the Lesotho Government, Churches and community. The Government is in charge of curriculum, which is centrally controlled. The Lesotho Ministry of Education, through its various programmes and commissions, manages education system in the country. The programmes include:

- The National Curriculum Development Centre (NCDC), which is responsible among others, for design and development of curricula that address the needs of the Basotho nation. It has the responsibility to centralize, develop, pilot and distribute instructional materials to both primary and junior secondary schools. Prior to the establishment of the Centre, it was observed that curriculum development in Lesotho was done in a haphazard and an ill-informed manner. In other words, it was an activity carried out without any well-guided and coordinated policy framework. To realize its mandate, the NCDC has established within itself, subject panels whose role is to develop curricula in different subject areas, organize in-service training for teachers and develop necessary supportive materials (Nketekete, 2005: p.14). According to Nketekete (2005), constituents of the panel include NCDC subject specialist, six teachers, a representative from related ministries/institutions/associations etc. and one representative from the relevant Ministry of Education department. When the curricula have gone through the development processes, they are sent to the National Curriculum Committee (NCC), whose functions are to ensure that: the government policy on curriculum is adhered to; there is coherence in and uniformity in the development of curriculum in accordance with the national policy; appropriate and relevant materials are developed and financial implications of curriculum policy decisions are affordable and realistic in terms of parents' ability to pay (Nketekete, 2005). This new policy to integrate school science with indigenous knowledge systems implies that the constituents of the science panel may have to be revisited and other stakeholders especially those with expert IKS knowledge might have to be considered.

- The Teaching Service Commission is responsible for the appointment, promotion and demotion, transfer and discipline of teachers whose salaries are paid by government.

- The Central Inspectorate keeps the government informed about the health of education in the country by undertaking systematic inspections. During the inspections, inspectors are expected to monitor and evaluate work of heads of schools and to provide assistance to them. The subject inspectors are required to assess viability of departments and scrutinize teachers' instructional practices. The inspectorate is entrusted with authority of providing support for professional development of teachers. It achieves this task by organizing and running in-service education for subject teachers, heads of departments and headmasters/mistresses.

  It is incumbent upon the inspectorate to ensure that teachers who are already in the field are prepared and undergo in-service to guarantee that integration takes place without any hurdles and bottle-necks experienced by science teachers.

- The Faculty of Education of the National University of Lesotho (NUL) trains graduate teachers for Lesotho secondary schools. It prepares and up-grades teacher educators, education officers and personnel for other sectors of the education system through specialized programs in education. It promotes innovative instructional processes and provides in-service education for the implementation of such processes. Since the proposed integration of indigenous knowledge systems with science is an innovative idea, it needs to be researched upon. For the same reason, the NUL will need to revisit its programmes.

- The Examinations Council of Lesotho (ECOL) is responsible for examinations at both primary and secondary education levels. Moreover, it runs orientation workshops periodically for teachers. Thus the ECOL plays a central role in assessment – particularly at the end of each level. If Lesotho finally implements, integration, indigenous knowledge too will need to be assessed. The question is to determine possible effect of the integration on the current and future assessment procedures.

- The community participates minimally in the running of secondary schools through schools' boards. The board is expected to ensure the efficient running of schools and to recommend to government the appointment, discipline, transfer or removal of a teacher. The board's participation is minimal in the sense that it is called upon when there is a major issue that a principal cannot handle. Normally, people who live within the locality of the school constitute the board. Hence, the integration of science with IKS proposed in the new curriculum implies that the local community will have to play a critical role than was the case with the old curriculum.

During the colonial period and even after independence in 1966, Churches, which own about 90% of the Lesotho schools, played a significant role in the promotion of literacy as well as promoting Christian values and moral standards. However, some of these moral values are largely based on Western values, which are at odds with the Basotho ways of life. Because missionary education came before colonial education, Western education introduced by the missionaries has tended to replace the Sesotho indigenous education which places emphasis on moral and cultural values, personal and family responsibilities, duties to one's clan and people, and awareness of one's origin (Muzvidziwa and Seotsanyana, 2002) with Western values. Before Western education was introduced, the Sesotho education was the responsibility of elders, local leaders and traditional doctors (Muzvidziwa, and Seotsanyana, 2002). In the context of current focus on African Renaissance, Africans are urged to re-discover their history and cultural achievements (Gueye, 1999). Presently, in Lesotho schools hold cultural days where learners and the community celebrate all forms of traditional arts including music and dances taught in traditional circumcision schools. As a result of this cultural revival, initiation schools have become more and more popular. For example, at the end of the 2005 academic year, more than 20 boys from one school enrolled in a circumcision school after sitting for the Junior Certificate examinations. The point being made here is that the call for integration of indigenous knowledge with school science is in-line with the ethos of African Renaissance.

In the pursuit of authenticating the Basotho culture, the Department of Education embarked on the formulation of a new curriculum policy. In line with this policy, the National Curriculum Development Centre (NCDC) embarked on developing an integrated science-IKS curriculum together with instructional materials and guidelines for implementation purposes (NCDC, 1986). The thrust of the new science curriculum is localization in contradistinction to the old curriculum which stressed mainly the acquisition of bits and pieces of scientific information.

1.3 Localization of the curriculum

Before and even after independence, education in Lesotho has always been influenced by the British system of education. Cambridge Overseas School Certificate (COSC) examinations dominate what took place at junior and senior secondary school levels of education. The syllabuses used in the schools were developed in Cambridge. In this regard, the junior secondary curriculum essentially prepares learners for the COSC. The Junior Certificate curriculum was constructed in such a manner that it conformed to the COSC in terms of objectives, content and the recommended teaching methods. However, in recent years, both educators and the general public have been questioning this state of affairs bearing in mind that Lesotho gained its independence in 1966. The question being asked from different segments of society is “why has it taken the education authority so long to develop a new curriculum that addresses the challenges and postulates of independence?” There is no simple answer to this question except that it is not a state of affairs that can remain a permanent feature of the Lesotho education system. To answer this question fully would require a more analytical, critical and reflective approach beyond the scope of this thesis. The NCDC’s attempt to localize the secondary school curriculum involves such activities as clarification of the educational goals; derivation of curriculum aims and specific objectives; determination of content, teaching/learning strategies; assessment strategies and development of instructional materials. So far, the localization of the curriculum has not gone beyond the Junior Certificate level for the simple reason that the Government of Lesotho is yet to pronounce a clear policy on the localization process. It is hoped that the outcomes of this study will contribute toward the formulation of that policy.

It is proper at this juncture to briefly state what I believe is a localized science curriculum for Lesotho. The main purpose of such a curriculum should be to address the needs of the Basotho. In the previous years, just after independence, the Ministry of Education used to hold public gatherings (*lipitso*) in various key villages where the public would voice their views about their needs. However noble the practice was, translation of these needs into curriculum goals and objectives had always been problematic. Second, values, attitudes and ways of knowing of the Basotho should be taken into consideration during curriculum development process. Basotho are a nation that has highly valued belief systems and customs that define them as a people. Curriculum development process should not ignore this. Examples in instructional materials should be drawn from the experiential life of the Basotho. Third, Lesotho is part of the international world. As such we cannot ignore the role played by western science in the economic development of countries both in Africa and elsewhere.

1.4 Levels of Secondary Education in Lesotho

1.4.1 Junior Secondary

The entrance point for the junior secondary education is grade 8, followed by grade 9, and the last one is grade 10 – meaning that junior certificate is a three-year program. At the end of grade 10, candidates sit the Junior Certificate Examinations (JCE), which is a joint venture by both Lesotho and Swaziland. Because space at the senior secondary level is limited, learners with first and second class passes have a better chance of admission into the senior secondary school level compared to those with third class passes.

1.4.2 Senior Secondary

This is the last stage of secondary education. Examinations at this level – commonly known as Ordinary Level (O' level) are under the control of Cambridge Overseas School Certificate (COSC). As mentioned earlier, the science curricula offered at this level come from

Cambridge. According to Nketekete (2005), Lesotho is the only BOLESWA country (Botswana, Lesotho and Swaziland) which still imports curricula from Cambridge.

1.5 Science Education

Science is taught at all levels of the education system mentioned above. At the primary level, it is taught as integrated science (combination of physics, chemistry and biology) and it includes issues related to the environment and as such is very much contextual. All the learners are expected to take science. The opening paragraph of the 1997 primary science curricular document, which has been developed in the context of needs as perceived by the Basotho, states that science is about helping children to develop important useful skills and attitudes, thinking in clear and logical ways, and solving practical problems. The statement states further that these processes, skills and attitudes are acquired through the medium of inquiry approach whereby learners are exposed to situations that stimulate their curiosity and interest to identify problems in their own environment and attempt to solve them.

At the junior secondary level, all learners are expected to take science, which is taught in its traditional disciplines of Biology, Chemistry and Physics. Since 1966, there has been a series of interventions aimed at improving quality of science and making it responsive to the needs and aspirations of the Basotho. For an example, the 1966 Education report shows that the Ministry of Education took the following measures toward improvement of science education:

1. Some junior secondary schools were supplied with science apparatus to enable them to cover practical work for the Junior Certificate Introductory Science and Biology.
2. Plans were made to provide and equip some high schools with laboratories.
3. Courses were organized for science teachers.

Source: (Ministry of Education, Annual Report, 1966).

The following issues arose from the courses organized for science teachers:

1. Teachers favoured integrated science to Introductory Science and Biology.
2. Syllabuses should be related to the local conditions.

3. Teachers were apprehensive about the annual supply and replacement of science apparatus.
4. There was a shortage of equipment and apparatus which hampered science teaching.
5. There was a need for the identification of local plants and animals.
6. Practical work was a mere verification of classical experiments; problem-solving activities were lacking.
7. Copying of notes from the board was a common practice.
8. Conservation and the scientific utilization of natural resources rated low in the teachers' statement of aims of teaching science.
9. Learners' inadequate knowledge of mathematics hampered their understanding of science. (Ministry of Education, Annual Report, 1967).

In 1972, a Junior Certificate Science Curriculum was developed with the aim of addressing issues raised by the science teachers. However, the newly developed science syllabus, LISP (Lesotho Integrated Science Project) was an adaptation of Scottish Integrated Science. It was found to be 'relevant' in the sense that it advocated among others constructivist thinking rather than accumulation of factual information or performance of standardized routines which was indicative of the Introductory Science. More importantly, LISP materials were highly practical consisting of 15 practical activities which were to be covered over a period of three years. However, there was no text-book to go with the materials.

In 1986, another science curriculum was developed. Unlike its predecessor, the sciences were separate and continuous assessment formed a critical component of the external examinations. The continuous assessment was piloted in 25 schools but was never implemented nationwide. In fact, it died during the piloting phase! It was observed that some teachers submitted fictitious marks for the continuous assessment.

The new Junior Certificate science curriculum, developed under the localization process, suggests that in handling the syllabus, learner-centred approaches should be used. Mention is made of the following:

- Practical work through experimentation
- Inquiry through investigations

- Projects involving analysis, synthesis and designing of articles/items.

The curriculum further acknowledges and stresses that learners come to school with some knowledge of science, which should not be ignored. According to Driver and Oldham (1986), Driver (1988), learners do bring their own explanations of natural phenomena into classrooms. These explanations depend on, amongst other things, cultural background of the learners as well as their personal experiences and commonsensical knowledge. The need to pay close attention to learners' traditional worldviews and commonsensical notions about diverse natural phenomena has been pointed out by various scholars (e.g. Aikenhead, 2000; Driver and Oldham, 1986; Jegede, 1995; Ogunniyi, 1987, 1988). Accordingly, in the context of the new curriculum in Lesotho, a number of questions that have emerged for analysis include:

1. If learners' ways of knowing are entrenched within the Basotho way of knowing, then what knowledge of science do these learners hold?
2. How scientifically valid is the knowledge about the natural phenomena held by these learners?
3. How do learners' cultural beliefs affect their performance in school science?

A critical look at the new version of grade 9 and grade 10 syllabuses shows that amongst the suggested equipment, one finds the incorporation of traditional items like home-brew strainer *(motlhotlo)*, levers *(moqala)* and Basotho clay pot *(lefisoana)*. These items are called by their respective Sesotho names. Moreover, some of the general learning outcomes take cognisance of the Basotho culture. Learning outcome 14 states that learners should develop awareness and appreciation of the role of science in everyday life, including Basotho forms of knowledge and culture (Ministry of Education and Manpower, 2002). Specifically, learners should be able to identify and apply scientific knowledge and skills outside classrooms. They should be able to identify and interpret the relationship between science and Basotho systems of knowledge. It is hoped that learners will relate the science they learn through this curriculum to everyday phenomena in their immediate environment and beyond. This learning outcome makes a gigantic assumption that science teachers themselves are in a position to identify and interpret the relationship between science and the Basotho systems of knowledge.

With a focus on static electricity, a brief comparison of the new (appendix 1) and the old (appendix 2) syllabus reveals the following:

- The new syllabus has outcomes such as hazardous nature and importance of lightning, safety measures against lightning, discussion and analysis of local practices, myths and beliefs regarding lightning.
- The new syllabus takes cognisance of the fact that there are local practices about lightning, which are entrenched within Basotho ways of life. It goes further to suggest that these practices have to be analysed. The old syllabus has not taken these issues into consideration. It assumes that science is to be taught in a vacuum.
- The new syllabus calls for discussion of among others, myths and beliefs about lightning.

The Ministry of Education has introduced a textbook rental system whereby parents pay a minimum fee for renting a textbook. To ensure that the books are of quality, the Ministry has requested various book publishers and individuals to openly tender and provide quality books that cover the appropriate syllabus and are user friendly. Clearly, the approved Junior Science book is expected to reflect the integration of science and Basotho indigenous knowledge.

At the senior level, science is not compulsory. According to Ntoi (2000), those learners that opt for science can register for the following science options:

- Pure Sciences (Physics, Chemistry, Biology)
- Human and Social Biology
- Science (Physics & Chemistry, Physics & Biology, Chemistry & Biology)
- Combined Science (Combined Science, and Additional Combined Science)

All these options and their corresponding syllabuses make no mention of the Basotho forms of knowing. This is understandable because they have been developed with no consideration of the Basotho in mind. But if the Ministry of Education is serious about including IKS in the science curriculum, this situation cannot be allowed to prevail for too long, otherwise the proposed integration will bring no meaningful change.

1.4 Statement of the Problem

The integration of traditional beliefs and scientific worldviews within school science teaching by inviting traditional doctors to talk about their practice and the analysis of IKS related practices would be considered inappropriate pedagogical strategies to discourses in Lesotho science classrooms. However, the new curriculum demands alternative instructional approaches beyond the competences of present day Lesotho science teachers. The new science curriculum recognizes and values a diversity of worldviews prevalent within the Basotho cosmology which it believes would enrich learners' understanding of various natural and socio-cultural phenomena. In other words, the curriculum envisages a holistic rather than a reductionist approach to the study of school science. Whether or not this stance is tenable is of course a matter of debate.

The concept of taking into consideration the African values and beliefs is not novel to the new school science curriculum. For some time now, the Catholic Church has been advocating for enculturation (Amecea, 1996). In other words, the Catholic Church has come to realize that there are values within African cultures which might enrich values explicitly taught by the church. It accepts that Africans have a great sense of the spiritual realm. They cherish elderly parents, relatives and other members of the family. It is on this basis that the church has called for the enculturation of African values into the church and life in general. The situation in the realm of school science raises similar questions. The ground-work for incorporating Basotho values and forms of knowing within school science has already been set. Ogunniyi (1988) contends that Africans should be allowed to invest in their traditional cultures while at the same time they are encouraged to absorb modern influences. However, the absorption of modern values and influences as well as staying African can create conflicts when the same concept is interpreted differently by both cultures. The same potential conflict is inevitable in the light of the new curriculum which encourages the integration of science with IKS. It is this potential conflict and possible resolution that forms the central thrust of this study.

1.5 Purpose of the study

The aim of the study was to determine learners' conceptions of lightning and thunder. Further, the study attempted to explore the effectiveness or otherwise, of an exemplary cross-cultural instructional approach on Lesotho secondary school learners' conceptions of Lightning and Thunder. Exemplary cross-cultural instructional approach as used in this study is a teaching method which integrates school science with certain knowledge prevalent in the socio-cultural environment of the learners. Specifically, it combines scientific and traditional cosmological worldviews about certain natural phenomena in a holistic rather than a reductionist manner. Further, the cross-cultural instructional approach draws inspiration from the works of Aikenhead and Jegede (1999) on cognitive border-crossing. According to Aikenhead and Jegede (1999) learners negotiate and resolve cognitive conflicts caused by the coming together of school science and traditional cosmologies through a process they call cognitive border-crossing. Details of this approach will be provided in the next chapter. Another way to describe a cross-cultural instructional approach adopted for this study is to situate school science within the context and socio-cultural experiences of learners. Other features of this instructional approach include intensive discussion, argumentation, group-work and occasional participation of IKS experts and much reflection. Although emphasis is placed on discussion and argumentation in groups of four or five students, the views presented are usually based on consensus reached in each group.

1.6 Research Questions

The study attempted to seek answers to the following questions:

1. What are grade 9 learners' initial conceptions of lightning and thunder and the effect of a cross-cultural instructional approach on these conceptions?

   (a) Sub-question: What are the learners' initial conceptions of lightning and thunder?

   (b) Sub-question: What is the effect of the cross-cultural instructional approach on these conceptions?

   (c) Sub-question: How do the learners deal with the presence of conflicting traditional and scientific conceptions within lightning and thunder

2. How has the use of an exemplary cross-cultural instructional approach influenced grade 9 learners' and attitudes towards science?

   (a) Sub-question: How do the learners deal with the presence of conflicting traditional and scientific conceptions within lightning and thunder?

Answers to these questions were sought by gathering both Qualitative and quantitative data details of which can be found in chapter 4.

1.7 Significance of the study

The study was undertaken at the opportune time when Lesotho was attempting to localize the science curriculum at both primary and secondary levels. In the last 40 years since independence, Lesotho has become conscious of the erosion of Basotho values and belief systems. In response to this awareness, curriculum developers realized the need to develop curricula that are relevant to the cultural ethos of the Basotho. It was hoped that the study would therefore contribute, among others, to identifying challenges and opportunities as well as provide empirical evidence of the feasibility or otherwise of a science-indigenous knowledge curriculum.

1.8 Limitations of the study

The ideal of an integrated science-IKS would be to cover many science disciplines including physics, biology, chemistry, agriculture and technology. It should include various topical issues within these disciplines including, amongst others, traditional medicinal plants, indigenous knowledge pertaining to agriculture, how Basotho interpret natural phenomena and disasters and so on. However, this study is limited to lightning as it is taught in the junior secondary level physics in Lesotho and as lightning is understood in the Basotho traditional corpus. It has been observed that often, the indigenous knowledge is localised and contextualized. Given this nature of the indigenous knowledge, the study focused on lightning as understood and explained by the learners of the study school and the traditional doctor who came to talk to the learners as well as the traditional doctors of the Maseru district who participated in the Bristol Myers Project. Moreover, since it is a case study, it is limited to a group of grade 9 learners in one school in the Maseru district. However, it is believed that the study will elucidate some significant issues that need to be considered during integration. More importantly, it will act as a springboard for further studies aimed at understanding the process of integrating school science with the Basotho systems of knowledge.

1.9 Delimitations of the study

The rationale for choosing lightning is guided by an understanding that static electricity is a foundation for electricity in general. Important themes such as charge, flow of charges, accumulation of charge, induction, potential difference, voltage are first introduced during the teaching of static electricity. From the scientific worldview, static electricity is one of the physics concepts that relate electricity and one of the most fearsome natural phenomenon, lightning. Due to its high elevation and rock type, lightning strikes are common in Lesotho. As a result, a lot of beliefs, myths and practices are attributed to this natural phenomenon. It is interesting therefore to integrate at this level where the two non-compatible worldviews seem to impact on the everyday life of the people.

The study has examined scientific and Basotho traditional conceptions (notions, explanations, and judgements) of lightning and thunder among selected secondary school learners aged between 14 and 18 years. The custom-designed instructional material to explore possibilities of incorporating aspects of Basotho conceptions into teaching and learning of lightning and thunder was unique to settings of the schools and learners involved in the study. The findings that have arisen out of this exploration may not apply across the secondary schools in Lesotho, or other countries with similar beliefs.

With the advent of Lesotho Highlands Development Authority (LHDA), electricity is becoming more and more readily available in Lesotho. Furthermore, it is a challenge to develop an integration approach that would come up with a curriculum where the two worldviews are mutually supportive and complementary.

The assumption underlying the study is that integrating two distinctly different worldviews would result in cognitive dissonance in the minds of the learners and that it is at this juncture that a well developed instructional intervention could help ameliorate such a conflict. In the same vein, it is hoped that the intervention would facilitate the process of border crossing between the notion of lightning that learners bring into school and what they learn in school science. Some scholars have argued that traditional worldviews are hindrances to the effective learning of science. They claim that learners, instead of accepting the scientific conceptions, hold on to their naive pre-school and traditional ideas. The contention is that the study would enhance (through dialogues) learners' understanding of the two systems of thought as well as help them develop critical thinking – an important aim for teaching science.

1.10 Operational definition of terms

- **Integration** is interpreted as the act of presenting two or more knowledge systems together. In this study, integration amounts to co-presentation of school science and Indigenous Knowledge Systems (IKS). For the purpose of this study, the focus is the integration of Static Electricity as taught in Secondary Schools in Lesotho and Lightning and Thunder as understood in the Basotho traditional corpus.

- **Cultural belief and traditional belief** are used interchangeably in this study.

- **Science** implies the natural science as understood from the positivistic point of view, which argues that claims should be made largely on the basis of empirical testability.

- **Cross-cultural instructional approach** means a teaching method which integrates school science with certain knowledge prevalent in the socio-cultural environment of the learners. It combines the scientific and the traditional cosmological worldviews about certain natural phenomena in a holistic manner.

- **Traditional doctor:** This type of doctor relies on herbs and other traditional methods to cure and heal his/her patients. People have confidence and belief that she/he has supernatural powers to control, amongst others, lightning. A witch doctor is another type traditional doctor, who relies on traditional methods to kill and destroy other people’s property. A witch is not acceptable in the Sesotho culture and hence a witch doctor has a negative connotation.

1.11 Overview of the chapters

The subsequent sections highlight the contents and issues raised in the rest of the chapters of the thesis.

1.11.1 Chapter 2: Literature Review

This chapter focuses on the literature review pertaining to the academic discourse in the field of multicultural science education and the nature of science. In particular, the review deals with how learners confront conflicting conceptions of the same phenomenon explained from the contextual and experiential worldview as against school science. Epistemological issues pertaining to the way learners hang on to two knowledge systems and how they handle the resultant conflict are raised, compared and discussed. Epistemological gaps that form entry point for the study are then identified.

1.11.2 Chapter 3: Research Methodology

The focus of this chapter is the research methods used in the development and piloting of the instruments and the collection, interpretation and analysis of the data. The chapter explores the effectiveness of qualitative methods and elaborates on how they were applied in the study to collect, interpret and analyse the results. Also, as part of the triangulation process, some data were subjected to statistical analysis.

1.11.3 Chapter 4: Description of the lessons

The theme of this chapter is the descriptive presentation of the lessons focussing on what actually transpired in the class and the administration of the research tools employed in the study. In qualitative research, there is need to present the learners’ responses verbatim and their behaviours as they participate in the meaning-making endeavours of science learning. The chapter further presents verbatim views of people that were thought to have a contribution to make to the study. The chapter concludes by bringing together the views of these people and comparing them with available literature on integrating traditional conceptions of a phenomenon and its counterpart in the realm of school science.

1.11.4 Chapter 5: Interpretation of the results

The chapter presents a systematic and an in-depth interpretation of the results from the learners, their observations as they work towards making-meaning of their practically based activities, the results of comparing their prior ideas before and after being exposed to the cross-cultural pedagogical approach. This chapter articulates the categories that emerged from the results using the reviewed literature as basis for characterizing such categories.

1.11.5 Chapter 6: Discussion

This chapter discusses the findings in the light of the two research questions and the literature reviewed. It further anchors the findings in line with current issues within a multicultural paradigm as issues are pertinent to integrating, co-presenting the way a Mosotho learner comes to terms with the scientific conceptions of natural phenomena e.g. lightning and thunder.

1.11.6 Chapter 7: Conclusions, Recommendations and Implications

The chapter focuses on the general conclusions and the implications of the findings to various stakeholders such as teachers, curriculum planners, policymakers, researchers and others.

CHAPTER 2: REVIEW OF RELEVANT LITERATURE

2.1 Introduction

The central focus of this chapter is to anchor the study within the on-going discourse on how learners make meaning of their worlds. Literature abounds with views about how learning takes place, and factors that mediate meaningful learning. Ways and determining factors that have been documented in the extant literature serve as guide posts for the study. The chapter starts by exploring some theoretical considerations of issues that deal with phenomenon of border-crossing. Of special consideration in this regard is a general exploration of the literature that has attempted to explicate the subject of cognitive border-crossing to the field of science education, particularly in non-western societies.

2.2 Theoretical considerations

Jegede (1995) enumerates critical strategies for integrating Indigenous Knowledge Systems (IKS) with school science. The strategies include relying on the learners' environment for information and relating the content of their IKS with that of school science. In this study, learners were introduced to scientific interpretation of lightning as presented in their curriculum using cross-cultural methods as proposed by Jegede (1995). Information about lightning was drawn from the living environment of the learners. The teaching strategies employed involved use of elders while those of science were in a form of experimentations and explanations of observations.

Research into how to integrate Indigenous Knowledge Systems (IKS) with school science is at the cutting edge of studies undertaken in Africa, Australia and Canada (Ogunniyi, 2004; Nichol et. al, 2000; Odora-Hoppers, 2002). The increased interest shown by researchers in these countries is prompted by the desire to protect, promote and develop their IKS (Odora-Hoppers, 2002) and to find a holistic approach in addressing societal priorities, needs and problems. Before embarking on the mammoth and complex endeavour of integrating science and IKS, there is a need to have a better understanding of the Nature of Science (NOS) and the Nature of IKS (NOIKS). In the case at hand, there is need to understand lightning from both the IKS and the scientific perspectives. The instructional material used in the study was grounded in the multicultural classroom context as espoused in the works of Aikenhead (1996, 2000, 2002); Cagete (1999); Fakudze (2003); Hodson (1993); Jegede (1995); Ogunniyi (1988); Snively and Corsiglia (2001).

The theoretical framework for this study draws inspiration from a genre of theoretical constructs about learning science. They include integration, collaborative learning, conceptual change, concept proliferation, multiculturalism, contiguity principle and border-crossing (e.g. Aikenhead, 2002; Jegede; 1995; Odora-Hoppers, 2002; Ogunniyi, 2005; Posner et. al. 1982; Sawyer, 2004; Stephens, 2003). Within a multiculturalism paradigm, learners' cultures and science culture are respected and learners collaboratively work together to discuss, share ideas and articulate their explanations using information derived from their culture and/or science. The sharing of ideas helps learners to either change their conceptions of phenomena or add onto what they already have. During collaborative learning, teacher becomes a culture broker (Aikenhead, 2000) and helps learners to navigate between their culture and the culture of the scientific worldview. The nucleus of the study is the integration of Indigenous Knowledge Systems (IKS) with the Scientific Worldview (SWV). In this regard, an instructional material that has both SWV and IKS worldview was developed and tested. Moreover, the study explored how learners deal with two apparently incompatible worldviews. The topic in the syllabus that has been identified for this study is Static Electricity. In particular, the study focused on the development of concepts leading to the scientific and IKS understanding of the topic of lightning and thunder and how these phenomena are experienced in everyday life of the learners. In the sections that follow, a more detailed exploration of issues of cognitive border crossing undertaken by learners as they move from home to school and vice versa is presented.

2.3 Concept construction and cognitive dissonance

Osborne and Freyberg (1985) admit that from a young age, and prior to formal teaching, children develop meanings of their world around them. According to them, learners learn through their senses as they interact with environment and construct ideas or concepts of what they experience. The meanings they construct are tested for their usefulness and then stored in memory units. The new construct about an already existing concept is compared against the already stored meaning and is accepted or rejected on the basis of its applicability. This form of learning is based on conceptual change theory which suggests that in order to learn new concepts related to a given topic, learners must first become dissatisfied with pre-existing ideas (Posner et. al, 1982; Kang et. al., 2004; Chan et. al, 1997). Further still, this form of learning is an elaboration of the conjectural nature of knowledge as understood within constructivist corpus. According to this view, knowledge is a human construction and humans are constantly undergoing new experiences and as a consequence, reconstruct knowledge. The implication of the conjectural nature of knowledge is that the interpretations that people formulate about one phenomenon or the other are forever uncertain and always changing. Fullan (1991) asserts that change may come about as a result of imposition or because people voluntarily participate and initiate it because of dissatisfaction, inconsistency, or intolerability. Conceptual change is pre-empted by cognitive conflict (Boujaoude, 1992; Cavallo, 1996; Chandran et. al., 1987) which, according to Berlyne (1970) is a condition in which mutually interfering processes occur simultaneously and in which selection of a motor response from a set of competing alternatives is therefore hampered. Literature abounds that supports the notion that cognitive conflict and dissonance mediates learning (e.g. Strike and Posner, 1992; Driver et al., 1985; Lemon, 2001; Tsai, 2000). In this study the focus was on the effect of deliberately creating cognitive conflict where there exist two different cognitive structures related to the same phenomenon (Hewson, 1988) namely, lightning. One cognitive structure of lightning derives from traditional beliefs while the other develops from school science.

There is a high tendency for children to cling to their existing ideas (Osborne and Freyberg, 1985). This view has been expressed by a lot of researchers in the field of conceptual change (Clement et. al., 1989; Driver et. al., 1985; Roschelle, 1995). It takes time for learners to accept alternative views in spite of learning experiences. The learning experiences they refer to include school science. Their findings reveal that without some appreciation of learner's existing framework of ideas, and the extent of modification needed for the learner to appreciate what is being taught, successful teaching becomes extremely difficult (Osborne and Freyberg, 1985). However, the conceptions that are under review in this study are not necessarily children's ideas as suggested by Driver and associates (Driver, et. al., 1985). Rather they are conceptions that are deeply embedded within Basotho forms of knowledge and as such are being held by many Basotho. Traditions within Basotho culture act as cognitive support and defence mechanisms (Strike and Posner, 1982) and this makes it easy for learners to hang on to their preconceptions. However, it has been noted that presenting learners with conflicting experiences does not necessarily induce cognitive dissonance (Burbules & Linn, 1988; Chinn & Brewer, 1993; Gorsky and Finegold, 1994; Shepardson & Moje, 1999; Tirosh et al., 1998). Klaczynski, (1997) claim that learners who are at an adolescent stage change their rules of evidence evaluation on a moment-by-moment basis to suit their existing beliefs These conceptions are fundamentally different from children's ideas in that children soon outgrow their childish ideas. In this study, learners were deliberately offered an opportunity of being taught two conceptions of lightning from the scientific perspective and the IKS perspective. The idea was to explore how the learners dealt with two conflicting conceptions.

Within constructivism, learning process is dependent on mental constructions of the phenomenon to be learnt that already exists in a learner's mental "schemes" of such a phenomenon (Driver et al 1985). Moreover, learning results from the transformation and interaction of cognitive networks that exist in the minds of the learners.

Cobern (1994) and the proponents of cultural perspectives (e.g. Aikenhead, 1996, 2000; Aikenhead and Jegede, 1999) have criticised concept construction described above. Aikenhead (2000) contends that conceptual change of learning perspective amounts to assimilation, which means that learners are forced to replace or marginalize their common sense notions with scientific ones. I vividly recall my experiences as a primary school learner. We were ridiculed for first thinking in our mother tongue and translating our thoughts into the English language. The consequence of this derision was to make us undermine our own mother tongue (Odora-Hoppers, 2002). Based on my personal experience, I find Aikenhead's proposition very persuasive. Within conceptual change paradigm, there is an embedded assumption that scientific conceptions are superior to other forms of knowing (Cobern, 1994). Cobern goes further to claim that conceptual change makes little sense when learners are expected to change their worldviews to a scientific one which in their opinion has little scope and force to their real and fundamental world. In his opinion, worldview is about metaphysical antecedent to specific views that a person holds about natural phenomena, whether or not one calls those views commonsense, theories, alternative frameworks, misconceptions, or valid science is another matter entirely. He contends further that a worldview is the total sum of whatever number of cultural components a person embraces. This study aligns itself with a perception of learning, which considers learning as an enculturation process that engages students with people around them and where they are going (Aikenhead, 2000). Learners in this study are Basotho children and the expectation is that they should remain so even after they have been exposed to school science. In other words, the aim of school science is to provide learners with an alternative worldview to theirs not to alienate them from their socio-cultural environment but remain part of it.

Aikenhead (2000) proposes what he calls "pluralistic multi-science approach". He propounds that learners should be enculturated into their own life-worlds where their cultural identity forms and evolves. This view of enculturation is different from the one advanced by Contreras and Lee (1990), which presupposes that the premise for enculturation is harmonization between the learner's culture and science instruction. Aikenhead claims that in the life of a learner, there are several knowledge systems that operate in relation to several contexts in their real life. The contexts include student's own cultural identity, community's indigenous or common-sense culture, the domain of citizenship and the culture of western science. In his opinion, science teaching is aimed at, among others, "making students to embrace abstract scientific concepts as valid representations of the natural world, and replace common sense concepts they have constructed or learned from others" (p.249). Within a framework of multi-science, Aikenhead proposes concept proliferation, whereby the new scientific concept that a learner learns, is added onto his/her conceptual profile. While one may agree with Aikenhead about concept proliferation, one also sees a situation whereby learners will compare various conceptions of the same phenomenon on the basis of their usefulness to their everyday life, the result of which may be a replacement of others not-so-useful. Today's Africa is a heavy consumer of Western technology which in most cases is apparently more appealing than the African one, and as such assimilation is like a flood in which an African child is being ripped of his identity. Jegede (1997) puts it succinctly when he says that an African child is enmeshed in a web of foreign economy. An African child sees Western ideology as a better way of life and such a perception is likely to amount to cultural assimilation rather than concept proliferation as explicated by Aikenhead.

Another equally viable concept that could mediate the development of this study is habitus conditioning espoused by Bourdieu (1977). In his view, habitus is a system of dispositions that an individual has acquired through cultural conditioning. The habitus conditions how one thinks and perceives the world. Thus the learners may appeal to their habitus conditioning in explaining lightning and thunder. It is worthwhile to point out that despite its attractiveness as a concept; the mechanistic connotation of conditioning in the behaviourist sense is not unproblematic. A particular problem in this regard is whether learning involves only induced conditions. What about insight, reflection, intention, purpose or goal and other factors that influence learning which are intrinsically motivated? But worthy as these issues are space limitation would not permit further elaboration.

2.4 Multiculturalism

The study adopted notions of multiculturalism proposed by Snively and Corsiglia (2001) and Hodson (1993) as a paradigm. To them multiculturalism refers to systems of thought or worldviews that have developed over time in a conglomerate of cultures. In an instructional context such systems of thought should be taken into consideration and not be ignored. The word culture as used in this study implies norms, values, beliefs, expectations and conventional actions of a group (Aikenhead, 1996 and Giddens, 2001). According to Giddens (2001) culture could also refer to those aspects of society which are learned and shared by members of society. Giddens contends further to state that culture comprises beliefs, ideas, values, objects, symbols or technology. This perception of culture seems to lie in the domain of symbolic anthropology whereby culture is seen to be public and located in the shared meaning (Foley, 1997) by members of a given community. The study agrees with proponents of cognitive anthropology as described by Foley. In Foley's opinion, advocates of cognitive anthropology conceive culture as learned. It is not the purpose of this study to draw similarities/differences between symbolic and cognitive anthropology. Suffice it to state that both fields of anthropology seem to agree when it comes to defining the concept of culture. Proponents of multiculturalism perceive science as a sub-culture and learning science as cultural assimilation whereby one has to learn scientific language, ideas, laws, facts and principles, symbols and ways scientists perceive the world. Their argument is that if science is respected, so should knowledge systems of other cultures. They contend further to suggest that contribution of other cultures to knowledge should be considered and that such knowledge should be included in school science. This study explored how such inclusion or integration as recommended in the new curriculum in Lesotho could be achieved. Some people who aspire for integration strongly subscribe to the multicultural paradigm and argue that Basotho forms of knowledge too can contribute to no lesser extent in the learning of science for Basotho children if, in particular, one takes into consideration those practices that could be explained using science.

Literature is replete with studies that have explored the nature and effect of the interactions between school science and traditional belief systems. On the African continent, and in addition to conceptual papers, researchers such as Jegede and Okebukola (1991a), Jegede and Okebukola (1991b), Ogunniyi (1986, 1987, 1988, 1996) and Kuiper (1991) have presented their findings on the issue of culture and school science. An attempt that has been made in this regard was to bring the two in a form of an integrated science curriculum. However, certain caveats are worthy of consideration.

As Aikenhead (1996) has suggested, attempts at integration should avoid the tendency to make local knowledge to conform to Western epistemology, which is endemic in school culture. In his view, lack of awareness of this fact could result in disrespecting Basotho culture. Aikenhead makes this remark after developing and administering a unit that gave Aboriginal students access to Western science and technology without requiring them to adopt the worldview endemic to Western science, and without requiring them to change their cultural worldview. The unit developed by Aikenhead helped students to feel at ease in both cultures and to move back and forth between school science and their culture (Aikenhead, 1996: p.10).

In his paper, “The Effect of Science and Technology on Traditional Beliefs and Culture”, Ogunniyi (1998), poses series of questions one of them being how people especially learners in a traditional culture resolve possible conflicts brought about by school Science and Technology. He argues against the notion that Science and Technology (S&T) should be attained at the expense of traditional beliefs and values. He cites the co-existence of traditional beliefs and technological advancement of the Japanese as support to his position. He goes further to suggest that efforts should be made to find answers to the fundamental questions raised, so as to justify the prominence of S&T in the school curriculum and to prevent a sense of despair that might arise from our failure to attain mass S&T literacy. It would be interesting to find out what would happen if learners in this study compare the scientific safety precautions with traditional ones. Would the learners adopt the scientific mode of protection against lightning and at the same time hang on to the traditional mode of protection which invariably relies on traditional doctors?

As mentioned earlier, learners and teachers are required to discuss, analyse and conceptualise Basotho conceptions and practices of lightning and compare these with the scientific worldview. The bringing together of the two perspectives may amount to conceptual change or concept proliferation. Aikenhead's (2000) proposal of concept proliferation leans towards Mill's (1968) and Feyerabend's (1975) notion that people are different and their opinions should be allowed to flourish. Feyerabend would further like to see astrologers and witches having equal share in society's resources, and have current scientific theories being allowed to run together with other incompatible ones. Aikenhead's concept of proliferation, even though it seems to learn towards Mill's and Feyerabend's viewpoint, it is quite different. According to Aikenhead, "concept model suggests that a new (scientific) concept is constructed within a new (scientific) context and added to a student's repertoire of specific context, or to a student's conceptual profile" (p.249). In fact, Aikenhead distances his view from Feyerabend's "anything goes" notion of proliferation. Drawing on Ogawa's (1995) viewpoint, Aikenhead explains that a multi-science view adds contexts to a student's repertoire of life-world contexts, with each context having an identifiably different view of the natural phenomena (i.e. concept proliferation).

In this study, learners were given both conceptions of lightning (i.e. scientific and traditional) with no intention to demean or prefer one over the other. Rather, it was to allow the learners evaluate each against its applicability in their everyday life. In a way this might be construed as proliferation. However, the goal was to avoid conceptual imposition. The scientific conception was presented as an alternative to what the learners already know about lightning. It goes beyond Jegede's Collateral Learning (Jegede, 1997) whereby traditional and scientific conceptions of a phenomenon are put side by side with minimal interference or interaction (Jegede, p.67) and that the learner is afforded the opportunity to reflect before deciding whether or not to appropriate another view different from what she/her holds. However, the idea of minimal interference is debatable and thus serves as the point of departure for this study.

2.5 Border-crossing

As stated earlier, this study is situated within the cultural-border crossing paradigm as espoused in the work of Aikenhead, Costa and Phelan (e.g. see Aikenhead, 1996; Costa, 1995; Phelan, 1991). Within the framework of this study, border crossing is seen as a back and forth movement between traditional (IKS) conception and scientific worldview, where in one context, a learner resorts to traditional mode of interpretation while in another context she/he resorts to scientific worldview (Aikenhead, 1996). Aikenhead, Costa and Phelan claim that border-crossing can be smooth (cultures of family, school, friends and science are congruent), manageable (cultures of family and friend are congruent, but inconsistent with the culture of science), hazardous (cultures of family and friends are inconsistent with the cultures of school and science) or impossible (the home and the school cultures are incompatible). The study explored the different types of cognitive border-crossings and what type or form of border crossings were demonstrated by learners.

Studies concerned with determining the nature of cultural or cognitive border-crossings (e.g. Aikenhead & Jegede, 1999; Jegede & Okebukula, 1989; Kuiper, 1991; Ogunniyi, 1987, 1988, 1995) have provided some insight into the difficulty of reconciling the different worldviews. It is therefore incumbent upon a science teacher to mediate border-crossings. Such a teacher is a "culture broker" Aikenhead (2002). Roles of such a teacher include making border-crossings explicit, identifying cultural context in which students' personal ideas originate, introducing another cultural context, making students aware of the culture she/he is operating in at any given moment, providing students an opportunity to talk within their own life-world cultural framework without sanctions for being "unscientific". The study attempted to implement some of these ideas and ascertained their relevance for the Lesotho situation. In particular, learners were given opportunities to talk and discuss their beliefs about lightning within a school classroom scientific worldview setting along the lines suggested in the practical argumentation and discursive course based on the contiguity theory framework (e.g. see Ogunniyi, 2004, 2005, 2006, 2007a & b). This is because while other studies in the area seem to consider border-crossing in a rather static form, the contiguity theory construes it as a dynamic phenomenon. Also, while the former tends to consider a system of thought e.g. IKS being replaced by school science in a science class, the latter talks of one becoming dominant while the other is suppressed until an opportune time when its status changes.

2.6 Contiguity theory

In this study, an attempt was made to test the applicability of Ogunniyi's (1997) Contiguity Theory or lately Contiguity Argumentation Theory (CAT) to the Basotho context. The aim was to see if learners displayed or mobilized any of the five types of CAT (see Ogunniyi, 2004, 2005, 2006, 2007a and b). In his opinion, learning by contiguity is an intellectual process in which, among others, similar or opposing perceptions are dynamically associated or combined to attain a higher form of consciousness. According to Ogunniyi (2005), the way a learner 'crosses' from one cognitive state to another depends on several factors such as the result of a given response, interest and desire (Fakudze, 2004). It is assumed that during instruction or reading scientific material, the two contiguous thought systems (science and IKS) clash and as a result, an intra-dialogue (a dialogue within an individual) ensues as the individual attempts to resolve the conflict. Ogunniyi goes further to suggest that within the framework of contiguity principle, there are at least five discernable cognitive states: the dominant, suppressed, assimilatory, emergent and equipollent. These are briefly described in Table 2.1 below:

Table 2.1: Cognitive states within the contiguity theory

Cognitive states	Description of the states
Dominant	This state occurs when the system of thought is more adaptable to an arousal context.
Suppressed	The system of thought is not warranted; it is less adaptable to an arousal context.
Assimilated	The system of thought is seen as inferior to a dominant one and hence the former capitulates to the latter.
Emergent	Knowledge is lacking or is not well formed and because of the appeal the new knowledge has, a new schema based on the new perception evolves.
Equipollent	Two competing ideas are exacting equal intellectual force in a given context.

Adopted from Ogunniyi (2005) – Contiguity Argumentative Theory (CAT)

Ogunniyi (2005) contends that the five cognitive states above exist in a dynamic flux. Hence, the context in which a given discourse takes place dictates what cognitive states an individual displays. The study attempted to determine whether these states of cognition were exhibited during administration of an instructional material as the learners tried to understand conceptions of lightning from two distinctly different worldviews.

2.7 Studies on students' conceptions of natural phenomena

There has been a growing interest in determining the nature of learners' prior ideas. This follows after several studies carried out by Driver and others (e.g. Driver et al, 1985). Driver and associates' work showed that learners' ideas tend to impact negatively on their attitudes and performance in science. Researchers have conducted studies to determine relationship between traditional cosmologies and learners' performance in and attitudes towards science (e.g. Kesamang & Taiwo, 2002). Kesamang and Taiwo (2002) found that Setwana mythology has some effect on the thought processes of Batswana learners. In their study they had items pertaining to the rainbow, lightning and thunder, the moon, behaviour of some birds and animals. Kesamang and Taiwo cite several studies which showed that traditional African beliefs have a negative impact on the learning of science. The reports include those undertaken by Jegede and Okebukola (1991), Nwana (1987) and Okebukola (1986). All these studies indicate that learners' traditional beliefs about natural phenomena have a negative impact on performance in science. Kesamang and Taiwo (2002) therefore recommended concept replacement, which is a counter argument to what others have suggested (e.g. Jegede, 1997). Thus the debate of integrating science and IKS is far from being concluded.

2.8 Integration of main stream science with indigenous knowledge

The theme of the study is how learners deal with two different and conceptions of the same phenomenon. To adequately deal with this issue, it was necessary to situate the study in a learning environment where two distinctly different systems of thought were deliberately brought together within conducive classroom atmosphere. The study adopts Odora-Hoppers' (2002) interpretation of integration where she argues for going beyond finding an aggregate position or middle ground between the knowledge systems (Odora-Hoppers, 2002), by giving each knowledge system the recognition it deserves. Odora-Hoppers goes further to state that in recent times, there is an outcry in many countries to explore ways of integrating the Indigenous Knowledge Systems (IKS) with the mainstream school science (For example, Curriculum 2005 in South Africa, the Alaska Native Knowledge Network in Alaska; Implementing the Common Curriculum in Aboriginal Schools project in Australia; Cross-Cultural Science and Technology for Northern Saskatchewan Schools in Canada). It is believed by many scholars that indigenous groups have their own knowledges, which can contribute to scientific understandings (Ninnes, 2000). Ninnes examined the extent to which textbooks in Canada and Australia have incorporated aspects of indigenous knowledges. His findings reveal that there is a sizable amount of indigenous knowledge within the books. However, he argued that the incorporation has not effectively overcome problems of racism and cultural imperialism (Ninnes, 2000). Odora-Hoppers (2002) celebrates the urgency of integration and argues that the challenge of creating an integrated and holistic knowledge framework for societal progress and development is not only real, but also urgent. Various educators from different fields are debating the same issue of integration in South Africa. Onwu (2004) argues for mutualism between science and traditional knowledge. He contends that there is need for a mechanism of integrating IKS into science curriculum in a mutually supportive and inclusive way. Odora-Hoppers further corroborates this statement when she states that both the Western system and IKS represent national resources. It is her view that the local contextual expertise and technologies that indigenous knowledge frames offer, can complement some of the mechanical and technical precision capabilities of the Western knowledge systems to generate forms of creativity that benefit and empower everyone. For example, long before the telegraphic code, Africans could transmit messages over long distances using drums. The Dogon people of Mali knew that the moon was a barren world. These people used their own form of astronomy (Sertima, 1999). I understand this to mean that the learning of science should support IKS and IKS too should not be a hindrance to effective learning of science. Is this possible? Onwu (2004) goes further to suggest that there should be a proper conceptualization of IKS as an epistemology. Much as one appreciates Onwu's plea, it is doubtful if IKS can fully represent an epistemology in that it deals with issues beyond epistemology. IKS deals with beliefs and metaphysical issues far beyond the confines of science. However, his suggestion to find out how the two knowledge corpuses can be related accords with the view of scholars in the area (e.g. Aikenhead, 1996; Jegede, 1995; Ogawa, 1995, 1998; Ogunniyi, 1988, 2004, 2005, 2006). However, the appreciation of the relationship between the two systems of thought implies that one should first identify and establish that indeed there is such a relationship.

For a comprehensive understanding of IKS, one has to consult with elders, who are the custodians of this knowledge and its methods. Aikenhead (2001) used this strategy when he developed the project 'Rekindling Tradition: Cross-Cultural Science and Technology unit'.

Several examples of the importance of involving local expertise have been cited (e.g. Ashley, 2000; Maikhuri et. al, 2000; Jones and Hunter, 2003). There should be cooperation and dialogue between these keepers and scientists/science educators with the purpose of cultivating national benefits from both systems and realizing linkages between them. The cooperation should be such that it enhances learning of science and indigenous knowledge systems. Odora-Hoppers puts it well when she advocates for public dialogue between fields that problematise relationship between knowledge, power and human development. In her opinion, the dialogue must be between scientific community, policy makers, individuals and organizations in civil society. The dialogue must be constructive and not be demeaning in any way.

Some researchers have done some work aimed at conceptualising both worldviews and putting them together anticipating to come up with a "culturally responsive curriculum" (Aikenhead, 2002; Stephens, 2003). Ogunniyi (2002) came up with 15 assumptions underlying both points comparing the indigenous knowledge systems and the scientific worldview. The comparisons were based on, amongst others, validity of their propositions on the universe; the basis of their explanatory models; effect of traditional cosmology in preventing success in school science; elements/constituents of these worldview etc. Below is a table that has come as a result of trying to compare the two worldviews. It has been taken from Stephens (2003).

Table 2.2: Significant constituents of scientific and traditional worldview

Traditional Native Knowledge	Common Ground	Western Science
• Holistic. • Includes physical and metaphysical world linked to moral code.	**Common Ground** Organizing principles.	Part to whole. • Limited to evidence and explanation within physical world.
• Emphasis on practical application of skills and knowledge.	• Universe is unified. • Body of knowledge stable but subject to modification.	• Emphasis on understanding how.
• Trust for inherited wisdom. • Respect for all things.	**Habits of Minds** • Honesty, inquisitiveness. • Perseverance. • Open-mindedness.	• Scepticism
• Practical experimentation. • Qualitative oral record. • Local verification. • Communication of metaphor & story connected to life, values, and proper behaviour.	**Skills and Procedures** • Empirical observation in natural settings. • Pattern recognition. • Verification through repletion. • Inference and prediction.	• Tools expand scale of direct and indirect observation & measurement. • Hypothesis falsification. • Global verification • Quantitative written record. • Communication of procedures, evidence and theory.
• Integrated and applied to daily living and traditional subsistence practices.	**Knowledge** • Plant and animal behaviour, cycles, habitat needs, interdependence; • Properties of objects and materials; • Position and motion of objects; • Cycles and changes in earth and sky.	• Discipline-based. • Micro and macro theory (e.g. cell biology & physiology, atomic theory, plate tectonics, etc). • Mathematical models.

Table 2.2 above, which comes from Stephens (2003), shows some of the significant constituents of both worldviews and the interfacing elements. A critical look at the table reveals that there are commonalities as well as differences between the worldviews. The intersection would include those cultural practices and experiences, which can be explained using school science. Jones and Hunter (2003) give what they call “common themes embedded within IK”. These themes include propositions such as IK is based on experience, often tested over centuries, developed collective data-base of observable knowledge, not possible to separate IK from ethics, spirituality, metaphysics, bringing the science of theory with the science of practice. The study applied this model to unpack and interrogate the Basotho perception of lightning and to interpret what some of the theoretical frameworks mentioned above would mean when perceived in the light of the table.

2.8.1 Non-interfacing planes

Many Basotho have an anthropomorphic belief about lightning whereby lightning is considered to have humanistic behaviours such as being angry and being able to avenge. There is an ingredient of respect accorded to lightning and its associate bird, Scopus umbretta. Ogunniyi (2002) observes that traditional worldview is embedded in religion and magic. This “man-made” form of lightning is evoked and can be manipulated by witches. The scientific worldview conceives lightning as a physical phenomenon whose explanation at the micro level requires electron theory.

2.8.2 Interfacing plane

At this plane, both systems of knowledge, the IKS and western scientific worldview grow and are modified depending on the nature of discourse and arguments used and or engaged in. Focusing on lightning, traditional doctors apply both knowledge systems to protect property and people. They also use the concept of lightning conductor together with their concoctions to protect people and property. Further still, both systems associate lightning with empirical observations in natural settings. In the Basotho case these natural settings would comprise among others, water, tall trees, high grounds. Once again Ogunniyi (2000) states that traditional and scientific worldview may not always be in conflict with each other.

Science can be used to explain why tall trees – including a willow tree - are prone to lightning, why someone on horseback has a higher probability of being struck by lightning

2.9 Towards an holistic approach to integration

The study aligns with Stephens' (2003) argument that a culturally responsive curriculum has to do with presenting science with the whole of traditional cultural knowledge in a way that embodies that culture, and with demonstrating that science standards can be met in the process. This is the holistic view of integration whereby learning is not compartmentalized (Nichol and Robinson, 2000) into Western science and IKS. One would also argue against an integration approach whereby traditional knowledge becomes subservient to the scientific worldview. It is critical that IKS must be taken and considered as a veritable body of knowledge in its own right with its methodology and epistemology. The holistic approach of integration (Jones and Hunter, 2003) should take this into consideration and include scientific and IKS methodologies in teaching. Often than not the two worldviews have incompatible methodologies. The study concurs with Mosimege when he said that we should not subject IKS to the same verification process – which is a procedural principle in the Western science – as we usually do with respect to Western science. One would also argue that in as much as we desire a smooth crossing (Aikenhead, 1996) from a traditional knowledge system to science, we should also consider a scientist who also has to cross from his/her worldview to the traditional or non-scientific one. In one of the workshops undertaken in the study, traditional doctors were challenged to explain how their herbs helped to cure HIV/AIDS. They were required to use the HIV progression chart and explain how these herbs destroy (if they really do) the virus after entering into the body of a patient. Naturally, the doctors could not understand the chart let alone apply it in their system of meaning-making. My argument against this approach was that the healers should not be forced to use foreign microscopic ideas to explain the effectiveness of their herbs. Rather, they should be allowed to verify through repetition (Stephens, 2003) that indeed their herbs worked. We have to avoid the common tendency of looking at IKS with the same lens of judgment as we would with Western science. Odora-Hoppers (2002) rightfully condemns this myopic perception of knowledge when she argues that other cosmologies that were incongruent with western ideology were either submerged or destroyed.

The instructional material developed for this study has certain critical features of the holistic approach to the integration. For example, lightning is considered from two perspectives in such a manner that it is anchored in the everyday context of the learners and the interrelationships, similarities and incompatibilities between the two perspectives are clearly defined (Nichol et. al, 2000).

For some people the integration would seem like “going backward”. However, for others plurality (more than one knowledge system) is the stable order for human societies and that natural ecosystems enlightened by ethno-science amounts to returning to the appropriate path after going astray for a while on the mechanistical road (Shiva, 1989). Integration presupposes a lot of change. Fullan (1991) puts it succinctly when he says that change involves loss, anxiety and struggle. He goes further to say that new experiences are always reacted to in the context of the familiar, reliable construction of reality. Most people have considered the scientific worldview as the one and only form of knowledge. In their view, accepting other knowledge systems is going to be a huge struggle.

2.10 Coalescence of the theoretical frameworks

Having discussed various conceptual frameworks that guided this study, I shall now attempt to synthesize them into one picture where a learner, with a conception of lightning from everyday experience, enters a school setting and is exposed to another conception of lightning as understood in the scientific community.

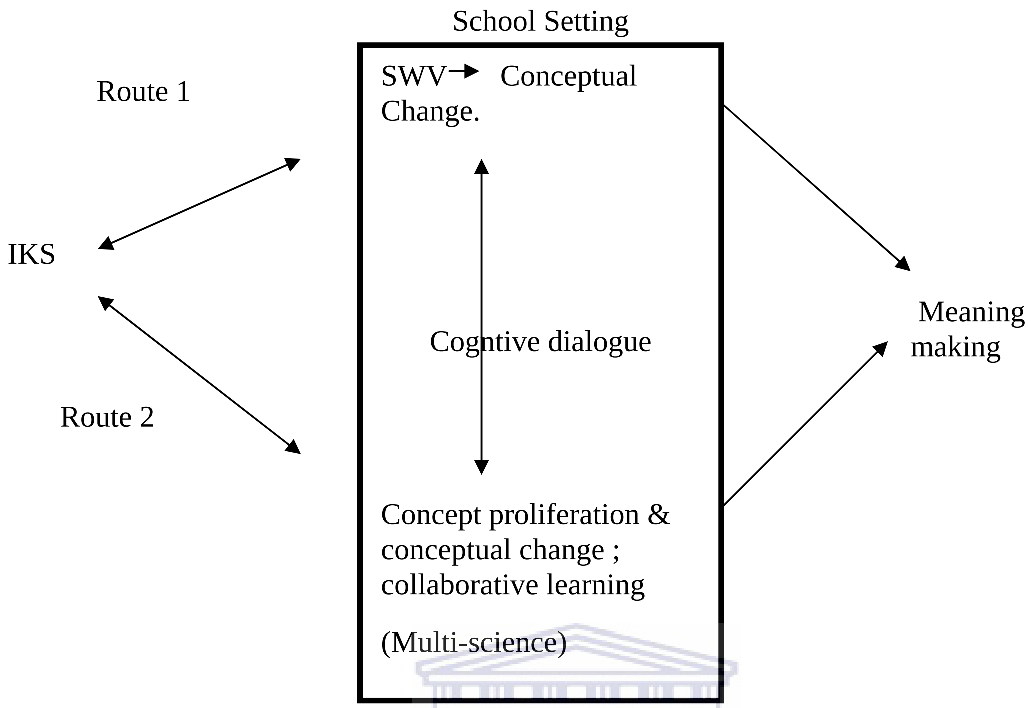


Figure 2.1: Possible routes followed in the teaching/learning of science

In route 1, the Mosotho learner is being taught the scientific perspectives of lightning (SWV) with intention of assimilating the learner into the scientific worldview (Aikenhead, 2002, Ogunniyi, 2005). The learner is left to choose between school science and what has been informally taught through cultural beliefs, customs and practices about lightning (IKS). The two knowledges are compared with the sole purpose of replacing the indigenous knowledge about lightning with school science interpretations. The outcome of route 1 is to make the learner demean her/his traditional knowledge. In route 2, the teacher, using collaborative learning and a cross-cultural pedagogical approach, teaches both conceptions from different perspectives (scientific and traditional) with the aim of guiding the learner to navigate between everyday conceptions of lightning and those presented through school science. At school, all forms of dialogues as espoused by Ogunniyi (2005) and interactions take place. The study focused on route 2 and attempted to find out the effect of these interactions and dialogues on the learners' conceptions of lightning. This figure should not be interpreted as being linear, but as a complex, dynamic, and interactive process. It accepts and acknowledges that what emerges out of collaborative learning (Sawyer, 2004) and cross-cultural pedagogy cannot be predicted in advance.

2.11 Traditional perspective about lightning

In the Basotho traditional thought system, there are two types of lightning: the "man-made" and the natural one (*maru*, pertaining to clouds). The "man-made" type is called *tlalimothoana* (*tlali* for lightning, *mothoana* for small person). It is believed that this type of lightning can be evoked by a witch-doctor (one who relies on witchcraft to kill people) using his/her concoctions. When *tlalimothoana* strikes, the quarry would have gaping wounds as if it has been struck with a sharp instrument. Invariably, when a person is fatally struck by lightning, or lightning destroys someone's property, this is attributed to *tlalimothoana.* Also, lightning is regarded as a weapon of revenge. There is a belief that the natural form of lightning does not fatally strike people. It is perceived to be lightning from God.

When lightning had struck a house or someone in a village, a traditional doctor has to be called to protect the village against evil spirits (in the local language: *o thakhisa motse, oa o upella*) (Ellenberger, 1912; Sekese, 1983). Everyone who was in the village when lightning struck, had to be scarified (*oa phatsoa*) and protected through the use of traditional medicines/ointments. Milk from the village cows is poured at one place and *lehala* (fresh milk that has been mixed with fluids from some herbs) is made out of this milk. The *lehala* is to be eaten by everyone and part of it is used to smear *lithakhisa* (short pegs that have been made from an evergreen plant). The pegs are also sprinkled with a mixture of carbonised herbs, fats and powdered flesh from various animals. The pegs are then driven into the ground at various points round the village. If lightning has fatally struck someone, his/her corpse is to be buried at a marshy place. According to the Basotho genesis of things, the first man on earth came from a marshy place. What could be the implications of this form of burial? Is the dead being brought to where he initially came from? In the Ugandan tradition, only those elders who have powers to evoke lightning can approach and bury the corpse of a lightning victim (Nzita and Niwampa, 1997).

Scopus umbretta (*Mamasianoke*) is a bird that is associated with lightning. This bird is most respected and feared by Basotho. It is not to be killed or ill-treated in anyway. Its' nest should not be destroyed. If one kills it knowingly, it is said that lightning would be angry and would kill that person. One lecturer from my department accidentally hit this "lightning bird" on his way to work. The consequences of killing this bird immediately came to mind. He drove back to see what he could do to the injured bird to "appease" lightning. The bird or its' remains were nowhere to be seen! The lecturer was very worried. This episode highlights the extent to which this bird is feared. According to Mokuku (2004), another bird that is associated with lightning is *motjoli* (Cape wagtail). According to Mokuku there is a spiritual connection between Basotho, animals and plants.

One should not talk about lightning during a thunderstorm. The following incident would highlight the extent to which this belief is held. One of the instruments called My Ideas about Lightning and Thunder (MILT) was given to final year student teachers preparing to teach physics and secondary level. The idea was to allow the students to have their input. It was raining. Suddenly there was huge clap of thunder. At the wink of an eye the students pushed the papers aside claiming that one should not talk about lightning during a thunderstorm! Some of the students had agreed to go with me to administer the questionnaires at one nearby school. As we approached the university gate, they were told that one teacher from one of the nearby schools had been fatally struck by lightning. The students started debating about the wisdom of continuing with the study. The idea of personifying and being able to communicate with phenomena like lightning is not unique to Basotho. In the Ugandan belief system, there are elders who have the power to summon lightning and guide it to punish thieves (Nzita and Niwampa, 1997).

Basotho are not exceptional in associating lightning with a bird of some sort. Various nations on the African continent have the same belief. The Zulus conceive lightning as *Impundulu*, or *Intakesulu*, the bird of heaven (Sluijs, 2001). Studies by Sluijs suggest that even in Europe, this myth exists. He writes that in some parts of France, if one kills a wren, that person would be struck by lightning and lightning would destroy his dwelling. According to the Basotho knowledge system, lightning lays eggs and urinates wherever it strikes. Sluijs reports that this belief too is common among the Bantu peoples.

There are plants that are associated with lightning. One of these is the weeping willow tree (Salix babylonica). People are discouraged from standing under this tree during a thunderstorm. It has been observed that Scopus umbretta lays eggs on this tree. It has also been observed that this tree is often struck by lightning.

Some of the knowledge sketched above is extinct; and most people no longer readily practise them. In particular, the process of protecting the whole village or community has long died. The protection is being practised on an individual basis. The system of protection for the Scopus umbretta and other wildlife is on the verge of being wiped out. Some of these valued practices may not sound so palatable to some communities because their utility is contextual. These values have pervaded the Basotho people for centuries. For example, the practice of honouring and venerating tribal emblems or totems is perceived to be barbaric and savage by some people such as Ellenberger (1912). However, it is a pride of any Mosotho to have a totem.

It is common knowledge that witchcraft is one of the socially repugnant traditional practices, and it is not acceptable in any society, including Basotho. Any person caught or suspected of witchcraft is forcefully removed from the village. A person who evokes lightning to kill or destroy other people's properties is regarded as a witch. Whether there is any romantic anecdotal evidence to suggest that a witch can manipulate lightning (in most cases such tales do exist), learners should be discouraged from perceiving that activity as of any use to human kind.

The concept of lightning and thunder sketched above is at variance with school science. This is just part of the knowledge that learners bring to school, which, as some researchers have argued, should be replaced by school science.

2.12 The teaching of lightning – Lesotho grade 9 science syllabus

Most secondary school books introduce this topic by first looking at static electricity. Learners perform experiments with simple and readily available items like rods, pens, strips, pieces of paper, thin stream of water, gold leaf electroscope, van de Graaf generator (Mpeta et al 2002, Abbott, 1989). The concepts that are pertinent to this topic include atomic structure (protons and electrons), separation of charges (positive and negative), attraction and repulsion between electric charges, insulators and conductors, electrostatic induction, ions in the atmosphere, lightning conductor and lightning. The experiments are such that they appeal to the learners' inquisitiveness and curiosity. The learners are motivated into wanting to know why things happen the way they do. Learners may also be required to come up with their own experiences of a phenomenon of static electricity. This is based on the principle of empiricism whereby only observations and experiments may decide upon the acceptance or rejection of scientific statements and explanations (Popper, 1963). One of the scientific principles used to explain these observations is the electron theory. Thus one has to use abstract conceptions like electrons and protons to understand and explain how a cloud is charged and how it discharges itself.

Both perspectives – the traditional conception of lighting and lightning as taught in secondary schools – are in conflict and as such are likely to cause some cognitive dissonance in the mind of the learner if they are taught together as suggested by the syllabus. Teachers are not equipped with instructional strategies on how to deal with such cognitive dissonance so created. Worse still, they are not informed as to why the two perspectives of lightning should be taught at the same time. Also, there is uncertainty about the purpose of co-presenting both perspectives. Is it to mediate dialogue between the two or to identify borders so as to help learners move from traditional knowledge system and be assimilated into school science? Whatever the purpose, there is need to help teachers.

2.13 Anti-multiculturalism sentiments

I am conscious of the expressed criticisms of the theoretical frameworks within which this study is anchored. The critics include Osborne (1996), Jenkins (2001), Good and Shymansky (2001). Good and Shymansky argue that conserving local practices and protecting individuals' pre-scientific ideas about the physical causality are not priorities for science. My contention however, is that if it is the priority of science to protect human life, irrespective of status, then that protection must consider a holistic person. The individual must be protected together with his/her values and belief systems, which emanate and are deeply rooted within the individual's habitus. In the views of the critics, integration should be such that Western science is compared with other systems of knowledge. It is my contention that integration should benefit learners and help them to be useful members of their own communities. While one acknowledges the basis for the argument made by these critics, one would also argue that though the scientific worldview describes with high predictive validity what would happen but is limited in guiding people how to behave morally (Aikenhead). The view here is that integration could help to achieve a meaningful science and IKS particularly in communities where the latter still holds sway.

2.14 Summary

This chapter focused on conceptual frameworks and theoretical considerations that guided the study. These theoretical considerations are current and previous deliberations and debates about interaction between IKS and the scientific worldview. These frameworks include concept construction which focuses on how learners construct meaning of the world around them and how the socially constructed concept interacts with the ones they meet at school the result of which could be cognitive dissonance. Other frameworks are multiculturalism, border-crossing, learning by contiguity and collateral learning. The argument that is posited here is that an African learner comes to school with some knowledge of lightning and he/she learns scientific conceptions together with traditional conceptions. The two knowledge systems are placed in different domains. Sometimes the two systems may create some conflict and perturbations. The chapter concludes by an attempt to coalesce all the frameworks.

2.15 Conclusion

In conclusion, the perspectives sketched above provide both the theoretical and methodological framework for conducting the study and guiding the process of material development, instrumentation, analysis of data and drawing conclusions on the subsequent chapters.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The purpose of chapter 2 was to situate this study within a paradigm, which integrates IKS with the scientific worldview and the effect such integration on learners' conceptions of lightning and thunder. Various but related perspectives that guided the study were presented and suggestions were made about how these various frameworks could be coalesced together into an overarching framework. This chapter concentrates on the research designs and methodologies that were used to collect data for the study. This was done with the aim of finding answers to the research questions stated in chapter 1.

3.2 Qualitative Research Design

It is the intention of this study to have an in-depth look at how to effectively integrate indigenous knowledge with school science regarding lightning and thunder. Because of the complexity and fluidity of the issues addressed in the study, a qualitative approach was adopted. This was to gain some insight into factors which a quantitative approach might prove ineffective or inappropriate (Asher, 1975; Cohen et. al, 2003; Fraenkel and Wallen, 1996, MacMillan & Schumacher, 1993). In qualitative research, it is important that the researcher collects data in form of words and notes the learning process and the resulting product. The research questions have been stated in such a manner that they are empirical in nature. This implies that they require data to be collected from the real life and classroom experiences of learners (Babbie and Mouton, 2001; Lecompte and Preissle, 1993; Moru, 2006). The qualitative techniques employed included questionnaires, interviews and group observations during practical activities. To interrogate learners' responses to the questions, an interpretive case study was chosen (Najike & Lucas, 2002). In line with interpretive case studies, a detailed description of data (i.e. narrative explanations) was adopted and subjected to interpretation in light of theories that underpinned the study. The case study was in a school whose teacher and learners were willing to participate in the study. The school was close to the university where I teach and hence was easy to reach. Another reason for adopting a case study was because I had no predetermined categories for describing the nature of the discourses that might emerge while teaching such a controversial topic as lightning and thunder. For the same reason the focus was to attain inter-observer reliability. According to MacMillan and Schumacher, (1993), inter-observer reliability is about the agreement on the description or composition of events, especially the meanings of these events, between the researcher and the events.

Initially, the idea was to analyse learners' options and written explanations to MILT questionnaire using the themes of the eight stories, namely control over lightning, animalistic/personification of lightning, protection against lightning and nature of wounds caused by lightning. The idea was to compare the pre-test responses and the post-test ones. However, having read the learners' responses, the categories compared and analysed were changed and those that emerged out of these responses were adopted. Also, the learners' questions during the traditional doctor's presentation were seen to fall within the newly identified categories.

Norris et al, (2005), drawing from literature, regards explanation as a cognitive operation of making something clear, understandable, or intelligible. In their opinion, explanation involves expanding meaning, offering justification, providing a description and giving causal account. Further they accept narrative explanation because it does not necessarily rely on general laws, which is a requirement in the scientific worldview. A narrative explanation has the following characteristics:

> *"…it explains an event by narrating the events leading up to its occurrence; cites unique events as explanatory of other unique events; posits some events as causes of others; seeks unification (but does not supply deductive tightness) by showing how the event to be explained is one of an intelligible series of events; rarely supports predictions, but rather relies upon retrodiction to indicate how the present is a consequence of the past". Norris et al, 2005: p.550)*

In this study, learners' narratives were perceived to be explanations provided they fall within the parameters given by Norris and others.

3.2.1 Collection of data

Data was collected for the following research questions:

1. What are grade 9 learners' initial conceptions of lightning and thunder and the effect of a cross-cultural instructional approach on these conceptions?
   (a) Sub-question: What are the learners' initial conceptions of lightning and thunder?
   (b) Sub-question: What is the effect of the cross-cultural instructional approach on these conceptions?
   (c) Sub-question: How do the learners deal with the presence of conflicting traditional and scientific conceptions within lightning and thunder

To answer these questions, I identified real-life and current issues within the concept of lightning, which would motivate and sustain learners' cognitive engagement and discussion. Themes were identified from fictitious stories developed for the purpose. The stories too had to be within a context and had to have some degree of believability. Using these stories, conceptions about lightning and thunder were collected from a group of 68 learners using the questionnaire entitled My Ideas about Lightning and Thunder (MILT) consisting of eight stories and three statements that learners were required to choose whether they strongly agree (SA), Agree (A), Do not Know (DK), Disagree (D) or Strongly Disagree (SA) with the statement. These were allocated ordinal numbers from 5 to 1 respectively. A space was provided where learners were required to write their own opinions and explanations of the event outlined in the story. Five typical learners in each category were 'followed' and their responses subjected to further interrogation using the categories outline above. MILT was administered to the experimental group and true control group 1 as a pre-test and later as a post-test. The second control group (C_2) received the MILT as post-test in line with the modified Solomon-3 Group design described in the subsequent paragraphs. The pre-test and post-test responses were then analysed using the Contiguity Argumentative Theory (Ogunniyi, 2007a and b) and Collateral Learning (Jegede, 1995).

Qualitative method was used for the narrative section of MILT. What learners wrote during the pre-test was compared to their responses after the administration of the exemplary instruction material. The analysis was based on whether or not the narrative was traditional, scientific, traditional and scientific or unclassified. The review of learners' narratives on the open-ended section of MILT helped me to have a richer insight into the learners' thinking (McMillan, 1992). By so doing, the emergent theory was better grounded on data collected during classroom situation (Cohen, Manon and Morrison, 2003). Thus the use of other questionnaires, interviews and narratives provided more grounds for a fuller description and interpretation of a complete phenomenon (McMillan, 1992) under study. The interview of the ten learners was guided by their responses of the MILT.

2. How has the use of an exemplary cross-cultural instructional approach influenced grade 9 learners'?

(a) Sub-question: How do the learners deal with the presence of conflicting traditional and scientific conceptions within lightning and thunder?

The exemplary instructional material was administered to the experimental group **E** and the control group 2. Physics Ability Test – PAT (Appendix 5) was administered prior to teaching using the instructional material. PAT was very much syllabus oriented. The aim of PAT was to determine the learners' performance in physics (specifically static electricity as taught at Junior Secondary in Lesotho).The theme of PAT was embedded within the scientific corpus of static electricity as presented in the learners' syllabus. Also, PAT was used to find out whether learners were able to recall some observations and explanations they experienced in the previous laboratory activities and the extent to which they could apply their acquired knowledge to similar situations. The same test was administered to all the three groups as a post-test at the end of teaching the unit. To determine the effectiveness of the material in influencing conceptual change, the paired-sample t-test was performed at 95% confidence level.

It was also necessary to determine the effect of the cross-cultural instructional material on the learners' attitude towards science and their culture. A relevant instrument, Science and Culture Attitude Scale Questionnaire (SCASQ) was developed and administered in the same manner as the MILT.

3.2.2 Validation of the research design

In qualitative research, internal validity refers to the degree to which the interpretations and concepts have mutual meanings between the participants and researcher (McMillan and Schumacher, 1993). McMillan and Schumacher have identified four strategies that help improve internal validity of ethnographic studies. These are lengthy data collection, comparison, corroboration, and participants' realities. They argue that:

…lengthy data collection period provides opportunity for continual data analysis, comparison and corroboration to work on the ideas and to ensure the match between research-based categories and participants' realities (McMillan & Schumacher, 1993: p.391)

To attain validity, data were collected over a period of two months at every science lesson (four lessons per week). During this period, a journal was developed which reported my experiences which I designated as good, bad or frustrating. This journal helped in the compilation of the progression of the lessons as described in chapter 5.

McMillan and Schumacher (1993) stress the importance of taking into account participants' language. They argue that "Informants' interviews, phrased closely to the participants' language, are less abstract than many instruments used in other designs". (p.391)

In compliance with this argument, MILT was written in English and Sesotho (Sesotho being the mother tongue of the learners). Moreover, the lesson of the traditional doctor was conducted in Sesotho to ascertain that phrases and terms used bring the true meanings as used and understood in the Sesotho culture and to help learners to interact fully with the phenomenon under discussion. In any case the traditional doctor was more comfortable in Sesotho than in English. Besides, these activities were done in a setting that all participants could identify with. The importance of conducting research in the natural setting of stakeholders is succinctly put by McMillan and Schumacher whey they assert that "participant observation and in-depth interviews are conducted in natural settings that reflect reality of life experience more accurately than do contrived laboratory settings" (p.392).

The study was conducted at a school setting and all participants' observations, interviews and video-taping were done within the school. The traditional doctor too had to come to this setting. However, he claimed that he felt out of place since he was not used to facing learners in a classroom setting. This was a bit of a setback in a sense that he was not fully free as one would have liked.

As mentioned above, the journal together with other curriculum documents such as scheme and record of work and daily preparation book were kept. These documents helped me to ensure that his pace of working synchronized with the school calendar and the scheme drawn by the science department of the school.

3.2.3 Reliability

To ensure reliability in data collection, the following strategies were adopted: member checking and participant review, verbatim accounts, mechanically recorded data, participant researcher (McMillan & Schumacher, 1993; Patton, 2002).

The reliability of the instruments was attained through a series of steps including having them examined by three experienced physics lecturers from the faculty of Science at NUL. These lecturers in particular examined content-related evidence. Content related evidence that they focused on had to do with content and format of the instruments. They also looked at the adequacy of the items in representing the content to be measured. They determined the extent to which items or questions in the instruments are representative of grade nine Physics as outlined in the syllabus.

Three experienced lecturers from the faculty of Humanities at NUL helped determine construct-related evidence of the Science and Culture Attitude Scale Questionnaire (SCASQ) and MILT. As a result of their views, the number of items of the SCASQ was reduced from 48 to 39.

To ensure that my interpretations of data were valid, I have quoted learners' statements verbatim even if such statements had spelling errors. Those statements that were written in Sesotho were also cited as they were presented by learners and then translated afterwards. Furthermore, some lessons were videotaped and subjected to copious reviews.

Literature suggests that whatever is being measured, educational research is never fully free of errors and the extent to which educational measures are free from errors contributes to the reliability of that measure (McMillan, 1992; Fraenkel et. al, 1996). Therefore to further ascertain reliability of the instruments and to minimize errors during piloting, Science and Culture Attitude Scale Questionnaire (SCASQ) was subjected to Conbach for Alpha coefficient. The positive items focusing on attitude towards science were found to hang together as they were above 0.7 (Pallant, 2002). Alpha for the three groups differed (0.71 for the experimental group, 0.72 for the group not pre-tested and 0.85 for the group not exposed to the treatment). The items of MILT were also found to hang together.

3.3 Quasi-Experimental design

As mentioned earlier, a quasi-experimental method was used for the analysis of data collected using the Physics Ability Test (PAT), My Ideas about Lightning (MILT) and Science and Culture Attitude Scale Questionnaire (SCASQ). I used a modified Solomon-3-Group design. Solomon-3-Group design is an experimental design, whereby a planned intervention is introduced into an otherwise normal situation and its effect is systematically studied (Fraenkel and Wallen, 1996, McMillan, 1992). In this study, three comparable groups were identified. The first group, the experimental group (E) and the control group 1 (i.e. C_1) were pre- and post-tested. However, the second group, (i.e. C_2) was post-tested only. It controlled for the pre-test effect. This was done so as to reduce internal threats to the validity of the study as well as to reduce Hawthorne effect (Fraenkel and Wallen, 1996). This is shown in table 3.1 below:

Table 3.1: A modified Solomon-3 Group Design

	Pre-test	**Treatment**	**Post-test**
Experimental Group **E**	Administered	Instructional materials administered	Administered
Control group **C1**	Administered		Administered
Control group 2	Not administered	Instructional materials administered	Administered

3.4 Data-coding procedures

The variables were coded in accordance with the requirements of the Statistical Package for the Social Sciences (SPSS) version 11 (Pallant, 2001). All subjects were identified as cases and each case was allocated a number that was carried over and used for all questionnaires.

Sex was allocated a nominal scale (female = 1 and male = 2). The other variables were given ordinal scale as described below.

All the 39 items on SCASQ were coded in such a manner that it would be easy to identify whether the result was a pre- or post-one. E.g.

Item1 = Pre-test; item 1 of SCASQ. Item2 = Pre-test; item 2 of SCASQ, etc.

Post1 = Post-test; item 1 of SCASQ. Post2 = Post-test item 2 of SCASQ

Prepat = Pre-test; marks of PAT (Physics Ability Test). Post-pat = Post-test marks of PAT

Pres1a = Pre-test; story 1 option (a) of MILT (My Ideas about Lightning). Pres2b = Pre-test; story 2 option (2)

Post3c = Post-test; story 3 option (c) of MILT. Post3a = Post-test; story 3 option (a).

In labelling the items, key phrases were used instead of the whole sentence. For an example item 1 was labelled as "interesting subject".

3.5 Implementation of the Exemplary Instructional Materials

The exemplary instructional material was used as the treatment in the study. Specifically, I taught the experimental and control group (C_2) using the exemplary instructional material. Thus these two groups were exposed to the treatment. Teaching strategies exemplified included, group work, investigations, argumentation, practical work, talk by a traditional doctor, demonstrations and plenary sessions. The topic was **Static Electricity.** The other control group 1 (C_1) was taught the same topic by their teacher using her usual methods.

One of the learning and teaching strategies that informed this study was collaborative learning. Collaborative learning refers to an instructional method in which learners at various performance levels work together in small groups toward a common goal (Gokhale, 1995) to construct their own understanding of a phenomenon (Doise and Mugny, 1984). The active exchange of ideas within small groups not only has potential to increase interest among participants, but also is a prospective candidate for the promotion of critical thinking (Totten et al, 1991; Sawyer, 2004). During collaborative learning, learners challenge one another's explanations of observations and conclusions (Felder et al, 1994). Learners share their strengths, become aware of their weaknesses and develop interpersonal skills to improve their understanding of the content under discussion. Sawyer (2004) argues that "the most effective learning results when the classroom proceeds in an open, improvisational fashion, as children are allowed to experiment, interact, and participate in the collaborative construction of their knowledge" (p.14).

There is persuasive evidence that cooperative teams achieve at higher level of thought and retain information longer than students who work quietly as individuals (Johnson and Johnson, 1986). Felder and others cite several research activities that confirm effectiveness of cooperative learning in higher education. During collaborative learning, learners discuss their various viewpoints, support each other's inquiry processes, negotiate and develop critical thinking skills that include the ability to reflect and improve on their learning (Sawyer, 2004).

In this study, and following from Felder et. al., (1994) Johnson and Johnson (1986) and Sawyer (2004) learners were exposed to the process of thinking through their explanations of how an event occurred (e.g. attraction between a rubbed pen and pieces of paper). The mental activities were sequenced in such a manner that learners performed an activity and observed what happened. Each learner individually explained the observation and articulated it and finally the explanations are discussed and the final group explanation agreed upon. Later in a plenary session, the explanations were further discussed; this time in my presence and finally I came up with the scientific explanations and appropriate terminologies used in the scientific corpus.

My Ideas about Lightning and Thunder (MILT): This instrument consisted of eight stories revolving around the conceptualisation of lightning from the traditional cosmological point of view. The first story focuses on a common practice of reducing the severity of a thunderstorm. When a threatening thunderstorm approaches a village, a traditional doctor of the village would take his/her charmed spear and point it in the direction of the approaching storm in an attempt to reduce the ferocity of the storm or to direct it somewhere else. The second story was on a belief that lightning urinates wherever it strikes. The third story is about the killing of Scopus umbretta. There is a belief that if one kills or ill-treats this bird of lightning, that person would be struck by lightning. The fourth story is about a house that had been struck by lightning several times and needed to be protected against lightning. The focal point of the fifth story is about the belief that lightning can be sent to steal for its owner. Stories six and eight are about a common traditional precaution taken by people during a thunderstorm while story seven is about the nature of the wounds of a person fatally wounded by lightning. To highlight the nature of MILT, story 1 is presented below.

Instruction:

Read the stories below and tick to show whether you Strongly Agree **(SA),** Agree **(A)**, Do not Know **(DK),** Disagree **(D)** or Strongly Disagree **(SD)** with the following statements.

Story 1

During a thunderstorm, Mr. *Ngakamatsetsela*, a well-known traditional doctor, went out of his house holding his metal spear and pointing it in all directions. He was suddenly struck by lightning. People say that:

	SA	**A**	**DK**	**D**	**SD**
(a) He was not a qualified traditional doctor *(ke ngakana ka hetla)*					
(b) He has been bewitched by other stronger doctors					
(c) His spear conducted charges through him.					

What do you say?

The story part of MILT is situated within the contextual framework of the participant's everyday experiences in relation to lightning. The options (a) to (c) are some of the explanations and experiences of the incidence derived from culture and science. The respondent was required to state the extent to which he/she agrees with the options. Moreover, the respondent was asked to provide a fuller conceptualisation of the incidence by writing freely what she/he thinks about the incidence. The intention here was to have a better insight of the thinking process that the respondent engages and also to compare the choices and his/her narrative. The purpose of the instrument was to help me find out learners' conceptions of lightning and thunder and also to determine the effect of the exemplary instructional approach in changing such these conceptions.

Science and Culture Attitude Scale Questionnaire (SCASQ): The instrument consisted of items from the Relevance of Science Education (ROSE) - by Schreiner and Sjoberg (2004) questionnaire while others were developed by me. This instrument consisted of attitudinal statements on science and culture and learners were required to indicate the extent to which they agreed or disagreed with the statement. Typical statements that measured attitude towards science included statements such as: *Science is a very interesting subject. Knowledge in Science is very useful*. Cultural statements included things like: *I need to know more about my Culture. My Culture helps me to live well with other people*. Information gathered through this instrument helped me to determine the attitude of the learners towards their culture and towards school science. I should hasten to add that the number of items was not balanced. There were more items focusing on attitude towards science than there were focusing on culture. It should however be remembered that one of the research questions is concerned with determining the effect of the instructional material on learners' attitude towards science and not on culture. However, I found it worthwhile to have culture as well since it has been argued by some researchers such as Kesamang and Taiwo (2002) that culture has a negative impact on the learning of science.

Physics Ability Test (PAT): This instrument consists of simple questions on static electricity. The questions were based on everyday and laboratory observations and explanations. It was developed and administered as a pre-test and post-test to the experimental group **E** and control group C_1. It was also administered to post-test only group (control group 2). This test helped compare the effect of the exemplary materials as against the method used by the teacher. Unlike MILT, which focused on learners' contextual conceptions (drawn from everyday experiences) about lightning and thunder, PAT focused on scientific worldview aspect of Static Electricity as it appears in the Lesotho Junior Certificate Science Syllabus.

Five science teachers in the school under study were interviewed to find their opinions about integration of local practices about lightning in the Junior Science Syllabus and the extent to which they engage traditional practices about lightning and thunder. Furthermore, the interview sought to find the teachers' views on integration issue. The interview also solicited the science teachers' opinions on implications that integration could have on instructional practice.

Subsequent to the analysis of MILT, 10 of the learners from both the experimental group and control group 1, who responded using both the scientific and traditional conceptions of lightning, were interviewed. The interview sought to determine their opinions about the way they were taught science particularly the co-presentation of lightning and thunder from the scientific and the IKS perspective. More specifically, the intention was to explore how learners dealt with two apparently incompatible worldviews as well determine the nature of the schemas within which they held or traverse the two worldviews.

Initially, my plan was to interview five traditional doctors. However, I was granted an opportunity to attend a workshop where traditional doctors were discussing their roles in the fight against HIV/AIDS pandemic. As a result, I interviewed 25 traditional doctors instead of five originally planned. The purpose of the interview was to solicit the doctors' knowledge of lightning and thunder and how they wished to ensure that indigenous knowledge they held about these phenomena were kept alive throughout generations to come. It was during this workshop that I gained a better insight into how traditional doctors share and transmit their knowledge. Interviewing the traditional doctors helped me to improve quality of MILT in a sense that I was able to get more information about traditional conceptions about lightning and thunder.

Both chairpersons of the national science panels (primary and secondary) were interviewed. The purpose of interviewing them was to determine their opinions about the reality of integrating science and IKS. In particular, by interviewing the chairpersons, I was able to gain additional insight into how the science panel perceives the integration process.

An experienced and retired professor of the Sesotho language was also interviewed with the purpose of finding his views on integration of IKS with school science particularly because within the Sesotho secondary school curriculum, one finds topics that cover Basotho forms of knowledge, traditions and cultures.

3.6 Development of the exemplary cross-cultural pedagogical instruction

This material has been adapted from an unpublished unit that was developed by the CIEMST (Centre for the In-service Education for Mathematics and Science Teachers) staff responsible for physics education at the Department of Science Education of the National University of Lesotho together with a team of science teachers involved in a programme called the School Focused Support Programme (SFSP). This programme aimed at promoting quality science education in a cluster of seven schools within the vicinity of the university. The idea was to develop activity sheets that helped learners to be active dexterously and intellectually in the sense that learners were to perform an activity and explain their observations.

Motivated by educational policy statements alluded to in chapter 1 and extant literature on the impact of culture on the effective learning of science, I revised the material and introduced within it some aspects of cross-cultural pedagogical approaches as described by proponents of multicultural science teaching (e.g. Aikenhead, 2002). Moreover, tasks that help learners to think through their answers and to make sense of their observations before discussing them in a group were also introduced.

3.7 Articulation of the key variables and concepts

The study focused on looking at the effect of an exemplary cross-cultural instructional approach on the:

- Learners’ **conceptions** of lightning and thunder: The conceptions had to be identified and the impact of the instructional approach on the conceptions was investigated.
- Learners’ **performance** in physics and **attitude** towards science and their culture.
- **Ways** learners deal with two distinctly different worldviews.
- The traditional doctors’ **perceptions** about the integration of Science and IKS.
- The Science Panel’s **perceptions** about the integration Science and IKS.

The cross-cultural instructional material, entitled Static Electricity, presents lightning as taught in grades 9 and 10 in Lesotho schools. It has both the scientific and traditional conceptions of lightning and thunder.

3.8 Piloting of the instruments

The main purpose of a pilot study is to trial the intended procedures, identify problems and find appropriate solutions (Fraenkel and Wallen, 1996). Prior to the main study, a pilot study was conducted at a nearby school, which had similar conditions as the school of the main study. All the instruments including the exemplary instructional material were piloted and checked for clarity, format etc. and were improved as a result of the piloting. For example, SCASQ items were reduced from 50 to 39. Items that gave learners problems were left out. With respect to the exemplary instructional material, initially there were no guiding notes that would help the teacher on how to present a particular lesson. Subsequent to the pilot study, it was found useful to include them. Furthermore, it became apparent to include plenary sessions where some activities were repeated and observations explained using scientific terms.

3.9 Ethical considerations

Prior to going head-on with the research, I visited the school selected for the study. I held discussions first with the principal and later with the science class teacher. The idea was to make both parties conscious of the fact that a traditional doctor would be invited to talk about lightning from traditional ideas about lightning and thunder, which was something new to other forms of research ever undertaken at the school. More importantly, the school is a church school, and like many Christian schools, it has some reservations about some traditional practices. It was necessary therefore, to ensure that participants and school authorities were not exposed to religious discomfort (Fraenkel and Wallen, 1996). Furthermore, it was necessary to ensure that whenever I visited the school to undertake the study and administer research instruments, I would not disrupt the school curriculum. I also ensured that the study synchronized with the scheme that had already been drawn by the class teacher. To adhere to confidentiality principle, the subjects were given fictitious names.

3.10 Summary

This chapter has outlined research methods that were followed in determining the effect of the cross-cultural instructional approach on the learners. Data was collected from three groups of learners that were found to be equivalent. The data were collected and analysed in line with modified Solomon-3 according to the two research questions. Qualitative research was adopted since the focus was on interpreting the learners' narratives. The next chapter will focus on theoretical frameworks that guided the study.

CHAPTER 4: DESCRIPTION OF THE LESSONS

4.1 Introduction

Patton (2002) contends that description forms the bedrock of all qualitative studies. The chapter describes the work-plan and how this was synchronized with the scheme of the science department. The focus of this chapter therefore, is to provide a detailed description of what transpired during the lessons on lightning and thunder (including the contribution of traditional doctor). The description is presented lesson-by-lesson and in some instances the learners' verbatim quotations of their explanation of events provided to communicate a range of views and experiences are given for the purpose of later critical in-depth analysis of the issues that emerged from the study.

4.2 Lessons on the atomic structure of matter: Introductory Lesson

The study started towards the end of January 2004 just as the Lesotho schools reopened for a new school calendar. The first week of the study was used to establish rapport with the learners and to familiarize myself with the site of the study. It was also during the same period when the headmistress, the head of the Science Department and the teacher who later taught the control group 1 (C_1) were informed about the nature of the study and what it entailed. The purpose of an initial visit was to familiarize myself with the learning environment of the school and to establish rapport with the learners. The science department of the school had already drawn the scheme for the first quarter. The first topic to be taught was the structure of matter, electronic configuration and bonding. I introduced my first lesson on the structure of matter with questions about *thokolosi (*a mysterious being supposedly created by witchdoctors for their mischievous activities). The introductory lesson aimed at finding out whether or not the learners had seen, experienced or heard about this mysterious creature. The learners said that they had never seen but had heard stories about this mysterious creature. The excerpts below reflect what was said about *thokolosi* by a number of learners:

Mpho: *The witchdoctors use porridge made from millet to make thokolosi*

Thabiso*: You cannot see it but you can tell when it is there.*

Khotso*: It can talk. It does not like salty meat.*

Thabo*: People use it for looking after goats and sheep*

Tsepo*: It can go through closed doors.*

Lineo*: It cannot be killed.*

'Mamosa*: It strangles people at night.*

From the above excerpts, one can deduce the following about the learners' perceptions of *thokolosi:*

1. Learners have an idea of how it is made.
2. *Thokolosi* is invincible but its presence is verifiable.
3. It can feed and can make a choice.
4. People make use of *thokolosi*.
5. *Thokolosi* is very small and immortal.

The idea here was to make the learners aware that some people believe in the existence of a phenomenon, which they had never seen. Learners should acknowledge the fact that traditional and scientific knowledge can be used to infer unobservable phenomenon (Stephens, 2003). According to the learners, people's belief in the existence of *thokolosi* is based on fear typified by the development of goose skin (empirical evidence). I attempted to link the learners' belief in the existence of unobservable phenomenon like *thokolosi* with the scientific belief in the existence of the electron, also an invisible phenomenon. A realist position was adopted and electrons were presented as existing even if they have not yet been seen. The learners were introduced to the structure of the atom as consisting of small, invisible particles (electrons, protons and neutrons). Electrons were introduced as particles that do not occupy specific positions in an atom, but particles that randomly move about the atom within specific energy levels. They were told that scientists have done experiments to detect the existence and whereabouts of these particles even though they are invisible. The argument here was that *thokolosi* (a traditional phenomenon) and electrons (scientific phenomenon) have never been seen even though people believe in their existence. We then talked about the picture on the TV and how it is related to electron flow inside the television tube. The purpose of this lesson drew learners' attention to the notion of evidence of existence amidst non-visibility, using the example of *thokolosi*. Other examples discussed in the lesson were the deviation operation and function of cellphones, computers, TV sets and how these relied on the invisible existence of electrons. We discussed charge on these particles. Finally, Neils Bohr atomic model for the first 20 elements were presented and discussed by the learners. The sections below illustrate some of the issues pertinent to the study that were discussed through a series of lessons over a two-week period. Five of the nine lessons were double lessons, which meant that they took 80 minutes while single lessons were allocated 40 minutes.

4.3 Lesson 1 (Double lesson): Static electricity – Creating Static Electricity

This lesson took place in the laboratory with learners working in six groups and with each group consisting of about five learners. The learners were provided with a worksheet and the following materials: plastic pen, thin stream of water, 2 polythene strips, woollen cloth, wire stirrup, plastic threat, 2 cellulose acetate strips, tiny pieces of paper, stand. The worksheet consisted of four activities namely: learners were to perform the activities; note what happened; individually explain the observation; and finally discuss their explanations within the group. It is necessary to mention at this stage that some outcomes run throughout the lessons. These are process skills that focus on, among others, developing manipulative skills and enhancing critical thinking. They will not therefore, be repeated for every lesson. Lesson 1 was planned to take two periods but it took three lessons because of the intensity of the learners' enthusiasm during group discussions. The learners were therefore allowed more time to discuss.

The envisaged lesson outcomes included:

- Explaining how charge is created when some objects/materials are rubbed together;
- Stating that charges are separated when certain materials are rubbed against one another;

- Noting that like charges repel and unlike charges attract.

To highlight the effect of discussion during group-work, the study reported on activity 1 and groups 1, 3, 4 and 5 (which comprise of learners exposed to the treatment), which are representative of the activities and discussions that took place. The theme of all the activities was to expose the learners to a situation where they observed a natural phenomenon and then to critically engaged their minds in talking and explaining what they had observed.

Group 1

1. *Rub your plastic pen on your sleeve and hold it near some tiny pieces of paper. What do you observe?*

(a) Individually explain your answer.

(b) In your group, discuss and explain why this happens.

Individual learner's and group explanations

All the learners had observed attraction between the pen and the pieces of paper.

The study provided for probing of the individual learner's explanations of the attraction and the group response and compared the appropriate worldview to which the response was leaning. The explanation that was closest to the scientific explanation was considered to be at a higher level of cognitive understanding. For this activity, the expected scientific explanation was that there is attraction because the rubbing created an imbalance of charge on the pen (rubbing created charge on the pen/ charged the pen) relative to the surrounding object. When the charged pen is brought near the uncharged pieces of paper, an opposite charge is induced on the pieces of paper and this resulted in attraction between the pen and the pieces of paper.

The individual explanations were very brief and focused on the observable phenomena such as heat, rubbing and attraction. To give an example, 'Mathabo wrote:

> *I think when rubbing the plastic pen and then hold it near pieces of paper, there is some heat.*

The group response seems to be a consensus of the explanations of the five members of the group. The learners concluded that because of friction, there is heat; and because there is heat, the pen becomes charged. It is this charge on the pen that caused the attraction.

Although the groups' responses were the result of the contributions made by individuals, no group member had mentioned the fact that an opposite charge was induced on the pieces of paper. For example, a group indicated that:

> *We think when we rub this plastic pen on our sleeves, there is more heat on it. It becomes charged and when it is near the pieces of paper, it attracts the pieces of paper.*

The excerpt above suggests that the learners were aware of one of the characteristics of science, namely evidence. From observing the pen attracting the pieces of paper, they inferred that the pen must have been charged by the rubbing process.

Group 3

A critical look at the individual learners' responses suggests that some learners in this group had some idea as to why there is attraction between the pen and the pieces of paper. One such learner fictitiously named 'Mampe wrote:

> *I think it is because of the friction. The pen has been charged and when two different charges come together, they attract.*

Others simply stated what they saw instead of providing an explanation of their observation. A typical example of this type of response was that of Rantso who asserted that:

> *I saw pieces of paper come closer to the pen.*

The group mentioned the type of charge on the pen (negative) and on the pieces of paper (positive). Initially, one of the members of the group had stated that the pieces of paper were neutral. However, the group finally agreed that there is attraction between the pen and the positive part of the paper. The final group explanation reads as follows:

> *We think the charge on the pen is produced by the friction, the negative pen will attract the positive part of the paper.*

Group 4

Like the previous groups, the learners' responses were rather brief. However, one of the learners, Ts'epo, seemed to have had an influence on the final group response. He argued that:

Because they have different charge that is why they attract each other and I thin the pen is positive and pieces of paper are negative.

For this group, it is not only the pen that is attracting the papers; the papers too are attracting the pen. The attractive forces are between the two oppositely charged bodies. The group's explanation was:

We think the pen is negative and the papers are positive and when they come together they attract.

Group 5

This was an interesting group! Even though they had observed attraction between the pen and pieces of paper, they debated about which of the two, the pen or the sleeve gained electrons. There was a division along gender line. The girls claimed that the sleeve gained electrons while the boys claimed that the pen gained electrons. I was called to come and settle the matter and I suggested that they should write whatever they agreed with. The group's explanation reads:

The girls say that when they rub the pen on the sleeve, the sleeve gains electrons from the pen. Boys say when they rub a pen on the sleeve, the pen gains electrons.

Looking at the individual learners' explanations for the attraction, none of the members had stated the type of charge on the pen after rubbing on the sleeve. The type of charge surfaced only during the discussion.

What emerges out of this analysis is that the collective explanations of all the groups reflect a higher cognitive level of understanding than the individual explanations. In other words, the answers are generally closer to the scientific explanation than those of individual learners. This is in agreement with earlier findings. For example Johnson and Johnson (1986), Felder et al (1994), and Sawyer (2004) argue that discussion leads to better conceptualisation of the phenomenon being studied. Sawyer (2004) drawing on the work of social constructivists (e.g. Cobb, 1995; Forman and Cazden, 1985; Palincsar, 1998) claims that collaborative groups are effective because they provide opportunity for what he called "improvisational collaboration" that results in deeper understanding.

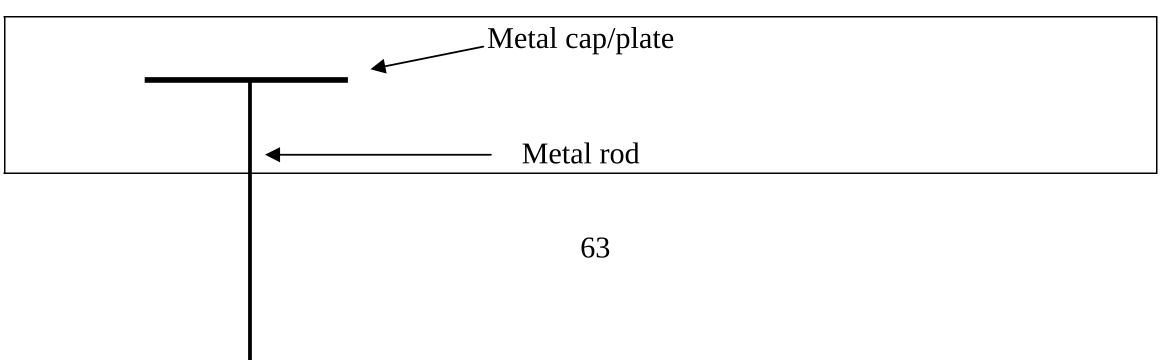
4.4 Lesson 2 (Single lesson): Plenary session for lessons 1 & 2

This lesson took place in the laboratory. The focus of the lesson was to allow the learners to present and discuss their group explanations. It also provided me the opportunity to present the scientific perspective in terms of what happened during the rubbing of the pen (electron transfer) and the charge induced on the pieces of paper and on the thin stream of water. I stated the first law of static electricity during the plenary session. The learners had already observed an incidence of this law while doing activities 2 and 3 of the Worksheet on Static Electricity (WSE1) and it was easy for them to relate the activities and the first law of static electricity.

It was necessary at this stage to make the learners aware of the difference between an observation and an explanation. For example, the gaining or loosing of electrons is not based on direct observation. Rather, it is a theoretical construct since electrons are unobservable theoretical entities (Sankey, 2000).

4.5 Lesson 3 (Single lesson): Structure of the gold-leave electroscope

After the first two lessons, I found it necessary to introduce the learners to the different components of the electroscope. The electroscope was introduced as one of the apparatus that learners would require to use in the laboratory during subsequent lessons. It was necessary to do this because the learners would be using electroscopes in the laboratory. The learners were to use appropriate names for the various parts of the electroscope. Therefore five electroscopes were brought into the class. In addition, the diagram in Figure 4.1 below was displayed on the chalk board to familiarize learners with appropriate nomenclature.



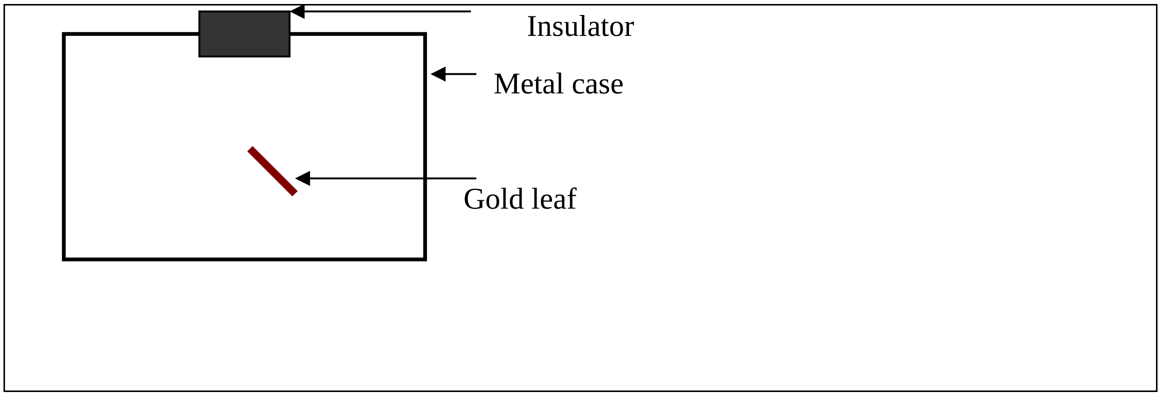


Figure 4.1: A simple diagram of a gold-leaf electroscope

4.6 Lesson 4 (Double lesson): Charging the electroscope by induction

This lesson took place in the laboratory. Like the first set of lessons, the learners showed a lot of enthusiasm. Unlike the previous lessons, this particular one was videotaped. The purpose for videotaping this lesson was to enable me to view and review the narrations, conversation, decisions and activities undertaken by the learners. The activities for this lesson were based on Worksheet for Static Electricity 3 (WSE3).

The expected learning outcomes were stated as follows: Learners should be able to:

- Describe the process of charging by induction;
- Identify the type of charge induced on the surface of the metal cap of an electroscope and on the gold leaves;
- Explain the process of electron grounding.

Materials that were required for this activity were electroscope, polythene strip and woollen cloth.

Activity 1

This activity had the following guidelines and questions:

Rub the polythene strip on the woollen cloth and bring it near the metal cap but not touching the electroscope.

What happens to the leaf?

Individually explain why this happens.

In your group, discuss and explain why this happens.

Scientific explanations of activity 1

From theory, rubbing the polythene strip with a cloth removes some electrons from the cloth and transfers them to the strip. The strip acquires a negative charge because of excess electrons from the cloth. When the negatively charged strip is brought near the cap of an electroscope, some electrons from the cap are repelled down the brass rod to the gold-leaf and the brass plate. A positive charge is induced on the surface of the cap. Since both the brass plate and the leaf have become negatively charged, the leaf and the plate repel each other – hence the divergence that learners observe. This is shown in figure 4.1.

Group 1

The learners observed the gold-leaf diverging and their task was, first, to individually write down an explanation of the divergence and finally discuss their explanations and come up with a group explanation. The group explanation was closer to the scientific interpretation even though there were some cognitive gaps in the learners' explanations. The group response is presented below:

> *We think same charge is induced on the plate and gold-leaf. The charge moves from the cap down the metal rod to the plate. So the leaf moves.*

The discussion during group-work went thus:

Learner 1: *This whole thing is negative, agreed?* (pointing at the electroscope)

Learner 1: *What I want to know is if this thing is charged* (pointing at the strip), *what actually happens to the plate?*

Learner 2*: There is some charge on the cap. Charge is ey … (scratching his head)…*

Learner 2*: Sir, tell us the science word. Yes, give us the word*

Learner 3: *Oh, I remember, charge is induced on the cap. This charge move down to the plate and leaf. The leaf is satisfied.*

The learners had observed the leaf *moving away from the plate, repelling the plate*. As the learners discuss and share ideas, they seem to be trying to remember the observations and explanations they had made in the previous lessons as well as the fundamental law of electrostatics. Even though they did not see any force of attraction between the strip and the cap, they could remember that some charge (opposite) had been induced on the cap. It was the charge similar to the inducing charge that moved down the rod to the plate and to the leaf, resulting in repulsion between the leaf and the plate. What emerged out of this discussion is that the separation of charges within a body during induction was not clearly understood by the learners. What was noticeable throughout the discussion of the group is a sort of intra-dialogue (Ogunniyi, 2005) – the learner searching for appropriate scientific words through his/her schema of knowledge and inviting members of the team i.e. inter-dialogue (Ogunniyi, 2005) to support his/her theory that the whole electroscope is negatively charged. This type of argumentation where the learners support each other is likely to result in appropriation of knowledge (Erduran, 2006).

Activity 3

Bring a charged polythene strip next to the cap of the electroscope as in activity 1. With the strip still near the cap, touch the cap with your finger.

What happens to the leaf?

Individually explain why this happens.

In your group, explain why this happens.

Scientific explanation

The learners observed that when one touches the cap of a charged electroscope, the leaf collapses. This happens because some electrons flow from the electroscope to the earth (process called earthing or grounding the electroscope). The learners were made aware that when they touched the plate they created electron path to the earth – a process called earthing. This concept was related to earthing used in house circuitry.

Group 2

For activity 3, all the members of this group focused on the charged polythene strip and the finger and finally wrote that the leaf collapsed because:

Polythene strip and finger have different charge.

Group 2, like the rest of the groups, had seen the *gold-leaf return to the plate, when a finger touched the cap.* It was the group's opinion that charge had been induced on the finger, not on the cap. It seems the effect of the finger on the separation of charges was not clear to the learners. They focused on one cause, the strip causing the separation of charges in the electroscope, repulsion between the plate and the leaf. The introduction of the third variable, the finger touching the cap, probably complicated the problem further and made it difficult for the learners to conceptualise the effect of the finger.

Activity 4

Perform the experiment as in activity 3. Without removing the strip, remove your finger from the cap and then slowly remove the strip.

What happens to the leaf?

Individually explain your observation.

In your group, discuss and explain your observations.

Scientific explanation

After first removing the finger and then the strip, the gold-leafs remains diverged. The electroscope has lost electrons to the earth and because of this loss, it becomes positively charged. The plate and the leaf have the same positive charge, hence the divergence.

Group 3:

This group was video-taped and the final group response together with the discussions that ensued is provided below.

The final group's response read:

> *We have touched the cap with a finger and that makes charge to remain on the metal plate that is why the leaves remain apart from the metal plate.*

Discussion in group 3 on activity 3

This is what transpired as the learners were performing the activity and trying to interpret their observations.

Tumisang: Why does the leaf come down when we touch?

Thapelo: The leaf comes down because there is no charge, it has been lost; it is no longer down there (pointing at the leaf and the plate).

Palesa: Now they move apart. They move apart like this (showing with diverging hands).

Teboho: No the plate does not move. There is some charge down there.

Palesa: Put the strip away and hide it; yes hide it.

The learners correctly concluded that some charges remained on the metal plate and the leaf after the removal of the finger and the strip. Once again the learners seem to be applying the fundamental law of electrostatics, which states that like charges repel and unlike charges attract. They were aware of the fact that the charged strip had some influence on the electroscope, and for that reason it had to be hidden away.

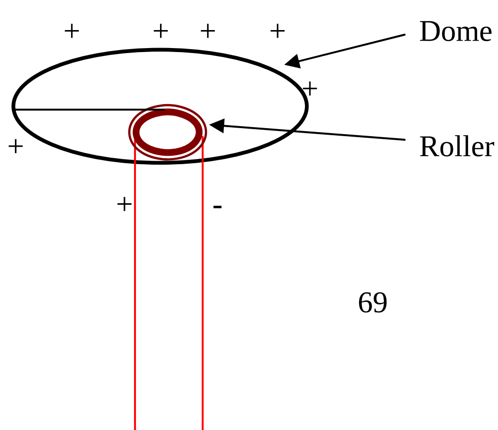
4.7 Lesson 5 (Single lesson): Plenary session for lesson 4

Like the previous plenary session, this lesson took place in the laboratory where the experiment (Charging the electroscope by induction) was repeated. The learners were sharing their explanations of the observations and I was explaining the observations using scientific terms. Having read the learners' individual and group explanations and listened to the discussion, the identification of the charge induced on the cap (a positive charge) was not much of a problem for the learners since they already knew that the charge would have to be different from the one that caused it (negative charge from the polythene strip). However, it was not easy for them to identify the charge on the metal rod and leaf. For these learners, the same positive charge was induced on the plate, the leaf and the rod. More difficult for the learners perhaps, was the explanation of the flow of electrons to the earth through the finger. In any case they agreed that the leaf collapsed because something must have happened. I had to make diagrammatic models showing the flow of electrons down the rod and this helped the learners to develop valid conceptions of earthing.

The plenary was scheduled for a single lesson, but since activities had to be repeated, it took a double period.

4.8 Lesson 6 (Double lesson): Connecting lightning and static electricity

This experiment was performed in a darkened laboratory as a demonstration, where the whole class was observing some learners as they volunteered and participated in performing specific activities detailed below. It was of utmost importance to adhere to the precautionary measures that suggest that learners have to be supervised. The precautionary measures include ensuring that learners who touch the dome stand on an insulating object (in our case it was a thick flat wood) and earthing the dome every time after use. Even though voltages produced with Van de Graaff generators can be very high, currents are normally low (about 10 microamperes) and therefore not dangerous. However, some sparks can be dangerous (Queiroz, 2003). The activity sheet for this experiment is Teacher Demonstration Worksheet (TDWS). A simple diagram of the Van de Graaff generator is shown below. Part of the structure that holds the dome is not shown.



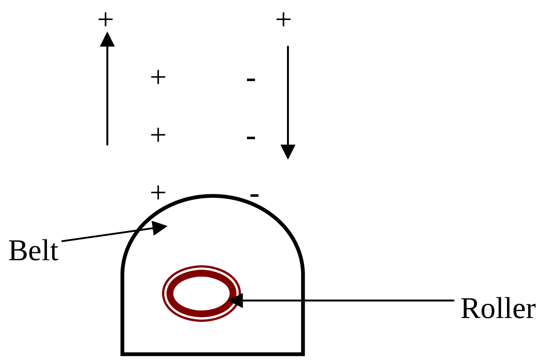


Figure 4.2: A Simple diagram of a Van de Graaff generator

The lesson aimed at allowing learners to be able to:

- Note that charge accumulates on the outside of the Van de Graaff dome;
- Note that charge accumulates on sharp points.
- Experience some shock as the Van de Graaff (VDG) discharges.

Materials needed for this experiment were: VDG, horse's mane and a thick piece of wood.

Approach for this lesson was different in the sense that learners in a formal classroom setting discussed their observations and explanations together as a whole class rather than in groups.

Van de Graaff activity 1

Place the horse's mane on the dome and start the machine running.

What do you observe?

The learners used Sesotho phrases to state their observations. Such phrases include *meriri ea baleha, moetse o iketsa linale*. In brief, these phrases simple mean that the "hair is standing on ends".

I had to probe (using explanations from the divergence of the gold-leaf) to make the learners come up with the explanation that this happens because the hairs had the same charge. One such question was:

Why do the hairs diverge or seem to move away from each other?

Van de Graaff activity 2

Standing on an insulated mat, bring your finger slowly next to the dome of the Van de Graaff generator while running.

What do you observe?

As a precautionary measure, I had to do this part and the learners were asked to observe, and explain the observation. The learners could see the spark and hear the crackling sound.

Later, the learners themselves came one by one to experience the shock (it was minor). Furthermore, learners used Sesotho phrases such as *le u nyekile*, *le u nkile*, *le u otlile* when one brought the finger next to the dome experiencing some shock. In general, these phrases simply mean that one has been struck by lightning. Finally, the generator was disassembled in order to explain how the dome becomes charged and the type of charge on the dome.

To ensure that the learners see some connection between the generator and lightning, it was critical to explain the rubbing between the belt and cylinder resulting in the spraying of charges on the belt and their accumulation on the dome.

The learners explained their observation in terms of the flow of charges from the dome to the finger. This lesson was seen as the apex of the preparation of the learners' conceptions of lightning and thunder. What was most interesting was that they could already see a relationship between what they were experiencing in the laboratory setting using the VDG and lightning as witnessed during a rainstorm or thunderstorm. This was as a result of seeing the spark, hearing the cracking sound and experiencing some shock. The phrases used by the learners are derived from the everyday people's discourse as they talk about lightning.

4.9 Lesson 7 (Single lesson): Lightning and thunder – the scientific understanding

This lesson was in the form of teacher-led discussions and probing. The questions were such that learners had to create mental models of how a cloud becomes charged using ideas and concepts from the previous lessons and their own conceptions. The expected outcomes of these lessons were:

Learners should be able to:

- Explain how lightning and thunder are produced.

- State dangers of lightning
- Suggest safety precautions against lightning with justification.

The learners worked in groups to respond to the following questions:

1. To create charges in the laboratory we rubbed some strips with fur. How do you think charges are created in a thunderstorm cloud?
2. How is a lightning spark (flash) created?
3. Explain how the thunderous sound is produced?
4. What are the dangers of lightning strikes?
5. How would you protect yourself or your property from lightning strikes?

In responding to the first question, learners came up with the following explanations:

> *Charges are created when cold or hot air rub against the cloud; they are created by the heat of the sun; when hot air collide with cold air; when air collide with clouds; when clouds hit against each other.*

Terms such as "rub", "collide" and "hit" were underscored and were referred to during the scientific explanation of how a cloud becomes charged.

Responses to the second question included*:*

> *The spark is created when lightning hits something; a witch wants to see the person he wants to hit with lightning.*

For question three, all groups agreed that the sound is produced when *lightning hits something*.

Dangers of lightning strikes: *It kills people; it steals, it burns houses, it injures people.* In their groups, learners had stories of people and houses having been killed and burnt by lightning.

On protection against lightning one group presented the following:

> *Ho phatsa (incisions); ho roala; do not stand under a willow tree; cover mirror; do not splash water; have lightning conductor; do not stand under tall trees.*

Some learners knew of some traditional doctors who claimed that they have the power to protect people against lightning.

After the learners had presented their responses to the activity questions on lightning and thunder to the rest of the class, I then guided the class in explaining the scientific understanding of how a cloud is charged. It was necessary to make the learners aware that up to now, scientists have not fully understood how a cloud is charged. However, scientists have come up with theories (what they think) about how this happens. These theories are the convective theory and the gravitational theory. In any case, scientists are continuously working hard to find a comprehensive explanation of how a cloud becomes charged. I chose to use the gravitation theory because the science text-book that the learners were using was inclined towards this theory. The gravitational theory argues that negative ions in the atmosphere, which are heavier than positive ones, gravitate to the lower side of the thundercloud, making the cloud to have the upper side positive and the lower side negative (Duncan, 1991). I made mention of charge exchange process between ice crystals or water droplets and hailstones. In Lesotho, most thunderstorms are characterized by the presence of hailstones.

The process of how a lightning flash is created was explained in terms of charge flow from the cloud to the ground (CG). The charge on the ground was explained in terms of induction as a result of the negatively charged cloud above the ground. The VDG was once again run and the sparks between the finger and the sphere were observed.

The thunderous sound of lightning: Once again the learners were reminded of the crackling sound heard from the VDG. The thunder was explained as resulting from a quick expansion and contraction of gases as the air between the cloud and ground is heated (to very high temperatures) and cooled. The learners were made aware that lightning flash and thunder sound occur at the same time. The time interval between the flash of the lightning and the sound produced by the thunder is a result of the difference in speed of both phenomena – sound in air travels at the rate of 330 metres per second while light travels at about 300 000 kilometres per second.

To discuss the dangers of lightning, we used their responses as shown below:

Protection against lightning: During the discussion, I tried to find out how many of them have been protected against lightning using traditional methods. Some said they were, but they appeared shy to really come out with their inputs. We then went outside to see how the schoolyard is protected against lightning strikes. Some learners said that their homes use lightning conductor for protection. Later we came back and talked about things that they should not do during a thunderstorm. These included working with water (washing etc); playing in the open field (football/netball); using electrical appliances (radio, TV); standing under tall trees (because of their height, tall trees have a higher chance of being struck by lightning); riding on horse-back (because of added height). Consulting traditional doctors for protection was not excluded even though there was no scientific explanation of how this works.

4. 10 Lesson 8 (Single lesson): Importance of lightning in nitrogen fixation

The expected outcome of this lesson was to make learners aware that even though lightning is very dangerous, it is useful. The lesson started with questions about the type of fertilizers used by their parents.

Responses included *moiteli* (animal manure), nitrates, phosphates, dead plants and animals.

The importance of nitrates to plants and animals was emphasized.

They were asked about the constituents of air: That air consists of nitrogen, oxygen, carbon dioxide and water vapour.

Learners already knew that nitrogen is inert; it does not readily combine with oxygen. We went further to explore through discussion the tremendous amount of energy released during lightning, nitrogen is able to combine with oxygen to form nitrogen oxide. The nitrogen oxide then dissolves in rain to form nitric acid, which is converted into nitrates in the soil. Plants can then absorb the nitrates and in turn, animals get their nitrates from plants. Through this level of teacher-guided discussions, learners were able to gain a positive picture and value of lightning.

4.11 Lessons 9 (Double lesson): Traditional conceptions of lightning and thunder

A local traditional doctor was invited to talk to the learners about his conceptions of lightning. Prior to the presentation, the doctor was briefed about the expected outcomes of the lesson which were to make learners:

- Discuss Basotho beliefs, practices and customs about the nature of lightning.
- Identify plants and animals associated with lightning.
- Identify differences and similarities between traditional knowledge and scientific knowledge relating to lightning and thunder.

Initially, the lesson was planned for a double period. However, it took three continuous periods totalling 120 minutes because of the enthusiasm from the learners and sharing of experiences that ensued. The teacher whose lesson we "hijacked" came in and listened to the traditional doctor.

I introduced the traditional doctor (TD) to the learners and he immediately embarked on his task. The language of instruction was Sesotho and what follows is my translation and excerpts of what the TD said:

> *We, traditional doctors, know different types of lightning. We know of the "man-made" lightning which we create using traditional medicines. I can instruct it to go and perform some tasks and at the same time I take my medicines and rush to the nearest stream. While at the stream, I stir the winds to create thunderclouds. I use the hammerhead. This bird is very dangerous. It is associated with lightning strikes. Any questions at this stage?*

Several learners raised up their hands.

An attempt is made to analyse the learners' questions and the traditional doctor's responses to the questions.

Most of the questions focused on the supernatural nature of lightning as understood in the traditional discourse. Learners wanted the doctor to explain some cognitive dissonances they experienced in their attempts to conceptualise "man-made" lightning. They expected the traditional doctor to explain the inexplicable so that they could have a sense of security and mastery over their environment (Mqotsi, 2002). Importantly, their questions reflected some elements of critical thinking. Some of the questions raised by the learners include:

Question 1. Sometimes there is lightning without any clouds. How does that happen?

Question 2. Does it mean that lightning is made in the form of a human being?

Question 3. It is said that where lightning has struck, it lays its eggs. Is lightning a person or a bird?

The traditional doctor's responses to such questions were rather brief and authoritative. For an example, when responding to the question about lightning without visible clouds, he said that such a thing does not and cannot happen. The learner did not pursue the question further even though such a phenomenon had been noted by some people and is one of the inexplicable experiences of nature. This type of lightning is invariably attributed to witchcraft and it was interesting to hear the doctor saying that it does not occur. Question 2 followed from the doctor's explanation that the owner of lightning provides arms to the lightning prior to being sent to perform the mischievous acts. The doctor agreed that "man-made" lightning manifests in the form of a human being. However, in response to the last question, he stated that:

it is a bird; it leaves eggs or its urine.

Once again the learner who asked the question did not pursue it further.

The third question was prompted by the reply to the second question. The question is indicative of what was taking place in the minds of the learner. The learner was wrestling with what she knows about the properties of birds - the laying of eggs, which is not an attribute of human beings. One would like to argue that the learner was applying the knowledge from school science, namely classification of things as taught in the scientific corpus, and attempted to put lightning in one of the categories of animals. In the Sesotho morphology, all things are classified into about 15 classes (man falling in the 1st class of things). Lightning falls under class five while animals would belong to class nine. The learner was probably experiencing 'triple' conflict of classifications – as taught in the Sesotho language, as taught in school science and as presented by the traditional doctor. Though there were glaring conflicts between what the doctor was saying and school science, the learners were not eager to follow their questions in an attempt to resolve the conflicts that might have arisen from the traditional doctor's lecture.

Some questions were relational in that the learners wanted the doctor to show some relationships between lightning and some animals and plants in the environment and that folklore has associated with lightning. Such questions include:

1. How is hammerhead related to lightning?

2. How is lightning related to the willow-tree?

The doctor responded by saying that they are related in that Scopus umbretta lays eggs on a willow-tree, a tree that is prone to lightning strikes. According to the doctor, lightning lays eggs in the same huge and frightening nest of Scopus umbretta.

The learners wanted the traditional doctor to describe the lightning strike process from the time its owner (also maker and dispatcher) identifies the victim to the stage it finally strikes. It was at the end of the description that they started to question him about his status – whether he was a witch or a genuine traditional doctor. The Basotho and the Xhosa perception is that the purpose of witchcraft is to kill and destroy property and lives (Mqotsi, 2002). What the traditional doctor had described to the learners was the destructive application of "man-made" lightning. The learners went further to question his morals and expressed some doubt on his belief in God, respect of life and human rights.

Some questions focused on the strengths of traditional doctors in controlling and manipulating lightning, protection and precautions, and non-fatal strikes of lightning. One of these questions was:

What happens when someone is struck by lightning but does not die?

To this question the doctor responded that:

Lightning has farted on the person's face. The person has inhaled the smoke of lightning. That person has to be cleansed and purified with special medicines.

The doctor went to say that he was qualified enough to undertake the cleansing.

The learners could not help but ask questions that perturbed them on everyday basis, including HIV/AIDS. One of these questions was: *Can you protect us against HIV/AIDS?* The doctor's response was:

> *Yes, there is a way. There is a special insect called maleshoane. I use other medicines that are very good. Last week someone came to me and I could tell that he had AIDS. The patient then went to someone else. He came back to me yesterday requesting that I should cure him. I was shown the medicines in a dream by my late grandmother. I have already given this medicine to three other people. Those people are much better.*

There were other questions that have not been included here. Some of these questions had to do with his knowledge of medicines that could help them to pass the tests, big snakes that live in water, *baloetsi* (small people that live in a special calabash). He told the learners that he lives with one of the snakes at his home and that he communicates with *baloetsi* on a regular basis.

At the end, I concluded the lesson by thanking the doctor and the learners for their cooperation, their attention and their interesting questions.

In general, some of the learners' questions required the doctor to explain and provide comprehensive explanations. In my view questions relating to the nature of "man-made" lightning and whether lighting is a person or bird were not clearly answered by the doctor.

The episode sketched above has portrayed two distinctly different explanations about lightning and thunder. The ideas about lightning and thunder presented in the laboratory depicted the scientific view of lighting while those presented by the doctor was an anthropomorphic view of the same phenomenon (e.g. Ogunniyi, 1988; Ogunniyi, et. al, 1995). When a learner holds both worldview side by side without experiencing cognitive dissonance, she/he can be said to be exhibiting parallel or secured collateral learning (Aikenhead & Jegede, 1999; Jegede, 1995) or equipollent contiguity (Ogunniyi, 2005). It was clear from the questions that some of the learners were doubtful of the validity of the worldview of lightning presented by the traditional doctor. In fact, questioning the morality of the doctor's stance about sending lighting to kill someone is indicative of his aversion to his worldview and professional practice. However, to determine the intensity or otherwise of their aversion would require a more close-up clinical interview beyond the primary focus of the present study. Whatever the case, the learners seem to enjoy the doctors presentation and hence their rapt attention and enthusiasm shown towards his lecture. I will explore the learners' sentiments further in the next section.

4.12 Lesson 10 (Single lesson): Commonalities and differences between the (Scientific and Indigenous) conceptions of lightning

The lesson aimed at allowing the learners to identify and discuss the similarities and differences between the two conceptions of lightning and thunder.

The lesson started by asking the learners what they thought of the doctor's presentation. They said they thought he would come wearing *mokhahla* (a dried and processed skin) with beads and horns around his neck. Instead his attire was like that of any other person. They said that they enjoyed his presentation and would like to have him again.

They were required to identify the similarities between lightning as I had taught them and as presented by the traditional doctor. They were also required to state the differences. The excerpts below are representative:

Similarities:

Lightning is associated with black clouds.

> *The doctor creates clouds for his lightning. We should not stand under tall trees. Scientific lightning and "man-made" lightning kill people. We should not play outside during lightning. We should not play with water.*

Differences:

> *The scientific one is interesting but more difficult to understand. There are too many difficult words (electrons, charges, induction, electroscope). What the doctor told us is not difficult to understand. The doctor did not go to the laboratory to show us. We enjoy working in the laboratory. I do not believe him. I was afraid of him. I think he is a witchdoctor. I think I believe in the scientific explanation. Those charges are there even if we cannot see them. You can feel the charges go through you.*

Based on the excerpt above, it seems obvious to these learners that the doctor's version of lighting and thunder was based on belief rather than testable evidence. Despite his version being shrouded in mystery, his use of Sesotho understood by the learners made the presentation relevant to their everyday experiences. If anything at all, he clarified for them what they must have heard in their community. By the same token, and in respect of the Basotho culture where elders are held in high esteem, the learners were not keen to confront the doctor even when his version of lightning and thunder raised doubts in their minds.

I had not expected the learners to come up with similarities and differences between the nature of science and the nature of IKS. I simply wanted to engage their mind and inwardly make them see that indeed both conceptions of lightning do have commonalities as well as differences. During the lesson I experienced a great deal of dilemmas and cognitive discomfort. My undeclared allegiance to the scientific community required me to say that the ideas presented by the traditional doctor were naive. At the same time, my social upbringing compelled me to accept some of the claims made by the doctor. Despite my misgivings about the doctor's presentation, I encouraged the learners to ponder on what they had heard and make their own choices of what to accept and valid or invalid. The resolution of this dilemma is a matter warranting a closer consideration in studies dealing with science and IKS.

4.13: Lessons 11, 12 and 13: Post administration of the instruments

Having been at the school the whole first quarter, it was incumbent upon me to prepare and mark the first quarterly tests. It was during this period that I administered the post-tests for PAT, SCASQ and MILT and conducted some interviews with learners and teachers.

4.14: Summary

The pedagogical strategies adopted during the lessons allowed the learners to be mentally engaged throughout the lessons. The learners were to manipulate apparatus, make an observation and individually explain what they had observed. The individual explanation further helped the learners to move from the concrete to the abstract. Allowing the learners to argue, debate, interrogate, share and discuss their ideas or explanations proved useful in helping the learners to externalize their thoughts, clear their doubts and even change their conceptions about lightning and thunder. Moreover, listening to the learners as they discuss and debates issues helped me to identify some of their problems. This approach corroborates Ogunniyi's view of classroom discourse. To him such discourse should be construed as a "collective search for valid and justifiable reasons for particular stance, rather than seek domination of one stance or another through skilful argument" (Ogunniyi, 2006: p.95).

The instructional material and the pedagogy were aimed at helping the learners to see that the knowledge that they had from their culture, home-background and belief systems was as useful (though in different contexts) as the knowledge they gained in the science lessons.

The learners could see the differences between the scientific mode of inquiry, which is characterized by amongst others, by laboratory experimentation and verification, and the traditional one where the traditional doctor, being the custodian of the knowledge on lightning, was telling them what he does to make lightning. Kang et al. (2005) contends that it would be difficult for learners to accept a new concept unless they know the difference between their existing conceptions and the new one.

In these lessons, learners were allowed to use Sesotho expressions that pertain to the specific concept, lightning. This language helped to mediate their interest, enthusiasm and cognitive understanding of the concept.

Learners tried to use scientific explanations to understand some traditional interpretations of lightning and thunder. This was exemplified from one of the learners' questions asking about the relationships between the scientific view of lightning, explained in terms of charges and the traditional one, explained in terms of a bird/man carrying weapons. Also, the learners in their minds are probably thinking of the scientific classification of animals, according to which birds do not fall in the same category as man. In the traditional paradigm, it is not difficult to conceive lightning as man in a given situation and as a bird in some other context. Ogunniyi (2004) puts it succinctly when he said that the indigenous knowledge system has a relatively elastic system of measurements, classifications, counting and description. Within the IKS phenomena are described in metaphorical, symbolic and anthropomorphic terms and should not be translated literally.

Most of the lessons were situated within the scientific worldview and the learners operated within the scientific corpus with no indication of relating what they were learning to the traditional wisdom. However, after opening up the discussion on the mysterious *thokolosi*, parallels were drawn between *thokolosi* and atomic particles (electrons, protons and neutrons). The idea was not to determine how learners deal with cognitive conflict between the conception, *thokolosi* and atomic particles. Three other 'science-led' lessons where the two knowledge systems converged were lessons 8, 9, 10 and 15. Lessons 13 and 14 were 'traditional-led'. These lessons were considered critical in establishing the existence or otherwise of intra-dialogues (Ogunniyi, 2005), after a learner has been exposed to two conflicting worldviews about lightning and thunder.

CHAPTER 5: RESULTS

5.1 Introduction

The focus of this chapter was to elaborate on the worldviews of observations made during the lessons described in chapter 4. It presented a range of results on learners' pre- and post-conceptions about lightning and thunder. Furthermore, the chapter focused on how learners deal with conflicting worldviews about lightning and thunder. The data were interpreted using categories identified in chapter 3 and theoretical frameworks presented and discussed in chapter 2. As mentioned in chapter 3, an intervention (treatment) in the form of exemplary instructional materials and methods was introduced. Its effects on the learners' conceptions of lightning and thunder were analysed both quantitatively and qualitatively in the sections that follow.

5.2 Grade 9 learners' initial conceptions of lightning and thunder

Main findings

I will begin this section by providing an overview of learners' initial conceptions about lightning and thunder followed by more detailed descriptions of what transpired in the classroom discourse. It was found that:

(a) Some learners hold scientific views about lightning even prior to classroom instruction about static electricity.

(b) Some learners hold traditional beliefs.

(c) Most learners hold both scientific and traditional conceptions.

(d) Learners oscillate between scientific and traditional conceptions of lightning in their responses.

(e) The use of these worldviews is context dependent. Sometimes learners use both worldviews in the same context.

Conceptions about lightning were solicited from a group of 68 learners (36 from the experimental and 32 from the control group) before and after they had been exposed to an exemplary cross-cultural instructional model. To obtain the data, the learners were asked to respond to a questionnaire consisting of eight fictitious stories. The eight stories had three alternative response choices to which learners were to express agreement, disagreement or lack of opinion. This questionnaire, called My Ideas about Lightning and Thunder (MILT) was described in detail in chapter three. The eight stories constituting the MILT were situated within the cultural milieu of the learners and had the following themes: control over lightning; animalistic/humanistic behaviour of lightning; protection against lightning and nature of wounds inflicted by lightning. It was up to the learners to decide whether or not their responses to a story would be based on scientific or indigenous knowledge. The learners' responses to each story were analysed in terms of quantitative and qualitative descriptions.

As mentioned in chapter three, to find the learners' conceptions about lightning, the Likert scale was used. The code that was used for the options were **(SA)** = Strongly Agree; **(A)** = Agree; **(DK)** = Do not Know; **(D)** = Disagree; **(SD)** = Strongly Disagree. These were allocated ordinal numbers from 5 to 1 respectively. During analysis, another column that showed the worldview of each option was added. The scientific worldview was represented by (**Sc**) while the traditional one was represented by (**Trad**).

Tables 5.1 to 5.22 show the learners' preferred response choices to each of the stories. For simplicity, **SA** and **A** were combined together to form **Agree** percentage while **SD** and **D** too were put together to form **Disagree** percentage. **DK** was transformed into unclassified category since some of the responses falling in this category could not be placed into any of the chosen fields. Below I provide the pre-test results of the learners' options on lightning and thunder. The results are presented story by story. These results were interpreted using theoretical frameworks such collateral learning and learning by contiguity. In grade eight, the learners were introduced to the scientific worldview of current electricity, its uses, dangers and safety precautions against current electricity.

Qualitative interpretation of the results of pre-test MILT

Theme of story 1: Control over lightning

The first fictitious story is based on what happens when a storm is about to hit a village. The story and the questions went as follows: During a thunderstorm, Mr. Ngakamatsetsela, a well-known traditional doctor, went out of his house holding his metal spear and pointing it in all directions. He was suddenly struck by lightning. People say that: (a) He was not a qualified traditional doctor, *(a traditional view).* (b) He has been bewitched by other stronger traditional doctors, *(also a traditional view)* and (c) His spear conducted charges through him to the earth *(a scientific view).* What do you say?

This fictitious story is based on what happens when a storm is about to hit a village. When the traditional doctor of the village sees the stormy black clouds (cumulonimbus), he would take his spear, which is smeared with special medicinal concoctions. Using the spear, he would stand outside, point at the storm with the intention to reduce its intensity and to divert its path. If the storm hits the village with all its intensity, people who believe in traditional Basotho belief would normally begin to doubt the credentials of their doctors. However, if the strength of the storm reduces, traditional doctors themselves would acclaim success in having quelled the storm.

Names used throughout this study are pseudonyms.

Table 5.1: Learners' pre-test conceptions about control over lightning

	Scientific belief only	Traditional belief only	Traditional & Scientific belief	Unclassified	Total no of learners
Experimental group	3 (9%)	24 (68%)	8 (22%)	-	35
Control group 1	2 (6%)	18 (55%)	10 (30%)	3 (6%)	33

Scientific belief only

A small number of the learners, 3 (8%) opted for the scientific explanation of the event and disagreed with the traditional Basotho belief. One of these learners with pseudonym Thato, wrote:

> *Because lightning does not choose a person, no: because lightning is not made by man, it is nature because spear is sharp and it can conduct lightning.*

This learner probably having experienced cognitive dissonance dealt with the conflict by relinquishing the traditional interpretation of the story. The learner went further to refute other traditional claims about lightning (lightning does not choose, it is not made by man). He concluded by positioning his conceptual interpretation of the incident and using some scientific terms such as “spear is sharp’ and ‘conduct lightning’ which are related to science. By rejecting and discrediting traditional wisdom of accepting “man-made” lightning, Thato reflected an assimilated state. In this context, Thato construed traditional knowledge as inferior to the scientific one.

Traditional belief explanation

A good number of the learners (24, which is equivalent to 67%) for the experimental group, was traditional in their options as well as in their narrations. These are some of the statements from the learners:

Pulane*:*

> *Ngakamatsetsela did not mix his medicines well.*

Teboho*:*

> *Traditional doctors challenge each other. The big doctors struck him with their lightning. I think Mr. Ngakamatsetsela he was the new traditional doctor he was teaching himself to prevent lightning but he did not succeed.*

These learners agree that Mr. Ngakamatsetsela was not a qualified traditional doctor. Were he a qualified traditional doctor, he would not have been struck by lightning.

These learners are faithful to their doctrine that contents that better fortified and experienced traditional doctors have the power to control lightning. They are cognitively entrenched in the traditional interpretations of the event and justify their point of view by providing the cause of the unfortunate incidence and blame the way the medicines were mixed. The traditional doctors themselves corroborate this finding. In a workshop situation all the 25 traditional doctors that were interviewed claimed that they could control lightning and direct it to strike predetermined destination. In this context, Teboho and the rest of the learners in this category, exhibit traditional belief as being dominant.

Traditional and Scientific belief explanation

Some learners from the experimental group, 9 (26%) responded using both the scientific and traditional schemata. All the 9 learners agreed with (c), which is scientific and either with (a) and (b) which are both traditional.

One of these learners, Lineo, wrote:

> *I think he did not prepare himself when he went outside.*

This learner made this statement having strongly agreed with (a), which is traditional and (c) which is scientific.

This learner preferred traditional belief system against the scientific one. If the doctor was well with his defences, he would not have been struck by lightning.

One of the learners in this category, Tsebo, having strongly agreed with (b) and agreeing with (c) wrote:

> *The spear is a metal, it conducted heat to him so he fell and lightning wanted powerful doctor with medicine.*

Tsebo explicitly acknowledged the scientific explanation (spear is a metal, it is a conductor). However, the traditional doctor was struck by lightning because he did not have powerful medicines. The learner’s faith was still within the traditional corpus which is seen as superior to the scientific one. Once again these learners exhibited traditional dominance in their thinking.

The phenomenon of holding on to two perceptions is not unique to this group of learners. Dart (1972) undertook a study on Nepalese learners and found that the learners could understand and switch their explanation of an event between the modern science and their indigenous science.

Theme of Story 2: Animalistic/humanistic behaviour of lightning

This story too is based on what happens after lightning has struck something. People would come and inspect the extent of the damage and signs that might have been left by lightning. This is how the story goes: During a thunderstorm, lightning struck one hut. After the storm, people came to inspect the hut. There was a pool of water at one place in the hut. Some people said that: (a) This was not water, but urine of lightning *(a traditional view)*, (b) it was possible that the liquid was water *(a scientific view – some degree of scepticism)*, (c) The owner of the hut should call a traditional doctor to come and throw divining bones *(a traditional view)*. What do you say?

Table 5.2: Learners' pre-test conceptions about animalistic/humanistic behaviour of lightning

	Scientific belief only	**Traditional belief only**	**Traditional & Scientific belief**	**Unclassified**	**Total number**
Experimental group	4 (11%)	20 (57%)	11 (31%)	-	35
Control	1 (3%)	17 (51%)	14 (42%)	1 (3%)	33

Scientific belief only

For this story, option (b) and **SD** of (a) were seen as scientific. Good and Shymansky (2001) include curiosity, openness and scepticism as scientific habits. Some of the key features of science include systematic methodology, scepticism (Stirling, 1999) and probability (Newton-Smith, 1990). It is being sceptical and considering other possibilities that science has developed. This is what some of the learners who opted for SA of (b) wrote:

Tseliso:

> *It was possible for water to get in the hut because if there is lightning, there is rain.*

Thabiso:

I disagree, but not quite, because it can happen that where there is lightning, there must be rain, so I can say that is a pool of water.

The learners agreed that there was a possibility that the liquid was water. To these learners the presence of water was not a puzzle that required an investigation by the throwing of bones. Their choice was based on the fact that it was raining. By so doing they explained their rationale for being sceptical; the cause of water (effect) was rain (cause). The learners therefore were seen as being faithful to the scientific process and mode of thinking. To them the scientific conception was more dominant and made more sense as compared to the traditional thinking.

Traditional belief explanation

The majority of the learners in both experimental and control group were very much traditional in their responses. The number of learners who responded in traditional terms and disagreed with the scientific option (b) was 17 (51%) for the control group and 20 (57%) for the experimental group. The learners agreed that the liquid was urine of lightning and if anybody was in doubt, traditional doctors have the authority to verify whether the liquid was water or urine of lightning. Once again, during the workshop, the doctors claimed that lightning urinates wherever it strikes. Some of these doctors added that they normally dug where lightning had struck with the intention to collect this "urine" and to mix it with their concoctions as a form protection against future lightning strikes. Some of the learners wrote:

Lirontso*:*

The owner of the hut should not believe anyone but the doctor.

Lehlohonolo*:*

The owner should do something; otherwise this may cause some problems.

From this information, we can safely conclude that the learners had the conception that lightning urinates wherever it strikes. They explicitly expressed their faith in the traditional doctor; the owner of the hut should not believe any other source of interpretation of what the liquid could be if that source was not an authentic traditional doctor. These learners were faithfully entrenched in the traditional interpretation in this context and categorically excluded any sceptical viewpoint.

Traditional and scientific belief explanation

The number of learners who agreed with the scientific conception (b) and either with (a) and or (c), which are traditional was 14 (42%) for the control group.

One learner, Tiisetso, having agreed with the scientific conception (b) and traditional conception (c), wrote:

> *I can say the hut was already had its problem of entering the water in it or it was having a well.*

It could be argued that learners in this category were weighing the validity of the traditional assumptions about the nature of the liquid as either water or urine of lighting. Since it was raining, there was a possibility of water seeping out of the floor as a well or run-off in the hut. These learners see a puzzle. Like the traditional only category, the traditional doctor would be helpful in resolving this puzzle. The learners believed in scepticism and the authority of the traditional doctor's ability to explain the puzzle. This is a manifestation of an equipollent cognitive state whereby both scepticism (possibility of the presence of water) and ability of the traditional doctor's authority are exacting equal force (Ogunniyi, 2005).

Theme of Story 3: Animalistic/humanistic behaviour of lightning

This story is based on a belief that lightning, like a person, is able to avenge e.g. the death of a hammerhead. Whoever kills this bird, will be fatally struck by lightning. This is how the story reads: Molisana killed a hammerhead *('Mamasianoke)*. The following day Molisana was struck by lighting killing him. People say that: (a) Lightning was angry with him because he had killed a hammerhead *(a traditional view)*, (b) He could have been standing on lephakatlali that is a place where lightning always strikes *(traditional view)* (c) This happened by accident *(scientific view)*. What do you say could be the reason for his death?

Table 5.3: Learners' pre-test conceptions about the animalistic/humanistic behaviour of lightning

	Scientific only	Traditional only	Traditional & Scientific	Unclassified	Total
Experimental	4 (11%)	20 (57%)	11 (31%)	-	35
Control	5 (15%)	18 (54%)	10 (30%)	-	33

Option (a) was based on a belief that hammerhead (Scopus umbretta) is a bird of lightning. If one ill-treats it knowingly, lightning would avenge the bird. Option (b) is derived from another traditional belief on a phenomenon called *Lephakatlali,* which is a magic circle about 9 to 27 meters in circumference (Ambrose and Brutsch, 1991). The magic circles are normally found in open plateaus and are traditionally believed to be places where lightning always strike. On the fringes of these circles, poisonous mushroom grow and some people believe that they are food for lightning and anybody who eats them is likely to be struck by lightning.

Scientific belief only

A small number of the learners, 5 (17%) for the control group opted for (c) which was categorized as scientific. One of these learners, Mosa, who opted for the fatal lightning strike to be accidental, (c) and rejected other options, wrote:

> *Ke nahana hore e ne le phoso feela. Ha se hobane a ne a bolaile 'mamasianoke. (I think it was just an accident. It is not because he had killed a hammerhead).*

This learner was conscious of the humanistic behaviour of lightning – being able to avenge, and traditional belief about magic circles. However, the learner categorically did not concede to it. She was faithfully entrenched in scientific conception of the event. In this context, Mosa suppressed the traditional belief in favour of the scientific one.

Traditional belief only

Majority of the learners 19 (57%) for the control group responded in traditional terms and rejected the possibility of a coincidence. Some of them wrote:

Tsepang*:*

> *Yes, I heard people saying that if you take hammerhead's eggs or killed it, the lightning will kill you because you kill its useful bird.*

Lipuo*:*

The reason of his death is that hammerhead is not to be made angry or killed because it is medicine itself and is used by traditional doctor.

Keketso*:*

Always a hammerhead, according to my culture, is a very strong bird, people are to stay away from it, and culture says, that bird kills.

These learners were cognitively entrenched in traditional belief in their explanations and their faith was as a result of their social upbringing. From this vignette, one gets an idea of how the learners linked the killing hammerhead (Scopus Umbretta) with lightning strikes.

Theme of Story 4: Protection against lightning

In the Basotho corpus, there are safety procedures against lightning. Story 4 is derived from one such procedure. This is how the story goes: Lightning struck Mofokeng's house three times in one year, destroying his radio, television set and telephone. To protect his house, Mofokeng should: (a) See a traditional doctor to strengthen himself and his house *(a traditional view)*, (b) Fix a copper strip from the top of his house to the ground *(a scientific view)*, (c) Make a prayer feast for his ancestors *(a traditional view)*. What do you think he should do?

Table 5.4: Learners' pre-test conceptions about protection against lightning

	Scientific only	Traditional only	Traditional & Scientific	Unclassified	Total
Experimental group	9 (26%)	15 (43%)	8 (23%)	3 (9%)	35
Control group 1	6 (18%)	17 (51%)	7 (21%)	3 (9%)	33

Scientific belief only

Option (b) in story 4 above is a scientific method for the protection of property against lightning. The protection is done through a lightning conductor which is a thick copper wire fixed to the highest point of the building. At the upper end of this strip is a metal rod with several sharp spikes. The lower end, which is connected to a metal plate or "earth met", is deeply buried to the ground. Many textbooks used in Lesotho (e.g. Avison, 1989 and Duncan. 1991) explain that the conductor provides the path for electrons to flow to the earth. When a negatively charged cloud passes above the conductor, there will be a large build-up of positive charges on the spikes, which strip air molecules of their electrons. This creates an electric wind of positively charged ions, which rush towards the cloud, helping in reducing the magnitude of its charge.

The results show that as many as 8 (23%) learners from the experimental group opted for (b) – scientific conception - and rejected traditional explanations. Some of these learners wrote:

Moeketsi*:*

He should turn off the radio, television set and telephone when the lightning comes.

Ntsoaki*:*

I think his house was not earthed that is why the lightning always attacked him.

Lebohang:

Because lightning is a flow of electrons radio and television attract lightning, he should fix copper strip from the top of his house to the ground.

The learners believed in the scientific worldview and used science related terms and conceptions in their answers (radio, television, telephone, earthing, flow of electrons, copper wire strip). They were cognitively entrenched in the scientific worldview in this instance and reflected scientific dominance.

Traditional only

In the Basotho belief system, the people alive are connected with their ancestors *(Balimo*). The ancestors are keeping watch on the living members at all times. It is incumbent upon the living to ensure that this link remains viable by remembering the ancestors and praying to them from time to time. If the link is broken, the ancestors become angry and this exposes the family to frequent various forms of danger.

A good number of the learners 15 (43%) from the experimental group opted for the tradition options and rejected the scientific explanation. Some of them wrote:

Motlatsi*:*

> *Sometimes peoples have to make sacrifices for their ancestors; their ancestors will protect them.*

Mafa*:*

> *Mohlomong Balimo ba hae ha ba ea khotsofalla liketso tsa hae. Ke hore a etse mokete a ba kope ts'oarelo. (Maybe his ancestors are not satisfied with his behaviour. He should make a prayer feast and request for forgiveness).*

These were the traditionally faithful and rejected the scientific explanations. They showed a strong belief in the ancestors' ability to use lightning to punish the living for their misbehaviour. The learners exhibited traditional dominance over scientific one.

Scientific and traditional belief

8 (23%) learners from the experimental group opted for both the scientific explanation as well as the traditional one. Thetso, after strongly agreeing with (a) the traditional mode of protection against lightning, wrote:

> *I can say that most of the time I can see a copper strip from the top of the houses to the ground, because this copper conduct charges.*

This learner accepted both safety precautions, the result of which would be double precaution, which is much better than one. This is an example of a learner displaying syncretism of both knowledge systems, which is the same as equipollent under contiguity principle.

Theme of Story 6: Protection against lightning

Traditionally, people are barred from handling water during a thunderstorm. They should not wash dishes, clothes or anything. One reason for this is that lightning likes water. This is how the story was presented to the learners: During a thunderstorm, people are discouraged from handling water. The explanation for this is that: (a) Lightning likes water *(traditional view),* (b) water is a good conductor of lightning *(a scientific view)* and (c) Lightning lives in water, *(a traditional view).* What is your explanation?

This story focuses on a traditional precautionary measure against being struck by lightning. Options (a) and (c) in story 6 emanate from the traditional milieu. In the traditional cosmology, lightning is attributed animalistic characteristics such as "it likes and lives" and people see a relationship between lightning and water. Option (b) is scientific. In school science learners are taught that water is a poor conductor of electricity. However, because of the magnitude of the potential difference between the thundercloud and the ground (it runs into millions of volts), the low conductivity of rainwater (about 35 to 100 micro ohms) becomes negligible.

Table 5.5: Learners' pre-test conceptions about protection against lightning

	Scientific only	Traditional only	Traditional & Scientific	Unclassified	Total
Experimental	7 (20%)	8 (23%)	17 (49%)	3 (9%)	35
Control	2 (6%)	8 (24%)	20 (61%)	3 (9%)	33

Scientific belief only

Some learners, 7 (20%) from the experimental group, considered water as a conductor of lightning. Some of these learners had somehow established that there was a relationship between lightning, electricity and water.

This is what some of them had to say:

Tebello*:*

> *When it strikes, the water can conduct lightning.*

Kholu*:*

> *Electricity is formed from water, so lightning is a flow of electrons and lightning is formed from water.*

Once again we see the use of scientific terms such as conduct and flow of electrons. The seven learners were categorized under scientific dominance. However, there is a problem with the last part of the statement (lightning is formed from water). I interpreted the statement as saying that lightning is associated with clouds, which in essence are water in a different state (i.e. water vapour).

Traditional belief only

The 8 learners who responded in traditional terms and rejected the conductivity characteristic of water, claimed that water shines, or that it is a reflecting surface and lightning strikes reflectors. This is a manifestation of their entrenchment in the traditional interpretation of the event. They said that during a thunderstorm, all shiny surfaces should be covered as a precaution against lightning. Some of the learners wrote:

Likonelo*:*

> *When you are holding water, lightning can easily beat you.*

Seipati*:*

> *It is because water shines.*

Mosotho*:*

> *The witch goes to the river after striking someone.*

Scientific and traditional belief

Majority of the learners, 20 (61%) from the control group opted for both the scientific and traditional conceptions. These learners explained conductivity in terms of the affinity between lightning and water. The learners said:

Tlohang*:*

> *Yes lightning likes water and is a good conductor of lightning. Water conduct with lightning so if you handle water during a thunderstorm you can easily be struck by lightning.*

Mooki*:*

> *Lightning lives in water because people wash the dirty clothes of dead people in the river.*

The affinity between water and lightning is anchored within the traditional interpretations while conductivity notion is a scientific conception. These learners were seen to exhibit a confluence of ideas from both knowledge systems, i.e. equipollent.

Theme of Story 7: Lightning wounds

Like the rest of the stories mentioned so far, this one too is based on what people do to a corpse of a person fatally struck by lightning. People would approach the corpse with utmost precaution. If possible, the first person to approach the corpse should be a traditional doctor. People would then inspect the body to determine how the person died. They would inspect the wounds and the armpits. This is how the story was presented to the learners: Mr. Moshoeshoe was struck by lighting and killed instantly. He had huge wounds on the forehead, mouth and chin. People came to inspect the wounds. They said that: (a) The wounds were scratches of the bird of lightning *(a traditional view).* (b) A witch hit him with a sharp axe or a sword *(a traditional perspective),* and (c) Lightning kills people in a strange way *(scientific view).* What do you say?

Traditionally, the corpse of a person killed by lightning should not be touched until a traditional doctor has inspected it. Recently lightning had fatally struck my relative and statements (a) and (b) in this story were from the people who stood a distance (about 30 metres) around the corpse after the incidence.

Table 5.6: Learners' pre-test conceptions about lightning wounds

	Scientific only	Traditional only	Traditional & Scientific	Unclassified	Total
Experimental group	8 (22%)	26 (72%)	-	1 (3%)	35
Control group C1	4 (12%)	20 (61%)	5 (15%)	4 (12%)	33

Scientific belief only

Twenty-two percent of the learners disagreed with traditional conceptions (a) and (b), and were in support of (c), which in this case was seen as scientific. They agreed that lightning kills people in strange ways. In the learners' view, the nature of the wounds does not tell us anything about the nature of lightning. The learners were entrenched in the scientific cosmology. One of them, Hlompho explained:

Lightning wounds are always strange, sometimes it burns.

Traditional belief only

Majority of the learners, 26 (72%) from the experimental group, rejected the accidental assumption and subscribed to the traditional interpretation (traditionally entrenched). In their view, the wounds were either scratches of the bird of lightning or were as a result of having been hit with swords or sharp objects by a witch. One of them, Tsilo, wrote:

Letono le tla ka mekhoa e mengata. La motho le tla ka lilepe, le lisabope. (Lightning comes in different forms. "man-made" lightning comes with axes and swords)

Theme of Story 8: Protection against lightning

Traditionally, a willow tree is thought to have some mystical relations with lightning. Because of this, people are discouraged from standing under this tree during a thunderstorm This is how the story was presented: Our parents tell us not to stand under a willow tree during a thunderstorm. Explanation(s) for this could be that: (a) A willow tree attracts lightning *(a traditional view),* (b) All tall trees attract lightning *(a scientific view),* and (c) Lightning lays eggs on a willow tree *(scientific view).* What is your explanation?

Once again the story is situated within the Basotho cosmologies about protection against lightning. This advice is normally given to herds-boys (i.e. boys who rear cattle). The heavy summer rains are often accompanied by thunderstorms. The boys cannot abandon their animals because of the storm. The tendency would be to seek shelter under tall trees with adequate foliage. The willow-tree (Salix babylonica) provides such foliage. Farmers plant this tree as protection against the hot summer days. It is natural for boys to seek shelter under such trees during rainy days.

Table 5.7: Learners' pre-test conceptions about lightning wounds

	Scientific only	Traditional only	Traditional & Scientific	Unclassified	Total
Experimental group	21 (60%)	11 (31%)	3 (9%)	-	35
Control group C1	11 (33%)	15 (45%)	5 (15%)	1 (3%)	33

Scientific only

School science teaches that tall buildings and trees are more prone to lightning strikes than low buildings. In the experimental group, 21 (60%) of the learners seem to have this knowledge. A closer look at option (b) would reveal that scientific as it is, it also has traditional connotations since traditionally people are discouraged from being prominently taller than anything else in their surrounding during a thunderstorm. This group of learners was categorized as scientific (scientific entrenchment) on the basis of their rejection of (a) and (c) which are clearly traditional. Tholoana wrote:

> *Something that is tall attracts lightning. All tall trees attract lightning because it is the only way it (lightning) could get to the earth.*

Traditional belief only

Because of the trees' proximity to the hammerhead's hunting ground (hunting for water animals like frogs) and foliage, hammerheads tend to build their nests on willow trees. As mentioned earlier, this bird is traditionally associated with lightning. Some of these learners associated the bird with witches. The learners adhered to this conception excluding the scientific option. Matseliso wrote:

> *I can say willow tree is a tree where hammerhead made its house so lightning can be caused easily. I think the witches will think that when you are standing there, you are going to steal the 'mamasianoke's eggs because it is where they lay eggs*.

This learner was seen to display traditional entrenchment of what causes lightning.

Scientific and traditional

A small number of the learners, 3 (9%) from the experimental group responded using both scientific knowledge and traditional knowledge. The learners seem to rely on cognitive confluence of the two knowledge systems. They see a willow tree as being tall (prone to lightning strikes from the scientific perspective and being loved by witches or as a lightning tree from a traditional worldview). This is what the learners had to say:

Mpho*:*

> *Willow trees are very dangerous because they are the very tall tree used by witches.*

Pitso*:*

> *I think lightning likes high or tall things like a pole of electricity because it attracts them.*

I used the pre-test results to determine learners' different conceptions and whether the learners would stick to one worldview throughout all the eight stories. I discovered that adherence to a given worldview is dependent on context and at times a learner would provide scientific and traditional conceptions within the same context. Only one learner was consistently scientific in his thinking and rejected traditional conceptions of lightning. Table 5.8 reveals the responses of three learners to the MILT. Their views are representative of the cognitive shifts made by learners at the pre- and post test stages. For ease of reference, my interpretive commentaries about such cognitive shifts have been italicized.

The way learners responded to the pre-test of MILT was analyzed using CAT (Contiguity Theory as espoused by Ogunniyi (2007a and b) and Jegede's collateral learning. The table below shows how three typical learners responded to stories 1, 2, 4 and 8.

Table 5.8: How learners oscillated between scientific and tradition conceptions of lightning (Pre-test)

Story	Leeto	Phoka	Tumo
1	Agreed with (a) and (b) which are traditional conceptions; disagreed with (c) which is scientific conception. Narrative: The big doctors struck him with their lightning. (*Leeto is clearly traditional*).	Agreed with (a) and (b) which are traditional; undecided about (c) which is scientific. Narrative: As a spear is a metal, it conducts heat, I think the spear conducted charges through him. (*Phoka demonstrates both scientific and traditional conceptions*).	Agreed with (a) which is traditional; undecided on (b) and (c). Narrative: He was not a qualified doctor. *(Tumo prefers traditional explanation of the event)*
2	Agreed with (a) which is traditional; disagreed with (b); strongly disagreed with (c) which is traditional.	Undecided on (a); agreed with (b) , which is scientific and agreed with (c) which is traditional. Narrative: As it was raining, I	Disagreed with (a); strongly agreed with (b), which is scientific; undecided on (c). Narrative: The owner of the hut should

	Narrative: It is the place where God's lightning strikes. (*Leeto hold to the IKS based belief*).	think that was water from rain. *(Phoka demonstrates both scientific and traditional conceptions*).	not call traditional doctor. *(Tumo is inclined towards the scientific thinking).*
4	Disagreed with (a) which is traditional; agreed with (b) which is scientific; disagreed with (c) which is traditional. Narrative: He should pray for his house to God. *(Leeto accepts the scientific and the religious viewpoints)*)	Disagreed with (a); agreed with (b) and disagreed with (c). Narrative: I think the place where that person live is rural, so I think there was not signal for current. *(Phoka displays a scientific conception of the event)*	Disagreed with (a) which is traditional; agreed with (b) which is traditional and strongly agreed with (c) which is scientific. Narrative: I can say it was just an accident; we are not sure that it was because he killed the bird. *(Tumo believes in both the scientific and traditional conceptions of lightning)*
8	Disagreed with (a) which is traditional; strongly agreed with (b) which is scientific; strongly disagreed with (c) which is traditional Narrative: None. *(Leeto prefers the scientific rather than IKS-based explanation of the vent)*	Agreed with (a) which is traditional; disagreed with (b) which is scientific; and strongly disagreed with (c) which is traditional. Narrative: Lightning likes water; that is why when it is raining, lightning appears. (*Though phrased in an anthropomorphic language, Phoka's viewpoint is essentially scientific)*	Strongly disagreed with (a); strongly agreed with (b) and undecided about (c). Narrative: I think his house was not earthed that is why lightning always attack him, he also has to pray hard. *(Tumo seems to hold an amalgamated belief which embraces the use of both the scientific and the traditional methods of protection against lightning)*

An examination of the learners' responses showed that even within the same context, e.g. protection against lightning, a learner could switch from one conception of lightning to the other. This could imply that accessing information is not only context dependent. A learner is capable of using information from both the traditional and scientific schemata at the same time and within the same context. This way of dealing with an idea (e.g. protection against lightning) is not amongst collateral learning strategies proposed by Jegede (1999). It is not parallel collateral learning (accessing one schema or the other depedending on context), neither is it secure collateral learning (convergence towards commonality), nor dependent collateral learning (modification of the other schema). However, it is closer to simultaneous collateral learning (ideas from two worldviews are learned and assessed at the same time). This is more in line with Ogunniyi's (2006) equipollent learning which argues that within the same context, both schemata are equally powerful and active and as such both exert intellectual force on the learner.

5.3 Determining effect of cross-cultural instructional approach on the learners' conceptions of lightning

The cross-cultural instructional approach seems to have impacted differently on different learners. In general, here are the main findings regarding the effect of this approach on the learners' initial conceptions of lightning:

(a) For some learners, the scientific conceptions of lightning became dominant while the traditional one was suppressed.

(b) Also, for some learners, the traditional conceptions became dominant while the scientific one was suppressed.

(c) The scientific conceptions of charges, flow of electrons and charge by induction etc were emergent in the learners' cognitive state.

(d) Both competing ideas (scientific and traditional) were seen to exert equal force in the learners' mental state (equipollent stance and simultaneous collateral learning). Thus learners used them both in responding to some questions.

To respond to the question about the effect of a cross-cultural instructional approach on the learners' conceptions of lightning, the experimental group and control group C_2 were exposed to the cross-cultural instructional approach and MILT was administered as a post-test during lesson 16 to all the three group of learners. For the groups that were pre-tested, their prior opinions on lightning were compared with post-test ones. For example, using MILT, the learners' responses on item pre-1(a), (He was not a qualified traditional doctor) were compared with its post-counterpart, namely post-1(a).

For this section, the quantitative data (using simple statistics) and qualitative data were synthesized together to provide a much richer interpretation of the learners' responses and the effect of the instructional material on their views about lightning. The Tables that follow indicate the extent to which the learners had cognitively shifted (where applicable) from their previous conception of lightning. I will focus on selected stories and learners, one from each group (who is representative) that illustrate the range of observations witnessed in the study. For a start I will follow one learner Seithati (he is representative) from the experimental group.

Table 5.9: Seithati's responses to the MILT

Story	Pre	Post	General comments
1	Undecided on (a) which is traditional; agreed with (b) which traditional; disagreed with (c) which is scientific. Narrative: The big doctors struck him with their lightning. *(Here, Seithati seemed to rely on his IKS belief about lightning)*	Strongly disagreed with (a); undecided on (b) which is traditional; agreed with (c) which is scientific. Narrative: His spear conducted charges through him so lightning struck him. *(Seithati seemed to have rejected the IKS worldview in favour of scientific conception)*	Initially Seithati appeared to rely on traditional conception and was probably unaware of an alternative explanation of what happened. After being exposed to the cross-cultural instructional approach, he seemed to prefer the scientific conception over that of IKS in explaining how the doctor was struck by lightning i.e. the scientific conception became **dominant.**
6	Disagreed with (a) which is traditional; strongly disagreed with (b) which is scientific; undecided on(c) which is traditional. Narrative: None *(Seithati seems to disaagree with the scientific and IkS conceptions).*	Agreed with (a) which is traditional; agreed with (b) which is scientific; disagreed with (c) which is traditional. Narrative: Water attracts lightning. *(Seithati appears to agree with both conceptions).*	Seithati accepts both IKS and scientific conceptions. Both systems of knowledge are probably exacting equal force on his perception of the event i.e. he seems to be exhibiting an **equipollent** stance.
8	Disagreed with (a) which is traditional; strongly agreed with (b) which is scientific; strongly disagreed with (c) which is traditional. Narrative: None	Agreed with (a) which is traditional; agreed with (b) which is scientific; disagreed with (c) which traditional. Narrative: A willow tree attracts lightning because it is a tall tree. *(Seithati seems to rely on scientific knowledge)*	Once again Seithati explains the phenomenon using **dominant**.

Using the Contiguity Argumentative Theory (CAT) cognitive categories as espoused by Ogunniyi (2007 a and b), Seithati's view about how lightning can be controlled (Story 1) seemed to have shifted from his pre-IKS-dominant conception to a post-test science dominant conception. In story 2, dealing with the supposedly animalistic/humanistic behaviour of lightning, Seithati seems to have shifted from the pre-IKS dominant stance to an equipollent or dualistic post-test conception whereby he mobilizes both scientific and the IKS conceptions to explain the phenomenon in question.

The next learner, Lisebo, was not exposed to the cross-cultural instructional material. This is how she responded to MILT before and after being taught static electricity by her teacher.

Table 5.10: Lisebo's responses to MILT

Story	Pre	Post	General comments
1	Disagreed with (a) which is traditional; undecided on (b) which is traditional; agreed with (c) which is scientific. Narrative: He was a qualified traditional doctor, his spear conducted charges that is why the lightning struck him. *(Lisebo accepts the IKS view about the qualifications of the doctor as well as the scientific view on how the traditional doctor was struck by lightning).*	Undecided on (a) and (b) which are traditional; agreed with (c) which is scientific. Narrative: His spear conducted charges through him because his spear is a metal. *(Even though undecided about traditional conceptions, Lisebo clearly accepts scientific conceptions)*	Though Lisebo has not completely rejected the traditional belief about the event, she has shifted considerably towards the scientific i.e. the scientific view is **dominant** at the post-test stage.
4	Disagreed with (a) which is traditional; agreed with (b) which is scientific; undecided on (c) which is traditional. Narrative: I say that was not urine but water because if lightning was there, then it was raining. *(Lisebo's scepticism is probably based on her preference for the scientific viewpoint)*	Strongly disagreed with (a); agreed with (b); undecided on (c). Narrative: It was possible that indeed this was water because when thunderstorm is there, there should be rain. *(Lisebo holds on to her scientific viewpoint).*	The **dominant** scientific viewpoint seems to have suppressed the traditional viewpoint.
6	Agreed with (a) which is traditional; agreed with (b) which is scientific; undecided on (c) which is traditional. Narrative: Water is a good conductor of lightning because water attracts lightning. *(Lisebo maintains both schemata in her memory)*	Undecided on the three options. Narrative: Maybe all these are true because lightning does not like water. *(Lisebo seems to prefer the scientific explanation to the IKS-based explanation)*	Lisebo's scientific viewpoint seems **dominant**.
8	Agreed with (a) which is traditional; undecided on (b) which is scientific; undecided on (c) which is traditional. Narrative: Lightning does not want people standing under the trees because trees attract lightning. *(Although Lisebo's viewpoint is*	Undecided on (a) which is traditional; agreed with (b) which is scientific; undecided on (c) which is traditional. Narrative: The tall trees may attract heat and lightning because the tree is a good conductor of lightning. *(Lisebo seems to prefer the scientific explanation to the IKS-*	Lisebo seems to reflect a **dominant** stance.

	apparent, she seems to lean more towards the scientific view.)	*based explanation)*	

Both Seithati and Lisebo reflect two types of cognitive stances within the CAT’s analytical categories (see Ogunniyi, 2006, 2007a & b) namely, the dominance and equipollent categories. As indicated earlier, Lisebo was not exposed to the cross-cultural instructional approach and hence little inclination towards the scientific explanation about lightning.

The next learner, Tlhoriso, was post-tested after being exposed to the cross-cultural instructional approach without being pre-tested. As explained under the research design in chapter 3, this was to remove the pre-test effect that might be influencing the learner’s post-test conceptions of lightning (see Ogunniyi, 1992).

Table 5.11: Tlhoriso's post-test conceptions of lightning based on the MILT

Story	Post-test	General comments
1	Undecided on (a) which is traditional; strongly disagreed with (b) which is traditional; strongly agreed with (c) which is scientific. Narrative: He should not have taken the spear because the electrons from the clouds might be conducted to the spear. *(Tlhoriso prefers the scientific explanation of how the traditional doctor was struck by lightning over the IKS-based explanation).*	The scientific viewpoint is **dominant** in Tlhoriso's explanation.
4	Strongly disagreed with (a), which is traditional; strongly agreed with (b) which is scientific; strongly disagreed with (c) which is derived from tradition. Narrative: He should fix a copper strip so that when the lightning s about to strike, electrons may go down to the earth through the copper strip. *(Strong adherence to science).*	Once again the scientific schema is very **dominant**.
6	Undecided on (a) which is traditional; strongly agreed with (b) which is scientific; undecided on (c) which is traditional. Narrative: I think that is giving lightning more power because traditional doctors use water to start lightning. *(Tlhoriso is explaining conductivity of water using the proposition that traditional doctors go to a nearest stream to evoke lightning).*	Tlhoriso attempts to apply scientific explanation to make sense of why the traditional doctors use stream water during a thunderstorm in terms of the negligible resistivity of water. Moreover, Tlhoriso seems to bring the two conceptions together in explaining why the traditional doctor was struck by lightning! This could be an instance of an **equipollent** stance (Ogunniyi, 2007a and b) or what Jegede (1995) might regard as **simultaneous collateral** learning.
8	Strongly agreed with (a) which is traditional; undecided about (b) and (c) which are scientific and traditional respectively. Narrative: The willow tree is used by doctors to mix their medicines when they want to strike someone or something. *(Adherence to traditional interpretation).*	Traditional schema is **dominant**.

Thoriso explains traditional conceptions of how lightning is controlled by using scientific understanding (water being a conductor during lightning). Tlhoriso, like the other two learners, exhibit some of the cognitive stages identified by Jegede (1995) and Ogunniyi (2005).

Consistency of the learners in their choices and explanations

It was critical to look at the consistency of the learners in choosing the options and explaining their choices and to try to interrogate the meaning of these choices and explanations. It was found that only one learner, Lebohang, out of a group of 35 learners from the experimental group was consistently scientific in his choices of options (pre- and post-test) and explanations of the events. Like the rest of the learners, very little was written on the pre-test section of the story compared to the post-test. During practical work he would call himself the *boss* of the group. He was the one manipulating the instruments and asking questions. This learner was the most playful and enthusiastic in class and always wanting to call attention of other students and the teacher. However, during the traditional doctor's presentation, he was relatively silent in comparison to the other members of his class. He even said that he did not believe that the traditional doctor is in a position to evoke lightning. This learner was conscious (submerged) of traditional beliefs about lightning. However, traditional explanations were not plausible enough.

Arguing from the conceptual change model presented in chapter 2, one would perceive this learner as having a strong conviction and belief in the scientific worldview of lightning and found it to be satisfying, intelligible, plausible and fruitful (Posner et. al, 1982). Even though the learner was present during the rest of the doctor's presentation, he deliberately refused to engage his mind in such a manner as to allow the doctor's claims to affect his way of coming to know.

The rest of the learners tended to vacillate between the scientific and the traditional interpretations and explanations depending on the event. There was some consistency in ways the learners responded to the stories. The responses could fall into two categories: (a) category where the learners could draw a link between science and indigenous knowledge and (b) where the link was unclear.

(a) Clear link between scientific and traditional conceptions:

For stories 1, 4, 6 and 8 the cross-cultural instructional approach made learners to draw direct links between scientific and traditional conceptions. For example, in story 1, the traditional doctor takes a metal spear which is sharp at one end and raises it up. Using scientific knowledge, learners were able to connect metal spear with conduction of charges; the sharpness of the spear with accumulation of induced charges and raising the spear with reducing the gap between thundercloud and the ground. This connectivity enabled the learners to accept the scientific interpretation and reject the traditional one. The new knowledge was seen to be consistent with the learners' prior knowledge (Duschl et. al, 2006).

(b) No clear link with science or link to science not strong enough

For stories 2, 3, 5 and 8, the learners did not seem to have adequate scientific knowledge to cognitively engage in argument or explanations. To the learners, the scientific options were not strong enough to challenge traditional ones which bore immediate relevance and sense to them. In these stories, learners tended to rely on the traditional conceptions because the change was too difficult (Duschl et. al, 2006) and hazardous. Consider for instance the second story. Some of the learners who opted for (b) that stated that it was possible that the liquid could be water also opted for (c) which calls for the traditional doctor to verify the nature of the liquid. These learners were seen to be sceptical (scientific process), but since the learners have confidence in the traditional doctors, traditional knowledge took ascendancy of science.

Below I present the learner's pre- and post- options for four stories, which were found to be representative of all the stories. The learners' responses too were found to be representative. The learners' responses were interpreted using figure 5.1, which has been taken from Ogunniyi (1988).

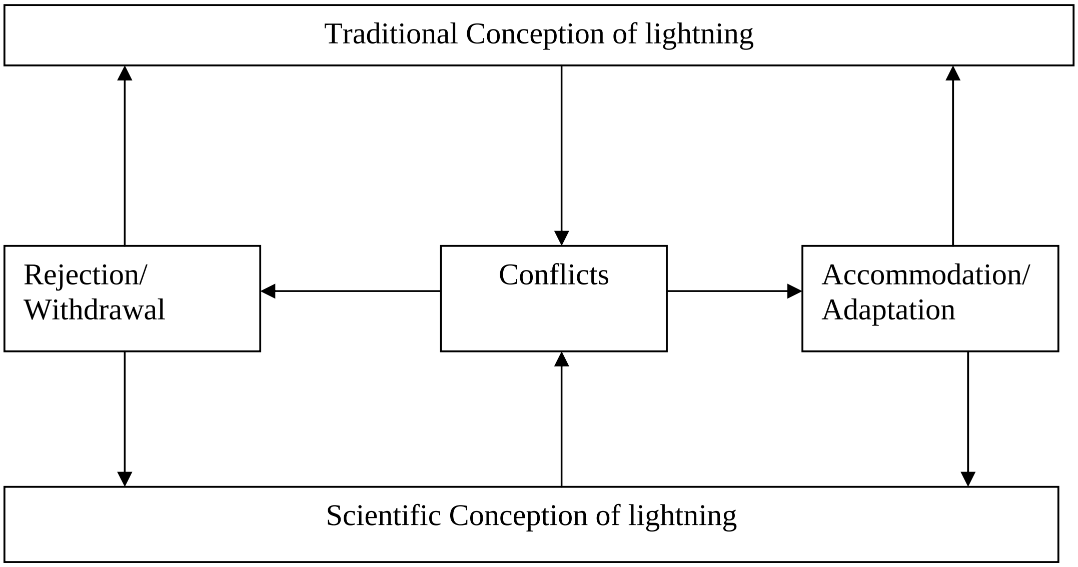


Fig. 5.1: Adopted from Ogunniyi, (1988)

According to this figure, scientific and traditional conceptions of lightning are two worlds apart (Jegede, 1997) for an African learner. Within the learners' cognitive domain, these worlds are separate. However, the different worlds do interact the result of which could create perturbations, cognitive dissonance and conflicts, which in turn could result in rejection or accommodation. For this study, the traditional doctor's presentation reinforced the traditional conception of lightning while my teaching was inclined towards the scientific interpretations and processes. The scientific or traditional interpretation would be accepted or rejected on the basis of its plausibility, intelligibility and fruitfulness (Duschl et. al., 2006).

5.3.1 Learners pre-and post- conceptions about lightning

Story 1: Scientific explanation

For option (c) which the scientific and explains why the traditional doctor was struck by lightning, a significant number of learners 15 (43%) from the experimental group and 13 (43%) from the control group C_2 were embracing the scientific assumption that the traditional doctor's spear conducted charges through him. The number of learners that were not exposed to the cross-cultural instructional approach who opted for the scientific conception in exclusion of the traditional conceptions was 9 (27%), which was found to be significantly different from the other two. There was a significant drop of learners who suggested that the doctor was bewitched. However, there is no significant change on the statement that the doctor was struck by lightning because he was not qualified to combat lightning. The group of learners who opted for scientific option seem to exhibit learning by contiguity; the scientific conception tended to dominate traditional ones. The learners used scientific terms such as electrons, charges and conduction to explain how the traditional doctor was struck by lightning.

Traditional explanation

There was a significant drop in the number of learners who remained completely traditional. However, these numbers remained high (39% and 19% for the groups exposed to the cross-cultural instructional approach and 15% for the group not exposed to the instructional material). My teaching (which was characterised by excursion of the school compound to explore how the school was protected from lightning strikes and demonstrations using van de Graaff generator) of the scientific conception of lightning reinforced the learners' scientific schema and at the same time the traditional doctor's presentation (who claimed that he could evoke lightning) strengthened the traditional schema resulting in making the learners to choose the conception that they found to be more understandable and useful. These learners could dialogue with me and the doctor at macro level (Ogunniyi, 2005) as well as internally (internal conversation) in an attempt to make sense of the two conceptions. However, the group that was not exposed to the cross-cultural instructional approach was not afforded the opportunity for macro level conversation.

Traditional and scientific explanations

Prior to the intervention, 22% of the learners embraced both conceptions. After the intervention, this figure dropped to 17%. This is what one of these learners, Likhopiso wrote:

> *Because there was a lot of charges during thunderstorm, I think the doctor did not do his medicines well, so lightning conducted with his spear and charges went through the spear, then through him.*

This learner is using scientific conceptions such as charges, conducted, charges went him. She is also thinking in terms of the traditional worldview and talks about preparing medicines well. This learner, like others in this category, seemed to be relying on collateral learning where the two systems of thought are exacting equal force.

Story 2: Scientific explanation

The number of learners that remained sceptical and opted for the possibility that the liquid could be water remained low. The number dropped from 11% to 6% for the experimental group. The learners' reasons for opting for scientific conception had not changed either. Their argument was based on the fact that it was raining. The scientific conception was dominant for this group of learners.

Traditional explanation

A significantly large number of learners from the experimental group became more convinced that the liquid was lightning urine (from 60% to 83%). Some of the learners in the experimental group quoted the traditional doctor who claimed that if lightning failed in its' deadly mission, it urinates. The learners who were exposed to the pre-test of MILT went further to ask him if he could verify whether a liquid was water or urine of lightning. He emphatically said that he could. As a result of the dialogue with the traditional doctor, the learners found scepticism not viable and chose to rely on the authority of the traditional doctor to verify the nature of the liquid.

Scientific and traditional explanations

The percentage of the learners who were initially sceptical and at the same time inclined towards traditional assumptions had declined from 31% to 10% for the experimental group. The cross-cultural instructional material reinforced traditional schema.

Story 3: Scientific explanation

The number of learners who said that it was an accident that Molisana was struck by lightning increased from 11% to 19% for the experimental group and the percentage for the group that was not exposed to the instructional material was 16%. This is how one of the experimental group learners, Seeta responded:

He strongly disagreed with (a) which is traditional; strongly agreed with (b) which is traditional; undecided on (c) which is scientific. This is what he said during pre-test:

Pre-test narrative:

Molisana was standing on lephakatlali.

Post-test narrative:

Molisana did not know what to do when lightning strikes. He could have sat down, hands not touching the ground. So ka lebaka la bokoata ha a tsebe letho (so because of his ignorance, he does not know anything).

This time Seeta disagreed with (a) and (b); strongly agreed with (c).

Initially, Seeta strongly agreed that Molisana was struck by lighting because he was standing on *lephakatlali* (magic circle). He was undecided as to whether the incidence was just an accident or not. However, after being exposed to the cross-cultural instructional approach, the learner rejected the proposition that Molisana was standing on the magic circle and strongly accepted the scientific conception. Seeta went further to expose Molisana's ignorance of scientific precautionary measures if one is caught up in a thunderstorm in an open space. Seeta had embraced scientific interpretations and rejected traditional ones.

Traditional explanation

The instructional material does not seem to have made any effect in terms of numbers. The learners that were traditional remained so. Most of the learners in this category focused on (a) which state that Molisana was struck by lightning because he angered lightning by killing hammerhead.

This is how 'Moi responded:

Pre-test narrative:

I have heard that there is a bird that goes together with lightning so we must be careful.

Agreed with (a) which is traditional; undecided on (b) which is traditional and on (c) which is scientific.

Post-test narrative:

I once heard that if you kill a hammerhead you are going to be struck by lightning because lightning and hammerhead flog together.

'Moi strongly agreed with (a) undecided on (b) and (c).

'Moi was relying on traditional wisdom which has been transmitted to her by others, probably peers or communal organization (Jegede, 1997).

Scientific and traditional

The number of experimental group subjects who initially opted for both scientific and traditional conceptions went down from 31% to 17%. The percentage for the group not exposed to pre-test was 33%. An example from Tankiso from the experimental group is given below.

Pre-test narrative:

> *Basotho said hammerhead is lightning by itself; it is not just an accident*.

Tankiso is undecided on (a) which is traditional, agreed with (b) which is traditional; strongly disagreed with (c) which is scientific. Narrative:

Post-post Narrative:

> *He was beaten by a witch. I really dislike lightning***.**

Tankiso is undecided on (a); agreed with (b); strongly agreed with (c).

This learner accepted that it was just an accident (nobody's making) that Molisana was struck by lightning. However, his narrative clearly showed that Molisana was bewitched, which indicated that it was not an accident. The line of argument for this learner was found to be illogical.

Story 4: Scientific explanation

In comparison with the group that was not exposed to the instructional material, there was a significant number of learners that shifted from being traditional only to being scientific (e.g. from 26% to 56%). The cross-cultural instructional material helped them reject the traditional mode of protection and adopt scientific methods. To illustrate, this is what Thulo said:

Pre-test Narrative*:*

> *Because it must be a witch who wants to kill him. If something is wrong with his house and lightning beats there every time, it must be fixed before it destroys the house.*

Thulo strongly agreed with (a) which is traditional; disagreed with (b) which is scientific; undecided on (c) which is traditional.

Post-test narrative*:*

> *He should unplug all the appliances and fix a copper strip from the top of his house to the ground so that the electrons could pass through.*

This time Thulo disagreed with (a) which is traditional; agreed with (b) which is scientific; strongly disagreed with (c) which is traditional.

We see here scientific conception taking ascendancy over traditional conception. Initially the learner responded using traditional conceptions. However, after being introduced to the scientific conception, the learner rejected traditional conception and accepted lightning as a flow of electrons and acknowledged copper strip as a path for electrons to the ground.

5.4 Various ways learners deal with conflicting worldviews

From the excerpts given above, i.e. learners' narratives and options, learners oscillated between the scientific and the traditional conceptions of lightning depending on the context, which in this study were represented by the eight stories. This has already been diagrammatically shown as (Fig. 5.1). This model is derived from Ogunniyi (1988) Harmonious Dualism Model and shows how two schemata (one based on the African worldview and the other on the scientific worldview) interact in the learner's mind. This model helps us to conceptualize how an African learner deals with two different conceptions of a phenomenon, lightning.

What the findings demonstrate is that if learners experiences a conflict between the conceptions, some of these learners tend to either reject the new information based on school science experience while in other circumstances, the learners partially accommodate the scientific view within his/her traditional worldview. For an example, the pre-test showed that for all the stories, most of the learners opted for traditional conceptions of lightning. It was observed that even before the treatment, some learners had some knowledge of both forms of lightning (man-made and natural) and had started to tussle with the resulting conflicts.

5.5 Results of the learners' interviews - The way learners deal with incompatible and irreconcilable conceptions of lightning

Ten of the learners from the experimental group were interviewed after analysing both their responses to the MILT before and after the intervention. The ten learners were amongst those that were found to be vacillating between the traditional and the scientific conceptions of perspectives of lightning. The focus has been to determine how they deal with these conflicting worldviews. The interview focused on the following: source of the learners' traditional conceptions about lightning, comparison of the ease with which the learners understood both conceptions, belief in the traditional doctor's control over lightning, protection against lightning and cognitive conflict created by being taught two distinctly different conceptions of lightning.

In responding to the question about their sources of views of lightning and thunder, the learners claimed that their knowledge came from their parents, grandparents and friends and other members of their society such as traditional doctors. This process of knowledge transmission about a natural phenomenon such as lightning that has been in place for centuries continues to operate in present-day society. The mode used in the transmission of knowledge was and is by telling some stories. Therefore, both the content of the knowledge being passed and the mode of learning sometimes had aspects that tended to be at odds with scientific content and processes, which thrive, among others, on empirical evidence and argumentation. At school, learners are not only confronted with new content, but also with a new strategy for gaining knowledge.

In response to the question: Which is easier to understand, traditional or scientific explanation of lightning? The learners find the traditional explanations about lightning easier to understand but more difficult to explain. On a closer look, the learners that were interviewed seemed to confuse understanding something and believing it. Norris et. al. (2005) see explanation as making something clear and understandable and providing a causal account. However, the scientific explanations seem to be easier to follow because they are backed by experiments and group discussions where learners had to argue.

It could be argued that explanation is not the central focus of IKS cosmology as it is the case in the scientific worldview. When learners are faced with a problem of having to explain their beliefs, they get to a state of blankness, and resort to presenting what they believe. For example, parents always tell their children to sit around a fire-place facing the fire. If one sits with fire behind his/her back, that person would turn into a monkey. Parents are not required to explain how one could turn into a monkey by not facing the fire; the child is to accept that as presented by the parent. In the scientific worldview, understanding is pre-requisite to being able to explain something. One has to understand a phenomenon in order for him/her to explain it often in different ways.

The learners were asked to state whether they believe that a traditional doctor is able to control lightning. This question was based on story 1, where some learners agree that Mr. Ngakamatsetsela was struck by lightning because he was not a qualified traditional doctor. At the same time some agree that his spear conducted charges through him to the earth. To illustrate the learners' responses, one of them asserts that: "*His spear conducted charges through him because a metal is a good conductor of lightning*". This learner makes this explanation despite having strongly agreed that Mr. Ngakamatsetsela was struck by lightning because he was not a qualified traditional doctor. Another one writes, "*Electrons went through him to the earth*". During the interview, the learners argued that it depended on the type of lightning. According to the learners, a qualified traditional doctor cannot be struck by "man-made" lightning. They contended that during the science lesson, the type of lightning that was discussed was the natural one not the "man-made" one!

The interviewed learners were required to state the importance of scientific and traditional ways of protection against lightning. The learners considered both methods to be equally important. In their view, the scientific protection would safeguard property against natural lightning while traditional protection would serve as a shield against "man-made" lightning. This is what Ogunniyi (2005) calls cognitive equipollent state, or what Jegede (1995) regards as secured collateral learning, i.e. the two thought systems exert equal force on the learners' cognitive structure.

The interviewees claim that the two conceptions of lightning do not confuse them because one explanation focused on the natural lightning while the "man-made" lightning was understood within the paradigm of the indigenous knowledge systems. In terms of collateral learning framework, the learners seemed to use parallel cognitive schemas without any attempt to bring the two together. As a result, the learners deliberately avoided cognitive conflict between scientific and traditional explanations of lightning. One of them, Teboho stated:

> *"Sir, you taught us scientific lightning, Ngakamatsetsela taught us "man-made" lightning. They are different".*

Main findings on effects on ways of dealing with conflicting views about lightning and thunder

According to this study, the effects of the cross-cultural instructional approach to the learners' changes in ways of dealing with conflicting worldviews and conceptions of lightning are:

1. The approach helped some learners to reject their prior conceptions on lightning and accept scientific conceptions. The acceptance of scientific conceptions was mainly due to their being able to explain some of the everyday experiences of lightning.

2. Because of the approach, some learners became more sceptical about some traditional propositions about lightning (e.g. that lightning lays eggs). The learners started to question propositions that suggest that lightning possess humanistic behaviours. This is what Jegede (1995) called dependent collateral learning whereby the scientific worldview challenged the traditional worldview resulting in learners rejecting the traditional ideas.

3. Some learners became more traditional in their thinking. This could be as a result of the traditional doctor's presentation, which reinforced their already existing conceptions about lightning.

4. Some learners accommodated both scientific and traditional conceptions of lightning and within the same context, learners were seen to accept and use both conceptions without experiencing any cognitive conflict. This is what Jegede (1995) calls secured collateral learning.

5. The cross-cultural instructional approach helped learners to explain some of the traditional propositions. Learners could explain why traditionally they are

discouraged from handling water during a thunderstorm. According to Jegede (1995), this is simultaneous collateral learning.

6. The use of the cross-cultural instructional approach promoted dialogues (inter and intra) between the worldviews. This resulted in contiguous learning as explicated by Ogunniyi (2007 a and b).

5.6 Effect of the cross-cultural instructional approach on the learners' performance in a physics test

As mentioned in chapter 4, the cross-cultural instructional approach was characterized among others by inquiry-based teaching strategy whereby learners had to handle apparatus and perform experiments, observe and explain the observations, discuss, debate, argue about the explanations of observations. Below I provide some general effect of this approach on the learners' performance.

1. Learners exposed to cross-cultural approach performed better as compared to those not exposed to the material.
2. Learners exposed to cross-cultural approach were seen to be more detailed in explaining observations.

Parts of this section present the quantitative and the qualitative interpretations of the learners' performance in the Physics Ability Test (PAT). The learners' performance on the PAT (Appendix 18) were further analysed using the Statistical Package for the Social Sciences (SPSS), with the aim to establish whether or not their responses were indeed the result of the cross-cultural instructional approach. The purpose of including quantitative interpretation was simply to complement and triangulate the qualitative interpretation, which was the focus of the method that guided the analysis.

5.6.1 Quantitative interpretation of the results

Performance was measured using the PAT, which focused on questions relating to the static electricity as taught during the science lessons. The test was marked out of 20. The groups were then matched and their means were subjected to the t-test (McMillan & Schumacher, 1984). The Table below provides a comparative analysis of the statistical values of the three groups.

Table 5.12: Analysis of variance of post-test scores for all the three groups on the PAT

Groups	No.	Means	S.D	p-value	t-values
Experimental					
Pre-test	35	**6.9**	2.6		
Versus					
Post-test	35	**12.4**	2.2	0.05	**14.29**
True Control C_1					
Pre-test	33	**7.0**	2.5		
Versus					
Post-test	33	**9.9**	3.2	0.5	**13.28**
Second control group C_2					
Post-test	30	**12.8**	3.2		

Key: N = Number of learners in a group; S.D. = Standard Deviation

The pre-test means for the experimental group and the true control group, C_1 are close to each other (6.9 and 7.0 respectively). This could indicate that these two groups were initially equivalent. For both the experimental group and control group C_1 (group not exposed to the cross-cultural instructional material), the calculated t-values are higher than the tabled values at 0.05 probability level. This implies that the two mean values, the pre-test mean and post-test mean are significantly different. This is not surprising since we would expect the learners to have gained more knowledge as a result of having been taught.

Comparing the Experimental group and the control group C_2 that received the same treatment, the cross-cultural instructional approach material may have had some effect on performance. Both these groups have their means close to each other (12.4 and 12.8 respectively). These two groups had been exposed to the cross-cultural instructional approach. However, post-test mean of the true control group, C_1 is significantly smaller in comparison with the other two. What we see here is that the exemplary cross-cultural instructional approach probably helped the grade 9 learners to perform better in comparison with those not exposed to the approach.

5.6.2 Qualitative interpretation of the learners' performance in science

It was necessary to critically interrogate the pupils' responses question by question so as to bring to light the depth to which the learners went in responding to the questions. More importantly, it was necessary to triangulate and to determine whether learners answered thoughtfully. However, the analysis focused on some of the questions that clearly highlighted the differences between the two treatment groups and the one that was not exposed to experimentation. These questions are 1, 2, 3, 4, 6 and 7 as presented below.

Question 1

Thabo rubbed his plastic pen on the sleeves of his jersey. He then brought the rubbed pen close to small pieces of paper.

(a) What will happen to the pieces of paper? Explain why this happens.

(b) Explain what happened to the pen during rubbing.

For the (a) part of this question, the expected answer was that the pieces of paper would be *attracted* to the pen. The learners who responded by mentioning force of attraction between the pen and the pieces of paper were awarded marks. Learners were also expected to explain why there was attraction. They were expected to mention that as the charged pen was brought near the pieces of paper, an opposite charge was induced on the pieces of paper and as a result an attractive force was created between the pieces of paper and the pen. The table below shows how the learners responded during post-test.

Table 5.13: Learners' understanding of how charges are induced

	% that mentioned attraction	**Explanation**				
		Yes	No	Heat/Friction	Charge on pen	Induced charge on paper
Expt **E** (35)	35 (100%)	31 (88%)	4 (11%)	4 (11%)	23 (66%)	13 (37%)
Treat **C**$_2$ (30)	30 (100%)	27 (90%)	6 (20%)	0 (0%)	19 (63%)	11 (37%)
C$_1$ (33)	29 (88%)	26 (79%)	6 (18%)	5 (16%)	17 (52%)	3 (0.0%)

For an example, of the 35 (100%) learners of the experimental group, all of them correctly stated that the pieces of paper would be attracted to the pen. However, 31 (89%) of these learners provided an explanation for the observation. Furthermore, only 4 (11%) explained the attraction in terms of heat or friction; 23 (66%) mentioned that attraction was a result of the charge on the pen and 13 (37%) mentioned that the pieces of paper were neutral. One of these learners from the experimental group, Tsepo wrote:

> *The pen was charged by rubbing, but the pieces of paper were charged by induction.*

In responding to the (b) part of question 1, i.e. explaining what happened to the pen during rubbing, 26 (74%) and 20 (66%) learners from the experimental group and second treatment group respectively gave answers in terms of electrons transfer taking place during rubbing. One of these learners, Thabiso wrote:

Pieces of paper are attracted to the pen. When rubbing pen, electrons move away from pen to sleeve of jersey. Pen is positively charged while sleeve or jersey is negatively charged.

The group not exposed to the cross-cultural instructional approach simply focused on what is observable – namely heat. Of this group, only 5 (17%) responded in terms of electron transfer.

The difference between the experimental group together with the control group 2 as against the true control group in terms of mentioning charge on the pen and paper could be due to the fact that the two former groups were exposed to inquiry-based teaching strategy. They had a chance to experiment with pens and pieces of paper and collaboratively discussed their explanations of the observations made. The true control group was neither exposed to experimentation nor to collaborative work.

During the interview, some of the learners that were exposed to the cross-cultural instructional material said:

Experiments makes me understand; re li entse ka laboratory (We did them in the laboratory); ke rata ho ruteloa ka laboratoring, re etsa li experiments, li etsa hore ke se ke ka lebala (I like to be taught in the laboratory, we perform experiments, they make me not to forget).

Questions 2

Two freely suspended strips, which carry the same charge, are brought close to each other. What will happen to the strips? Explain your answer.

The three groups performed equally well in responding to this question. The learners correctly stated that the strips would repel because they have the same charge. One learner (Sents'o) went as far as stating the fundamental law of static electricity. It is possible that Sents'o used this law to support his argument.

Performance for question 3 was similar to question 2.

Question 4

Two balloons are brought close to each other. If one balloon is positively charged and the other one is not charged, what charge will be induced on the uncharged balloon? Explain your answer.

All the three groups correctly stated that a negative charge would be induced on the other balloon. However, all the learners failed to explain the induction process. This question required the learners to go beyond just remembering what went on the laboratory, but also to apply the knowledge they acquired to a different situation. I had expected the groups that were exposed to experimentation to provide an explanation why a negative charge would be induced on the part facing the charged balloon. This question was similar to question 1. It should however be noted that the induction process in insulating materials, plastic balloon in this case, is very complex.

Question 6

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

(a) The sparks (b) Thunder? Explain your answer.

Learners from the experimental group and treatment group tended to explain the sparks and thunder in terms of scientific conceptions such as flow of electrons, ionisation, burning of air, electrical discharge. One of them writes:

> *The sparks are caused by electrons when they pass in air. Thunder is sound that occurs when air is been burned.*

However, the learners that were not exposed to the instructional material explained lightning and thunder using intuitive conceptions such as collision of clouds, collision of hot and cold air, meeting of clouds with different charges, burning of the clouds. One of these learners wrote:

> *The sparks are caused when clouds hit each other. They also cause sound.*

It could be argued that the true control group C_1 based their responses from everyday experiences of hearing sound when things collide. They also know that when a match stick is struck, sound and fire are produced. Learners from the experimental and control groups not only relied on their everyday experiences but also from their knowledge of science.

Question 7

Explain how a cloud becomes charged.

Once again learners from the experimental group and control group 2 explained the formation of charges in a cloud using appropriate scientific terms such as droplets/cloud particles/precipitation particles colliding with each other resulting in the exchange of charges. However, most learners in both groups explained the charge formation using collision and friction between clouds. Two of these learners mentioned that *scientists are not sure*. One of these learners writes:

> *It is believed that precipitation particles collide and electrons are removed or gained.*

Once again invariably the post-test-only group explained the charge formation in terms of collision/friction between clouds, or between cold and hot air.

The difference between treatment groups and post-only group was in terms elaboration. The treatment groups were more detailed than the group that was not exposed to the instructional material. For an example, one of the treatment group learners went further and stated that:

> *The clouds move, there is friction between clouds and charges separate.*

With hindsight, one is tempted to argue that I taught this topic static electricity as a pre-requisite to the learners' understanding of lightning from the scientific worldview, while the teacher of the post-test-only group simply focused on the syllabus requirement, particularly the examinable science. More importantly, the use of group-work, discussions and learners discussing their explanations of a phenomenon could be considered as the main cause of the apparent differences. It was observed that learners of both the experimental group and treatment group were more elaborate in their explanations than the true control group. Once again the importance of explanations and empirical evidence cannot be overemphasized. Notably, there is a paucity of reliance on empirical evidence in IKS mode of learning.

In general, the effect of the cross-cultural instructional approach on performance includes:

1. The groups exposed to the cross-cultural approach performed significantly better than the post-test-only group. Their better performance could be attributed to a component of the cross-cultural approach, namely inquiry-based learning which is characterized by among others experimentation (manipulating instruments in the laboratory), discussion and plenary sessions.

2. Learners exposed to the cross-cultural instructional approach developed better ability to be more elaborative in their explanations. Once again this could be the result of learners questioning each other and the respondent having to provide a more articulated answer.

5.7 Effect of the cross-cultural instructional approach on the learners' attitude towards science and their culture

Attitude towards science

To determine the effect of the instructional material on learners' attitude towards science, results of Science and Culture Attitude Scale Questionnaire (SCASQ) were subjected to paired samples t-test. The pre-test scores indicate that most learners were already positively inclined towards science. With scores on the Likert scale ranging from 1 to 5, most learners scored between 4 and 5. To illustrate, I will focus on two items that explicitly required learners to express their opinion on science.

In item 7, the learners were required to express the degree to which they agree or disagree with the statement that doing experiments makes them understand better. The pre-test results for the groups that took the pre-test were 4.7 and 4.8. The post-test means for all the three groups were 4.9 for the experimental group, 4.8 for the control group 2 and 4.6 for the true control group. Clearly this points to a possibility that these learners before and after the administration of the cross-instructional material, they already had a positive attitude towards experimental work. This finding corroborates the already known conception about the centrality of experimental work in enhancing interest in the learning and teaching of science and attitude of learners towards experimental work.

Item 17 required learners to express the degree to which they agree or disagree with the statement that science helps them understand how things are in nature. Learners in all the three groups agreed with the statement that science helps them to better understand nature. Again this points to a possibility that these learners believe in the methods of science.

The information above can be interpreted as saying that the learners appreciate science and they can relate it to their everyday life. This may call for the science teacher to contextualize his/her teaching and to ensure that issues presented during science lessons are within the everyday experiences of the learners.

Attitude towards culture

Comparing the importance of science and their culture in their life, the learners expressed some indecision. This is clearly captured by items 26 and 30. Item 26 required the learners to state the extent to which they agree or disagree with the statement that their culture is more important and interesting than science. Once again the pre-test groups expressed indecision before and after. Also during post-test all the three groups continued to show indecision.

What one can say about this information is that the learners have not made any decision as whether their culture is more important and interesting than science. In any case, is it important to compare the two cultures? Aikenhead (1996), Jegede (1995) and Ogunniyi (2002) argue that African learners compartmentalize knowledge from traditional and scientific worldviews, and apply each knowledge system when they think it is relevant in a given situation. Therefore comparing the two systems of thought may not be that important to the learners.

Item 30 required the learners to state the extent to which science is not good for their culture. Here the learners were to express their opinion about the effect of school science on their culture. The groups that were exposed to the cross-instructional approach disagreed that science is not good for their culture. The group that was not exposed to the cross-instructional approach was undecided. This could possibly mean that it does not matter whether indigenous knowledge and school science are co-presented, integrated or not; this may not have any effect on the learners' attitude towards their culture. This could possibly be explained in terms of compartmentalization of both knowledge systems.

5.8 Possible effects of the cross-cultural instructional approach on learners' conceptions of lightning and attitude towards science.

1. In all the three groups, experimental, control group 1 and control group 2, and for all the 8 stories, some learners accepted the scientific worldview and rejected the traditional worldview. The experimental and treatment groups were seen to be more relevant and detailed in using scientific knowledge to explain an incidence than the group not exposed the cross-cultural instructional approach. The interview showed that some learners from the experimental and treatment group attributed this shift to science being able to provide explanations as against traditional conceptions that rely only on belief. For most of the learners in the group not exposed to the cross-cultural instructional material, the spaces in the worksheet where they were supposed to

respond freely were left blank, indicating a possible lack of information and or explanation.

2. Each story created a scenario which fits into the common or familiar set of events in the Basotho settings. The stories were thus formulated to invite interpretations from learners over phenomena they had encountered or heard about in the Basotho socio-cultural milieu. It was up to me as the researcher to cast the submitted interpretations in either the traditional or the scientific worldview. All the learners but one, were seen to oscillate between the themes of the 8 stories. The bulk of the learners thus tended to opt for scientific interpretation and explain the same incidence using science and later under a different theme, they would shift towards the traditional understanding. Within a theme, some learners were found to combine scientific and traditional views in one explanation, forming what I called **'cognitive confluence'**- i.e. a merger of the two cognitions of lightning. Some learners **preferred** either traditional or scientific interpretation and identified weaknesses in the other. Others were found to be **entrenched** in both scientific and traditional worldviews in their options, explanations and during follow-up interviews. Such dually entrenched learners expressed their faith in terms of intelligibility, plausibility and fruitfulness of the conception. The oscillation between and within scientific and traditional knowledge systems was interpreted in terms of collateral learning, border crossing (back and forth movement between traditional and scientific worldview) and contiguous learning (intellectual process where among others, similar or opposing perceptions are dynamically associated or attain a higher form of conscience). It is argued that cognitive confluence, cognitive preference and cognitive entrenchment resulted from the dialogues between learners (both the experimental and treatment groups were exposed to collaborative learning) and within a learner (learners from the three groups had both scientific and traditional worldviews of lightning).

3. Before and after the intervention, the learners were found to have a more positive attitude towards science. Those that were interviewed after the intervention credited this attitude shift to the plausibility and robustness or clarity of scientific conceptions of lightning and thunder.

4. Learners that were found to have a positive attitude their culture claim that cultural beliefs have guided their grandparents for centuries. They argue that culture and

traditional beliefs guide their life. They are therefore bound to consider them as useful. At the same time those with a negative attitude towards their culture attribute this to the deficiency of benefit. They do not reap anything beneficial by embracing culture.

5.9 Views on the integration of IKS and science

5.9.1 Teachers of the study school

Five science teachers of the study school were interviewed in a round table set-up. The group consisted of two males and three female teachers. The purpose of the interview was to determine the extent to which the teachers support or otherwise, the co-presentation (integration) of a concept in both scientific and traditional worldviews. Furthermore, the intention was to determine how the teachers would address conflicts created by co-presentation of concepts from scientific and from traditional perspectives.

The teachers agreed that the integration would help pupils understand school science better. In their opinion, the integration should be such that it helps pupils to conceptualise scientific principles. This is what they said:

T1. At school we force pupils to accept the scientific explanations at the expense of the traditional conceptions. For an example at school we teach pupils to eat eggs as a rich source of protein. However, at home, teenage girls are traditionally discouraged from eating eggs. Yes, we will confuse them. Obviously it is up to them whether they eat eggs at school or not. We will have done our part as teachers. We therefore force the child to live two existences.

T2. The non-science explainable component of IKS should also be taught. However, we should find ways of explaining them, whether the explanations are metaphysical or not. For an example, a girl is discouraged from standing on doorways, this should be taught but again it should be explained.

T3. IKS should be assessed differently from school science. In fact, it would be best if within the school science syllabus as we know it, or within a relevant topic, there is a related section on IKS conception of a given concept. Children need these things; we have to assess them as well. This is still problematic in the sense pupils come from different tribes (liboko) as the way they do things depend on their tribal inclination.

T4. In our upbringing, we really never sought explanations of these things. This has created a lot of problems for us in the sense that true explanations have now become extinct. Something will have to be done to regain that knowledge.

We believe in our traditional culture and still practice these things. For an example, during the first pregnancy of my daughter-in-law, she will put on a special skin cloth. It is our tradition; I went through it myself, I do not know why I am doing it, but I will do it.

Yes, we do these things; for example I put on a morning cloth, and during the cutting of hair, I have to come after my tribal elders and if someone tribally younger than me cuts his hair before I do, I will not continue; it is tradition, that is how things are.

Obviously the science teachers of this school believe in the integration for various reasons. Ogunniyi (2006) also found that most teachers in his study were in support of the integration of science and IKS. One reason is that the integration would aid in explaining scientific concepts. Secondly, these teachers themselves embrace their traditional practices and would want to see them acknowledged. The teachers perceive a problem when it comes to explaining IKS practices that they themselves uphold. For example, all the teachers are in support of hair cutting during bereavement, but cannot explain the rationale for this practice. Furthermore, the teachers, like their learners, experience some conflicts. Teacher 4, for an example, claimed that she did not understand why pregnant women in her clan have to put on a special skin cloth. However, she supported the practice. Coll et al., (2004) also found this 'I do not know' behaviour in one religious scientist who believed in virgin birth as well as conception as understood within the scientific worldview. The scientist and the teacher mentioned above are seen to be experiencing cognitive dissonance, which will have serious implications on the curriculum. For example, if teachers are already experiencing cognitive dissonance, how then will they be able to teach in such a manner that they do not convey the dissonances to the learners? This too has implications on teacher training institutions.

5.9.2 Chairperson of the science panel

One of the responsibilities of the National Science Panel in Lesotho is to interpret and translate the national goals pertaining to science and technology into curriculum objectives and classroom objectives. Subsequently, the panel has developed outcome 14.2, which states that pupils should be able to identify and interpret the relationship between science and the

Basotho forms of knowledge. It was important therefore to interview the chairperson to have the panel's views about integration.

The chairperson agrees that there is a relationship between science and the Basotho forms of knowledge. She went further to identify some of these relationships thus:

> *There are relationships as well as differences between the two. For example, as safety precautions, traditional doctors use sharp objects attached to long poles that protrude above their buildings. How did these doctors know about this thing? Another example is the way they make clay pots. These pots are made in such a way that they are stable and keep contents cool for a long period of time. There are several examples that teachers could use to highlight the relationship.*

The chairman of the National Science Panel acknowledged having not mapped-out the scope and content of Basotho forms and structure of knowledge. She however feels that there is need to do so. This is what she had to say:

> *No we have not. I think it is important that we should. However, we are currently engaged in developing curriculum and assessment policy. All activities including the localization process have been halted.*

The mode of integration and incorporating Basotho forms of knowledge with science is still problematic, and left to the classroom teachers to grapple and make sense of. This is what the chairperson said:

> *Yes we did think about inviting people who are conversant with traditional knowledge. However, we have left this to the teachers as a way of getting information for their respective topics. It should also be remembered that some of IKS is private knowledge, it is an initiation secret (koma). For example, if one wants to know fully about what happens during circumcision, one has to go to the circumcision school.*

The panel is fully conscious of the fact that integration is likely to result in some instances of conceptual confusion if conflicting ideas of the same concept are taught together or by persons of varying views. The chairperson suggests that integration should focus on those explanations that are in concert with the scientific knowledge system and leave out the conflicting ones. In this respect, the panel differs with the teachers of the study school who contend that the non-science explanations should also be taught. What emerged from this discussion is that the panel is yet to conceptualize the nature of IKS and the nature of science. This is what the chairperson had to say:

> *We are only focusing in those aspects of IKS that could be explained using scientific methods. We have not as yet thought about the metaphysical aspects that cannot be explained using scientific methods. We cannot ignore the fact that these aspects could be important. Who knows, some of these learners could be traditional doctors.*

While the teachers of the study school agree that IKS too should be assessed in the same manner as scientific knowledge, the chairperson of the panel is of a different opinion. She argues that we can only assess that part of IKS can be explained using scientific methods.

5.9.3 Traditional doctors

I was fortunate to attend the workshop held for traditional doctors. After the workshop, I visited one traditional doctor and had an informal interview with him at his home, to solicit views of the traditional doctor about integration of school science and traditional culture. It should also be recalled that the panel had suggested that science teachers should be free to invite traditional doctors to talk about their practice where appropriate. An open interview was chosen with the intention of allowing him to be more approachable and to ask questions that follow from the talk. The discussion was in Sesotho and what follows below is the translation of the interaction.

The traditional doctor is in support of the integration. However, he sees a problem with secrecy as mentioned by the chairperson of the science panel. This is what he said:

> *I tend to agree. The problem is that Basotho believe in secrecy and confidentially. They do not want their knowledge to be common because they sell this knowledge – it is their livelihood. That means that if they have to be open about it, they will have nothing to support their survival. They will have to be remunerated. For example, if I tell you the names of the medicines that I use against lightning, I will have given you the inheritance of my children.*

The traditional doctor has prepared a notebook where he has prescriptions for various ailments. He was not discreet to talk about the contents of the note-book, which included protection against lightning. This is how he explained the functions of the different medicines:

> *I have here prescriptions for pitsa (for women who cannot conceive), sejeso (for one who has been poisoned), mofetsé (cancer), litoromo (foot ailment), protection against thieves in the fields and at home, protection against lightning etc.*

The traditional doctors strongly claim that one can evoke and control lightning. The doctors are not only able to create lightning, but they can also turn water droplets into hail. Lightning and hail are some of the natural phenomena that cause havoc to the people's property. Basotho, like any traditional African society, need some extraordinary measures to bring them under control (Mqotsi, 2002). Mqotsi further argues that when the people are faced with the practical and urgent problem of controlling, harnessing and explaining the environment, one cannot sit and do nothing about threatening disasters. This is what the doctor had to say:

> *Oh, yes, they do. They can turn water droplets into hailstones. To evoke lightning they use things like fat from puff-adder; hlokoana-la-tsela (this can easily be send wherever you want it to go); tabola, phela, setima-mollo, sehlooko (this one is very important, it takes away the heat which has to be the right amount), male organs of lenoabo (Chameleon) this animal is very slow, it's organs help dazzle the victim; claws of a hawk (these are used for scratching), and many other things. The victim has to be called by his/her name and clan.*

The solidification of water droplets into hail as well the turning of water vapour into hail (sublimation) can be explained scientifically. However, the idea that these processes (solidification and sublimation) can be manipulated by a traditional doctor is difficult to comprehend. The characteristics of the animals mentioned in this excerpt are well known in Lesotho. Puff-adder (African Bitis aretans) is very poisonous; chameleon is known for its camouflage and slow movement that synchronises with the movement of the leaves on which the chameleon is sitting, and the hawk for its speed. The plants, *tabola, phela, setima-mollo* and *sehlooko* are normally used as medicines. How these things are mixed to create lightning is the knowledge that lies with traditional doctors. The doctor is of the same opinion as Mills (1968) who argues that witchcraft should be taught together with science. This is what the doctor said:

> *Yes, one has to be taught witchcraft and protection against it. The learner has to know when he has been bewitched and which diseases are the consequences of witchcraft and which ones are not. We have "man-made" lightning and the natural one. The natural one is a mighty and dangerous kind of wind from the clouds that come down causing a lot of damage.*

To address the problem of conceptual dissonance, the traditional doctor suggested that chronological and cognitive developments of the learners are critical factors that should be taken into consideration.

> *Yes, that is possible, but you will have to take their age into consideration. Do not teach these things to small children, who will not be able to deal with cognitive dissonance. You should also remember that the language could be strong. Teachers will have to tell the learners interesting stories. Also, learners have to know the good side and the bad side of life. Otherwise how do they know?*

The doctor is willing to try his medicines and find out their effect in combating HIV/AIDS. He has requested a nurse to try his medicines on a HIV+ patient. This is another indication of their openness and support to the systemic approach in the fight against the HIV pandemic.

5.9.4 Expert of the Sesotho language

I thought it wise to solicit the views of other experts in the educational field. Specifically, I wanted their views on integration of IKS and the school science as well as the effect of the integration. I then approached one retired professor of Sesotho language and this is what he has to say. This is what he has to say:

> *The integration would be an acknowledgement and appreciation of the reality that IKS was a valuable heritage that has to be preserved and modified as necessary for the benefit of our society and other societies. Secondly, the Sesotho IKS needs to be rediscovered, carefully checked for authenticity and well documented for availability and careful application of appropriate elements thereof at various school or educational levels. Thirdly, school science would find in IKS, valuable soil whence it would germinate and be nurtured into full growth and varied developments.*

The expert is of the opinion that the Basotho system of knowledge is integrated and that there is need to study and analyse it and explore how it fits into various scientific fields. His support of the integration was very much political and aimed at promoting acknowledgement of indigenous knowledge. He further argued that:

> *Sesotho IKS, even though forming an integrated knowledge – could be seen as divisible into various fields of knowledge or disciplines, including science. Scientific elements – of content, approaches etc would therefore need to be known and studied. For an example, those related to fauna and flora, weather and the elements,*

> *food, medicines, humans' relationship with nature, agriculture, arts and crafts, health and behaviour patterns and many more would need to be studied carefully.*

The interviewee is conscious that integration is likely to cause some conceptual confusion to the learners. He argues that if the IKS elements and approaches were not identified and applied in a professional manner, by knowledgeable specialists using appropriate media and language, then cognitive dissonance is likely to occur in the minds of the learners. He therefore calls for both IKS and modern science to be carefully studied at college, university, and teacher education institutions.

The interviewee offered two ways of analysing and discussing the Basotho knowledge about lightning as suggested by the syllabus. He supported the scientific methods of empirical evidence through controlled experimentation. This is how he put it:

> *First, through the use of simple, appropriate observations in a carefully regulated experiment. Observed phenomena should be identified and discussed carefully using appropriate concepts. Second, the stages could be identified (e.g. pre-conditions for lightning and thunder) and each stage carefully observed (and analysed), discussed simply ensuring full understanding, rather than memorization of "dead" facts. Third, the IKS and modern Science contents and approaches would be analysed carefully and each discussed simply, clearly and appropriately. The holistic nature of IKS would be noted and its significance noted and compared with modern science. This could be done in the upper grades where the learners would be in better position to effectively do the comparison.*

The interviewee proposes that the comparison of IKS and modern science could form an area that could be assessed.

In general, the Sesotho expert is in support of integration. However, he observes the need to have a thorough understanding of the Basotho forms of knowledge, and how science as taught in school could be presented in a complementary manner.

5.9.5 Learners interview about integration

Some of the learners were asked questions pertaining to the integration of indigenous knowledge with school science.

This is what some of them had to say:

‘Mannete:

> *Ke ne ke thabetse ho tseba ka letono ka mekhoa e ‘meli, e leng oa Sesotho le oa science. Ke ile ka fumana mekhoa e mengata ea ho its’ireletsa.(I was happy to be taught about lightning from two perspectives. I was provided with two methods for protection against lightning).*

’Mannete is quite happy to have been taught both conceptions of lightning. Her support for integration is based on the functionality of both systems in protection – she would have two methods of protection against lightning. ’Mannete’s performance in science was above average. She is among the 77% who claim that studying science and traditional beliefs helps them understand better.

Lipalesa*:*

> *Nka thabela ho rutoa ka tsona li le peli. Ha ke rutiloe science, ha ke fihla lapeng, ke bolelloa ntho e itseng, ke sebelisa science ho fumana hore na ke hobaneng ho thoeng joalo (I would like to be taught from both perspectives; when I get home, and told about something, I can use science to find out why such a thing happens).*

Lipalesa supported integration so that she could use scientific methods to explain and understand traditional propositions at home. She based her acceptance/rejection of traditional conceptions on how explainable they are using scientific methods. Lipalesa’s performance in science is above average. In the Physics Ability Test, she obtained 60%

Moeketsi:

> *Nka thabela ho rutoa ka mekhoa e ‘meli; nka hlalohanya, ka bapisa science le Sesotho (I would like to be taught from both perspectives, I can compare and contrast science and Sesotho).*

Moeketsi too is in support of integration for comparison’s sake. In his opinion, he learns by allowing the two systems of thought to interact (Ogunniyi, 2005). Moeketsi’s performance in science was seen to be average (50%).

Puleng:

> *Che, lia ferekanya, ho rutoe science feela (No, they are confusing, we should be taught science only).*

According to Puleng, being taught lightning and thunder from traditional and scientific conceptions is confusing. She would therefore prefer to be taught the scientific conception only. Puleng seem to deal with the confusion by rejecting being taught traditional conceptions of lightning. Puleng is among the 51% of the learners who agree that traditional beliefs are confusing while 25 % are undecided and 23% disagree.

Tanki:

> *No, ke rutoe ka science feela, lingaka tsa Sesotho lia thetas, li buoa ka ho phatsa le mahe a letono (No, I should be taught science only, traditional doctors lie, they talk about incisions and eggs of lightning).*

This learner was not in support of integration because he did not trust traditional doctors. He did not believe in traditional medicines and practices. This learner is one of the 23% of the learners who are not in support of the integration.

5.9.6 Views of the custodians of the integration – convergence and divergence

Some of the people interviewed are in support of the integration, while others think otherwise. Those against integration of IKS argue that teaching the two perspectives together would only create confusion. The table below summarizes the view of various respondents on the issue of integrating the scientific and the IKS perspectives about natural phenomena.

Table 5.14: Various views expressed by the subjects on integrating science and IKS

	Teachers	**NCDC**	**Sesotho Expert**	**Traditional doctor**	**Learners**
Rationale (Why integrate)	To enhance science learning; recognition of traditional practices.	Policy issue; enhance science learning.	Acknowledgement of IKS; to enhance science learning; promote knowledge of IKS;	IKS is important;	Some like to be taught the two; better understanding; comparison purposes; application at home. Other learners are not in support because they would become confused.
Mode(how to integrate)	Holistic approach – include metaphysical interpretations; assessment is problematic.	Mode of integration seen to be problematic (left to the teacher to address); focus on science explainable issues; protection of knowledge (patent); relationship between IKS and SWV established.	Learners' cognitive stages considered; phenomenon studied carefully (empirical evidence provided); holistic nature of IKS noted; comparison of knowledge systems.	Acknowledgement of secrecy; custodians of IKS be paid; include metaphysical and witchcraft; consider learners' cognitive stages;	Traditional doctors could come; they should explain; do experiments; no witchcraft should be allowed in class.

With few exceptions, the teachers, chairperson of NCDC, the traditional doctor and the expert of Sesotho culture are unanimous that the integration would enhance the understanding of science and promote learners' awareness about IKS. This implies a perceived benefit for the two knowledge systems. Some of the learners too are in support of the integration. Such learners would like being taught a concept from the scientific and cultural perspectives. The interviewees differ in terms of the mode of integration. Teachers, the expert of the Sesotho language and the traditional doctor advocate for a holistic approach whereby science and metaphysical are taught together. The curriculum developer finds it problematic and passes the buck to the teachers and by so doing placing the classroom teacher in a dilemma. The challenge of assessment in this regard remains a problem that needs to be addressed. Despite their positive remarks, some learners are very careful, and would not want the inclusion of witchcraft in their classrooms. Learners generally agree that traditional doctors could come and teach them. However, learners want proof that the medicines prepared by such doctors are effective and that the appropriateness of the drugs are based on empirical evidence.

5.10 Summary

The results of the study show that learners bring their traditional conceptions of lightning to science classroom. Learners do not leave traditional ideas at home as some authors suggested Also some of the learners come with some scientific conceptions about lightning. The scientific worldview (as taught during classroom discourse) is then added collaterally and contiguously to the learners' cognitive domain and conversations begin to take place between the two. For some learners the conversations result in the learners rejecting or accepting either conception depending on their plausibility, intelligibility and fruitfulness. The cross-cultural instructional material facilitated conversations and different types of dialogues.

Learners exposed to the cross-instructional material were seen to perform better. They were seen to be stronger in explaining and presenting their argument logically. All the learners from the three groups were seen to be positively inclined towards science.

Most of the stakeholders are in favour of integrating IKS and scientific worldview. However, they differ on the rationale and mode of integration. However, some learners perceive co-presentation of both scientific and traditional conceptions of a topic as confusing. They would rather prefer to be taught science at school and leave out traditional ideas.

CHAPTER 6: DISCUSSION

6.1 Introduction

This chapter discusses the findings in response to the two research questions. The first question sought to find out the effectiveness of the cross-cultural instructional approach to grade 9 learners' conceptions of lightning and thunder. The second question focused on the change in the learners' attitude towards science and culture as a result of the intervention. The findings are discussed using the conceptual framework and cognitive concepts that inspired the study. The issues are pertinent to integrating, co-presenting the way an African learner comes to terms with the scientific conceptions of phenomena.

6.2 Learners' prior ideas about lightning and thunder

The learners bring into the science classroom, their ideas about diverse phenomena, which they have learned through traditional beliefs, values and practices (Aikenhead, 2002; Duschl et. al 2006). In the traditional worldview, a child acquires the values, beliefs, cultures, ways of thinking and doing that she/he is exposed to throughout his/her chronological and cognitive development. Children form ideas and interpretations as a result of everyday experiences in all aspects of their lives, which include practical and physical activities, talking with other people around them and through the media (Driver et al, 1985). Aikenhead (2002) argues that when learners go to school, they are either (a) enculturated or assimilated into western science, replacing their common-sense notions with scientific ones, or (b) engaged and embedded in their identity and folklores or their socio-cultural milieu. Many people see learning as cultural transmission (e.g. Wolcott, 1991). From this exploration on children's prior ideas about lightning and thunder, it was found that learners bring traditional conceptions of lightning and thunder into school science. It was also found that some learners had already acquired some scientific ideas about lightning and thunder. Prior to being introduced to school science, learners are not cognitively conscious of the conflict between the scientific and traditional conceptions of lightning and thunder. These key findings concur with Aikenhead (2000) who argues that people's core cultural identities may be at odds with western science to varying degrees. In this study, the degree of oddness was seen to be minimal. It has been found that most non-western countries adopt the western framework of science learning with little regard to what learners bring from their indigenous environment (Lixun, 2004). This educational practice ignores the fact that what one has acquired through totality of learning experiences makes that person what he/she is.

In this study, learners came to the school learning environment with their own traditional and religious ideas about lightning into the school science classroom. Some of these ideas do clash with school science. The learners had prior ideas about the nature of lightning, how it is formed, how it is controlled, how it behaves, and how one can avoid being struck by lightning. Learners had scientific and traditional conceptions about lightning. They had already drawn a demarcation between lightning as understood in the scientific milieu and lightning as conceptualized by tradition. The scientific conception of lightning was referred to as natural lightning while the traditional one was referred to as "man-made" lightning. It could be argued that collateral and contiguous learning begins earlier even prior to learners being exposed to school science. The second thrust of this study was to examine possible effects that a cross-cultural instructional approach could ameliorate some cognitive conflicts that might arise when learners' traditional conceptions about lightning come in contact with school science constructs. What emerged from the study in this respect is presented in the sections below.

6.3. Effect of cross-cultural instructional approach on the learners' conceptions of lightning

Aikenhead (2000) argues that cross-cultural approach to science teaching affords learners access to tools for dealing with potential conflicts that might arise between scientific and traditional worldviews about diverse natural phenomena. Fakudze (2003) and Jegede (1997) claim that the mind of an African learner functions within a unique traditional socio-cultural environment and that his/her success in science is dependent on the mediating structures or processes embedded in the socio-cultural environment. Drawing inspiration from African scholars (e.g. Jegede, 1995, 1997, 1999; Ogunniyi, 1997), Fakudze (2003) argues that often an African learner finds himself/herself having to cross the cultural border between his/her African worldview and that of school science as he/she learns scientific concepts presented to him/her in the science classroom.

The need for the back and forth cultural border-crossing was deliberately established by the nature of the cross-cultural instructional approach used in this study, which facilitated presentation of scientific and traditional conceptions of lightning and promoted collateral and contiguous learning as explicated by Jegede (1997, Ogunniyi, 2007a and b). Other characteristic features of the cross-cultural instructional material were collaborative and inquiry-based learning. The learners were engaged in simple electrostatic experiments where they observed and collaboratively discussed explanations of the observations. It could be argued that aspects of learning assisted the learners to become critical thinkers (Totten, Sills, Digby, & Russ, 1991) and helped them to cross from traditional conception of lightning to the scientific one. The cross-cultural instructional material assisted in identifying the cultural borders between scientific and traditional conceptions of lightning (Aikenhead & Otsuji, 2000). Evidence of this perceptual change towards science is reflected in the learners' responses to stories 1, 4, 6 and 8. For an example, during pre-test, 15 out of a total of 36 (compared to 14) of the learners did not believe that the traditional doctor was struck by lightning because he was not qualified and fully embedded in the ramifications of traditional lightning control.

According to Jegede (1997), collateral learning represents a process whereby a learner in a non-Western classroom constructs, side by side and with minimal interference and interaction, Western and traditional meanings of a concept. In this study, the side by side construction of lightning was deliberately guided by the use the cross-cultural instructional approach.

The pre-test showed that a majority of the learners 24 (69%) as against 9 (3%) that rejected traditional conception and responded in scientific terms, believed in the traditional doctor's ability to control lightning. Initially, the learners used parallel collateral learning as they were first introduced to the scientific conception of lightning and allowed this new information to coexist with the traditional one (Duschl et al, 2006; Jegede, 1997). Because of this coexistence, an intellectual dialogue between these competing ideas ensued (Ogunniyi, 2005). The intellectual dialogue and the processing of both conceptions resulted in what Jegede calls simultaneous collateral learning the characteristics of which include learners finding differences and similarities between the conceptions.

In this study, the learners were able to state similarities and differences between lightning as understood in the traditional corpus and scientific worldview. Some of the learners argued that the traditional doctor's version of lightning was based on belief rather than testable evidence, which could be interpreted as acceptance of the scientific enterprise. The learners accepted that ability to distinguish between belief and empirical evidence is a source of knowledge and that evidence supports truth of a claim and its plausibility (Duschl et. al, 2006). Prior to the introduction of the cross-cultural instructional approach, the learners believed that only the "man-made" lightning kills and destroys property while the "natural one" strikes trees and rocks and never strikes people. However, after being introduced to the scientific conception, they agreed that both forms of lightning are equally dangerous to human beings.

Dependent collateral learning was also observed in this study. One of the indicators of this type of learning is rejection of a currently held conception and embracing the new one, which is a result of one schema challenging the other (Jegede, 1997). Several learners rejected the notion that a traditional doctor can control lightning and accepted the scientific one, which perceives lightning in terms of charges.

Secured collateral learning results from the learner questioning the validity of assumptions from conflicting knowledge systems. Jegede (1997) goes on to explain secured collateral learning. He states that:

> *A situation of reinforcing the schema learned in one worldview by a similar one from another begins to occur. The learner evaluates seemingly conflicting worldview or explanatory frameworks and draws from them a convergence towards commonality. This strengthens the learning process and secures the 'new conception' in the long term memory (p.77)*

The cross-cultural instructional approach made the learners to scientifically explain why traditional doctors make use of a long pole at the end of which is a sharp metal smeared with medicinal concoctions as protection against lightning. Learners applied scientific ideas to explain this traditional understanding. This resulted in secured collateral learning.

I will attempt to apply the "African Learner Model" proposed by Fakudze (2003) to tease out what probably influenced this group of learners to be more favourably disposed to the scientific explanation rather than the traditional doctor's viewpoint. To do so, I applied figure 5.1, which is from Ogunniyi (1988). The scientific conception of lightning strikes was presented to the learners who already had the traditional and religious understanding (prior knowledge). The traditional understanding states that "man-made" lightning strikes people and a stronger traditional doctor cannot be struck by it, while religion teaches that God is our protector and through prayer we can access protection against lightning. It should also be recalled that the traditional doctor in his presentation reinforced this traditional understanding. The three types of information were related and compared probably on the basis of their applicability and plausibility, which is a consequence of believability (Duit & Treagust 2003; Duschl et. al., 2006; Ogunniyi, 2005). Under these circumstances, one cannot overrule the possibility of assimilation whereby scientific conception dominated the traditional thought system (Ogunniyi, 2005) or the replacement of common-sense conceptions about lightning (Aikenhead, 2000). This group of learners could have experienced some form of dissatisfaction (Berlyne, 1970; Fullan, 1991; Osborne & Freyberg, 1985; Posner et al, 1982) with the traditional conception of lightning and accepted the scientific one because of its applicability in explaining why the traditional doctor was struck by lightning. It could also be argued that the learners are shifting towards logical positivism – the view that the content of empirical concepts and the evidential support for beliefs about the world must derive from sensory experience (Sankey, 2000). However, it should also be noted that it is not only logical positivism that looks at empirical evidence. Even within IKS, sometimes there is need to have evidence. The learners rejected metaphysical statements such as "the traditional doctor had been bewitched" because such statements lack scientific verification and their explanation or confirmation using cultural conceptions is most difficult (Jegede, 1997). Fakudze argues that all this tussling between conceptions takes place in what she calls "working memory" and the result would be a form of border crossing as explicated by Aikenhead (1996).

Several scholars (e.g. Aikenhead, 2000; Aikenhead & Otsuji, 2000; Jegede & Aikenhead, 1999; Ogunniyi, 2005) perceive learning as a cross-cultural event for many learners. Duschl et al., (2006) acknowledge the complexities and challenges of science learning. They argue that science learning presents a special challenge to educators and learners because of both diversity and complexity of mature scientific knowledge. They go further and state that one challenge in teaching and learning science is to understand learning progressions by which learners bridge their starting point and the desired learning outcomes. As noted in this study, the learners' starting points included traditional and religious worldviews of lightning. The results of this study indicate that for those stories that had a clearly stated scientific knowledge-base, the learners showed a significant change in accepting the scientific claim and rejecting the traditional ones.

The study also showed that 14 (40%) of the learners remained loyal to the traditional conception about lightning and rejected the scientific explanation that the doctor was struck because charges went through him. This is not surprising since negotiating transition between everyday thinking and the thinking valued in domains like science is a challenge for all learners. This transition may be particularly difficult for learners who have had less experience with the forms of reasoning that are required in science classrooms (Duschl et al., 2006, Driver et al., 1994) puts it succinctly when she said that border crossing between the culture of science and the culture of everyday world is demanding for all learners. However, it may not be proper to claim that for this group of learners, the border crossing was impossible because it never was the intention of the cross-cultural teaching strategy to force the learners to cross the border between their worldview interpretations of lightning to the scientific ones. Rather the instructional material was meant to enhance their valuing who they are (Aikenhead, 2000) and the extent to which they believe in their traditional worldview. The traditional conception of lightning remained viable and retained its higher status and ascendancy, the subsequent of which rendered no conceptual change (Duit & Treagust, 2003; Duschl et al., 2006) and the scientific one was not relevant. This group of learners took the traditional doctor to be an authority in matters of this nature and as such should be believed (Halloun and Hestenes, 1985; Lixun, 2004; Stephens, 2003). This is the group that rejected the scientific interpretations and remained *entrenched* in the traditional worldview.

There is another interesting group, 6 (17%), the one that responded using both conceptions. To illustrate, I once again present what one of these learners, Thabo, wrote:

> *Because there is a lot of charges during thunderstorm, I think the doctor did not do his medicines well, so lightning conducted with his spear and charges went through the spear, then through him.*

Here we see the use of knowledge from two different and collaterally positioned schemata – the traditional worldview and the scientific worldview (Aikenhead and Jegede, 1999) to explain how the Ngakamatsetsela was struck by lightning. The first part of the statement that says *there is a lot of charges during a thunderstorm* is from the scientific worldview. However, the next part, *the doctor did not do his medicines well*, is from the traditional worldview, while the last point is from the scientific conception. This can be interpreted as an example of simultaneous collateral learning, whereby the learners deal with the conflict by combining the two to form a confluence of worldviews. This could also be seen as a manifestation of what Ogunniyi (2005) calls the intra-dialogue within the schemas where each schema contributes in the discussion.

It could be argued that border crossing is not one-directional; on the basis of the outcome of self-conversation, a learner is capable of moving back and forth between worldviews. The learners were able to identify some of the differences between scientific and traditional interpretations of lightning. The differences between the two knowledge systems have been well outlined by some authors including Ellen and Harris (2000).

The studies reviewed above and in the previous chapters, focus on the two distinctly different schemas in the mind of the learner and propose how the learner deals with these differences. This study has shown that there could possibly be another state to those proposed by Ogunniyi (2002), namely cognitive confluence, whereby the conflicting ideas are brought together to form something new. All these cognitive states are context dependent and very fluid and temporary. A learner may exhibit one cognitive state in a given context but exhibit another when the context changes. This conceptual change is context-driven (Duit et al., (2003). The inconsistency of the learners to hold on to one conception was observed by amongst others, Hallooun and Hestenes (1984). Halloun and Hestenes observed that many students held Aristotelian and Newtonian physics about motion. Below I provide explanations of the observed cognitive states.

Cognitive confluence: The learners who use this mode of cognition merge the ideas together (Gilbert, et al., 1982; Jung 1993) to form a confluence of the two. For example, one learner from the group exposed to the cross-cultural instructional approach argued that a traditional doctor who evoked lightning becomes charged. Here we two systems of knowledge being brought together. This is similar to syncretism, which is defined as the mixing of different philosophies or ideas. Arguably, whatever comes out of this confluence may not necessarily be logical and systematic. However, to the learners, particularly 14 to 16 years of old, may not realize this. The process of putting together conflicting ideas from scientific and traditional worldviews, results in distortion as the learners attempt to reconcile the two contradictory beliefs (Duschl et al., 2006). The non-logical reasoning and inability to make a decision has also been observed by Kolstoe (2003), who further cites other researchers as having found similar results. For an example, learners equally accept both scientific and traditional safety precautions. Learners in this category deal with the conflict by what Chinn & Brewer (1993) call 'peripheral conceptual change'.

Cognitive Dominance: Learners who use this mode in dealing with conflicting ideas subscribe faithfully to one knowledge system. They draw examples from it to explain or elaborate a point. For instance learners in this category use the concept of the flow of electrons to explain how the traditional doctor was struck by lightning. Learners argue that the traditional doctor should not have used a spear to divert the storm. The scientific conception in this case is powerful enough in explaining why the doctor was struck by lightning. However the learners still believe that a qualified traditional doctor can divert a storm (traditional thinking), but in doing so, the doctor should not use a metal which is a conductor (scientific thinking).

It is possible that learners who operate using this mode appeal to one worldview to explain an event, but still consider it inferior to the other. For example, some learners argue that even if lightning is a flow of electrons (appealing to the scientific view), a well qualified traditional doctor cannot be struck by lightning (traditional worldview). Hewson (1991) claims that the newly acquired conception (in the case at hand, scientific conception of lightning) does not generate dissatisfaction; it is then captured alongside the old.

6.3.2 Effect of the cross-cultural instructional approach on attitude towards science

One of the key factors contributing to the learners' participation in the teaching and learning of science is interest and motivation (e.g. Millar & Osborne, 1998). The learners' motivation and attitude towards science play a critical role in science learning, fostering learners' use of effective learning strategies that result in deeper understanding of science (Duschl et. al, 2006). Their interest in science is also dependent on strategies employed by the teacher (e.g. Odubunmi & Liphoto, 1999). Activities such as actively speaking, listening, responding discussion and exchange of ideas among learners have been found to promote interest and productive participation which is characterised by learners in a group being engaged in cognitive activities such as testing, providing empirical evidence, and explaining their observations, resulting in intellectual progress (Duschl et al, 2006). All these activities formed a critical component of the cross-cultural instructional approach. The study by

Odubunmi and Liphoto (1999) corroborate other findings of the Relevance of Science Education (ROSE) that secondary school learners in the South of Sahara are generally interested in science (Schreiner & Sjoberg, 2004). ROSE collects information from learners about their opinions on factors that have a bearing on Science and Technology (S&T) including their motivation to learn Science and Technology. Lesotho participated in the ROSE-project and it was found that Lesotho learners expressed a high opinion on items dealing with science, technology and society, trust in science, the future and the environment, experience with school science, future work, plans and priorities, working with science or technology.

In this study, the cross-cultural instructional approach did not seem to have much effect since the learners were already positive about science. This is interesting when one looks at the fact that 40% of the learners rejected some scientific conceptions of lightning. The study ran short of determining whether the learners' attitude towards science is a result of their experience of educational, social and cultural environments (Duschl et al., 2006). It should also be remembered that attitudinal change is a complex process that takes time and it was not possible to measure or determine the effect of the material in the limited time scope of the study. But it is hoped that the input made by the well selected and implemented strategies will contribute and impact an evolution of appropriate attitudes among learners encountered in the study.

6.3.3 Effect of the cross-cultural instructional material on performance

Performance in science is incumbent upon several factors, including learners' interest in the subject and teaching strategies employed by the teacher. Naidoo (2003) undertook a study in South Africa regarding factors and processes that contribute to good performance in physical science. He came up with a pool of process indicators at various multi-level frameworks of context, school, classroom, teacher and student. At the student level, he identified positive attitude towards science and the school as prerequisite for good performance in physical science. It has already been mentioned that all the learners in the study were positively inclined towards science. The study has also shown that the learners exposed to the cross-cultural instructional approach performed better than those not exposed to the material. This finding is in-line with Naidoo's (2003).

6.3.4 Dealing with conflicting worldviews

The literature is replete with statements suggesting that the scientific worldview and the traditional worldview are incompatible and that African learners experience cognitive conflicts when they get to school to learn school science. Jegede (1997), defining collateral learning, suggests that there is minimal interference between these worldviews. The learners in this study do not seem to have experienced much cognitive conflicts. This finding corroborates the findings of Ogunniyi (1988). In his study, Ogunniyi found that the traditional and scientific worldview might not always be in conflict with each other. Learners in this study seem to sieve the information from both worldviews in their Working Memory (Fakudze, 2003) and place it in different mental compartments for retrieval depending on circumstances and context.

This study has shown that learners deal with the 'perceived' possible conflicts by moving among three cognitive states: cognitive confluence; cognitive preference; and cognitive entrenchment. They adopt a pragmatic approach and choose whichever cognitive state would function in a given context. This movement between cognitive states is not surprising since the acquisition of scientific knowledge is not always smooth, but calls for 'paradigm shift' (Roschele, 1995). As deliberated in section 6.3.1, the learners in this study seem to deal with incompatibilities and irreconcilables by using what Hewson and Hewson (1984) call 'conceptual status'. According to them, the status of an explanation of a concept is context-specific. Duit, (2003) argues that learners "will be able to learn science concepts and principles only if they are aware about their shift of their initial metaconceptual views towards the metaconceptual perspectives of science knowledge" (p. 675).

The cross-cultural instructional approach made the learners to be aware of their meta-conceptual views about lightning and at the same time provided them with a choice to shift or retain their traditional perspective. The shift towards science requires a long time and a socially rich context (Roschele, 1995) and one would not expect learners to deal effectively with conflicts within a period of two months. It is not surprising therefore to see the learners oscillating between the scientific and traditional worldviews. Roschele argues that "scientific knowledge is not a type of knowledge, but rather a refined product, for which prior knowledge supplied the raw materials and social interaction supplied the tools" (p.5).

The oscillation between scientific and traditional interpretations of lightning could also be interpreted as 'cognitive patch-up' where learners patch-up inconsistencies in a superficial way without really experiencing any conceptual change (Kang et al., 2005).

6.3.5 Integration

The findings of this study suggest that integration of indigenous knowledge and school science is a viable possibility. This stance concurs with earlier recommendations in the area as well as organizations promoting such integration. For an example, the Native Science Annotated Links (2004) published web pages of at least 50 organizations involved in indigenous knowledge and scientific worldview. Such organizations include those that support scientific research that enhances cultures and protection of indigenous cultures and those that consider indigenous knowledge and the carriers of traditional knowledge as important. The IK Monitor articles of 1993 up to 2003 show the following as areas where people have shown a lot of interest for integration: medicinal plants, conservation of wild-lands, land-resources and use, water management, weather prediction, agroforestry systems. Jones and Hunter (2003) claim that:

> *The new paradigms in education emphasize localism and globalism make the enshrinement of indigenous knowledge into the national curricula an ideal situation from which to begin developing the necessary social, cultural, and educational capital necessary to become an equal participant in the global community (p.1)*

In their support for integrating Maori indigenous knowledge into Western science instruction, Jones and Hunter call for the definition of science from the multicultural perspective (Aikenhead, 2000). They argue that issues of Western epistemological domination and cultural imperialism must be explicated. The traditional doctor, the science teachers, the chairperson of the science panel and the expert in the Sesotho language and culture involved in this study, are all in support of the integration. Lucarelli (2001) claims that the integration of local knowledge with the science curricula in Thailand yielded impressive results, which include opening up classrooms to student-centred learning approaches and preserving local knowledge. We see in this study, what Odora-Hoppers (2002) calls the objects of analysis becoming speaking subjects and defending their own knowledge system. Barton and Yang (2000), drawing from several feminists and critical science educators, appreciate the importance of allowing students to appropriate the scientific concepts and practices as long as the practices connect to the students' out-of-school lives. However, the different interviewees differ on how such integration should be carried out. The chairperson of the science panel is of the same view as Barton and Yang. For her, there is need for a connection between school science and the learners' out-of-school lives.

The input of this study has been to adopt a systemic approach, which would require that all the people who have interest in the matter be adequately represented in discussing the modality for such integration. The chairperson of the science panel argues for what Aikenhead (2002) would call a token addition, whereby only those issues of the indigenous knowledge that enhance the understanding of scientific worldview are added. Sommer et al., (2004) seemed to propagate this mode of integration. In their opinion, the use of traditional knowledge in science lessons gives added depth and meaning to difficult scientific concepts.

Some stakeholders interviewed e.g. Sesotho expert and traditional doctors, seem to point in the direction of a holistic approach whereby even those aspects of the indigenous knowledge that are not acceptable in the scientific paradigm be taught so long as they have value in the lives of the people who are the beneficiaries of the education system. Going beyond the limits of science may not sound palatable to modernists. For example, the South African Minister of Health is currently being requested to resign by some members of the scientific community for emphatically encouraging the use of beetroot, garlic and African potatoes as viable means to combat the HIV/AIDS scourge. However, the Sesotho language expert, who is also a custodian of the Sesotho culture, is in favour of teaching science as understood in the realm of modernity where it is seen to be consistent with empirical evidence. In teaching IKS, he advocates for a holistic approach whereby the two knowledge systems (IKS and Science) are compared. The study further shows that the level of scepticism increases when the learners are exposed to conflicting knowledge systems.

The process of integration is pregnant with dilemmas and cognitive conflicts for the 'science' teacher. Being the product of the scientific discipline and at the same time socially engineered in traditional customs, belief systems and values, when real conflicts do arise, the teacher may not know how to help the learners to undertake border crossing in either direction. The teacher is likely to push and recruit the learners to accept his/her own point of view. This has implications for teacher training. Student teachers in teacher training institutions will have to be educated on how to guide learners to undertake border crossing.

The study further shows that integration of science and IKS might divide the learners into three main groups; those that will embrace the scientific conception and reject the traditional knowledge; a group that will accept both systems of thought and those that will remain traditional and reject the scientific explanations. The size of each group will vary with the context and the concept under discussion. The outcome of the intra- and inter-dialogue (Ogunniyi, 2005) between the two systems of knowledge is likely to depict multiple perspectives such as: cognitive confluence; cognitive entrenchment; and cognitive preference, which have been found to be context bound.

One cannot ignore the fact that religion will have to be taken into consideration during integration. It became clear during the traditional doctor's presentation that religious values and morals have had some impact in the learners' experiential life and they were asking him questions based on their religious background and fluid. For example, one learner asked the traditional doctor whether he believed in God. Also, some learners suggested that they would use holy water and pray rosary as a form of protection against lightning.

Integration of the scientific and the IKS worldview about lightning with the scientific conceptions does not imply that all the learners would reject the scientific explanations and accept the traditional ones. What the study has shown is that depending on the concept under discussion, the reverse could be true. This could be interpreted as suggesting that the learners' level of scepticism (Good and Shymansky, 2001) tends to increase as the learners are exposed to both knowledge systems. This phenomenon could be interpreted as cross-cultural event (Aikenhead, 2002; Cajete, 1999; Maddock, 1981; Sutherland, 1998). However, this needs to be investigated further.

It is interesting to note that traditional doctors seem to be willing to talk about their practice. This was shown by the fact that one doctor was agreeable to learners asking him questions about his practice. Furthermore, during the workshop, the traditional doctors were again openly discussing their medicines with nurses and accepting ideas and pieces of advice from the nurses and workshop organizers. During my interview of a traditional doctor who was not present at the workshop, he was much willing to talk and to go to school and share his knowledge with the learners at school. However, he was well aware of the cognitive dissonance that was likely to arise in the minds of the learners as result of his answers to their queries. He therefore suggested that the learners' age be taken into consideration. In other words, he would not like to discuss smatters beyond the cognitive level and maturity of the learners. This accords with the Piagetian theory of cognitive development.

6.4 Summary

In summary, this study has shown that:

Initial conceptions about lightning and thunder:

1. Lesotho grade 9 learners come to school with traditional and some scientific conceptions about lightning and thunder. Prior to being introduced to school science, learners do not seem to experience any cognitive conflict. They have some scientific conceptions probably as a result of some overlap between IKS and science.

Effect of the cross-cultural instructional approach

2. In general, the cross-cultural instructional approach seemed to help the learners accept the scientific conceptions of lightning and thunder and reject the traditional ones. The learners see the scientific conceptions as explainable.
    - Learners apply scientific conceptions to explain some traditional practices.
    - They sometimes mix both conceptions in describing a phenomenon.
    - The cross-cultural instructional approach has made some learners to move back and forth between the traditional and scientific conceptions of lightning and thunder depending on circumstances and context.

Effect on attitude towards science and culture

3. The cross-cultural instructional approach has made some learners to remain loyal to the traditional conceptions of lightning and thunder depending on circumstances and context.

4. The learners were found to be positively inclined towards science. Science is held in high esteem by the learners and the cross-cultural approach managed to maintain this status.

5. Learners were able to identify some of the differences between scientific and traditional interpretations of lightning and thunder.

Integration

6. It is hypothesized that:

    - Integration will enhance dialogue between school science and IKS, which at times are found to be conflicting.
    - A systemic and holistic approach to integration is critical. All stakeholders will need to be consulted about the best strategy to be adopted during integration.
    - With integration, the level of scepticism (a requirement in the scientific) will be greatly increased.

CHAPTER 7: CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Introduction

The study aimed at finding out grade 9 learners' conceptions of lightning and determining the effect of an exemplary cross-cultural instructional approach on their conceptions of lightning and thunder. This approach had both traditional and scientific conceptions of lightning and thunder. The pedagogical teaching approaches adopted included inquiry-based processes which focus on processes such as performing electrostatic experiments, observations, individual articulation of explanations of observations, group discussion of observations, diagrammatic models, allowing learners to try out their own ideas, plenary sessions and presentations by traditional doctor.

In pursuance of this aim three groups of learners were exposed to different instructional strategies on the topic about electrostatics. The experimental group (E) and the control group were pre-and post-tested. However, only E and control group 2 (i.e. post-test only) were exposed to the cross-cultural instructional model. The true control group (C_1) through pre- and post tested was only exposed to the traditional expository instructional approach. Also various stakeholders: teachers, curriculum developer, traditional doctors and an expert in cultural issues were interviewed. This chapter reports the outcomes of the study and their implications.

7.1.1 Learners' Pre-Conceptions of Lightning and Thunder and effects of the instructional material on the conceptions

Learners' conceptions of lightning and thunder and their attitude to science will be summarised in terms of three themes namely control over lightning, humanistic/animalistic nature of lightning, and protection against lightning.

Control over lightning: Learners have the conception that traditional doctors have supernatural powers to make, control and manipulate lightning. They believe that the degree of control is dependent on the knowledge and medicinal fortification of each doctor. The cross-cultural instructional material that integrates both the scientific and the traditional conception of lightning seems to have had some impact on this conception in that after being exposed to the cross-cultural instructional approach, they rejected the idea that a traditional doctor has some control on lightning. Learners do not seem to experience any cognitive conflict. They compared the scientific and traditional conceptions and on the basis of their comparisons, decided which one was plausible. A good number of learners of the experimental group (E) and control group (C_2) found the scientific conception more viable and adopted it, while at the same time other learners retained the traditional conception as presented by the traditional doctor.

Humanistic/animalistic nature of lightning: Prior to the introduction of the cross-cultural instructional approach, learners believed that lightning could hurt and punish anyone who ill-treats or kills Scopus umbretta. Lightning was seen as a bird; and as such it was supposed to lay eggs and wherever it stroke, it urinated. Learners were attributing animal characteristics to a conception that has no mass and does not occupy space. One learner had had problems in attributing humanistic aspects to lightning. For this particular learner, this conception was unacceptable.

In sum, the cross-cultural instructional approach has had some effect on this anthropomorphic belief about lightning in that some learners were able to subsequently express scepticism and started to be doubtful about the humanistic/animalistic nature of lightning.

Protection and safety precautions against lightning: It is common belief that some tradition doctors are capable of evoking lightning and in a position to protect someone from being struck by lightning. The learners too were of this opinion. The protection depends on the strength or medicinal fortification of the traditional doctor.

The cross-cultural instructional approach has had a significant effect in shifting a good number of learners to adopt the scientific methods of protection of using a copper strip to create a path for charges. However, there was an increase in the number of learners who opted for ‘double’ protection derivable from the lightning conductor and IKS such as not standing under tall trees including willow tree, a plant believed to be prone to lightning strikes. Other precautionary measures indicated by the learners include not using water, avoiding playing outside, and avoiding riding on horse-back.

In some, the cross-cultural instructional material does not seem to have changed the learners’ perceptions of lightning considerably. Rather, the material seemed to have provided the learners the scientific conceptions of lightning in addition to the prevailing IKS notion in their cultural environment. To the individual learners strongly embedded in IKS notion of lightning and thunder, what the instructional material has done perhaps, was to introduce another schema of lightning and thunder to the already existing traditional one. In some instances the scientific conception of lightning was preferred to the IKS version while in other context, the reverse was the case. Looking at this through the contiguity principle lens, the instructional material has placed the learners to that state of cognition where one would be able to recognize the dominant, suppressive, assimilative and the emergent states. Neither could it be concluded that the two systems of thought are exacting equal forces (Ogunniyi, 2005) in the minds of the learners since they readily found different ways of dealing with conflicting worldviews. All one can say at this stage is that the cross-cultural instructional approach helped them to move freely back and forth between the two knowledge systems and placing different status of each depending on the context.

7.1.2 Effect of the exemplary instruction approach on attitude towards science

As a result of the instructional material, the learners have enhanced their already positive attitude towards science as evidenced by the attitude scale instrument. The enhancement could be as a result of using pedagogical methods such as handling and manipulating apparatus, use of clear worksheets, allowing them to dialogue within themselves (intra-dialogue) and between other individuals (inter-dialogue), plenary sessions where the learners were exposed to the scientific worldview. More importantly, the use of what Jegede and Aikenhead (1999) call a "cross-cultural pedagogical paradigm" might have helped to enhance the already positive attitude towards science.

However, the effect of this approach on learners' attitude towards their culture needs to be revisited. According to this study, their attitude towards wanting to know more about their culture seems to be declining with more exposure to science in spite of situating the learning/teaching within the context of their environment.

7.1.3 The way learners deal with two irreconcilable and incompatible worldviews

Some of the learners traverse between the traditional worldview and the scientific one without experiencing any cognitive dissonance while others clearly stated that they experience confusion. If learners are given a chance, they use both conceptions at the same time, at the same place and under the same context. While this could be explained in terms of what Jegede (1995, 1996, 1997) calls collateral learning, the separate schemata do not seem to conflict – learners do not experience ongoing cognitive dissonance, probably because they readily found ways of dealing with the apparent conflict. It could be argued that this was achieved by using what Jegede (1995) calls conceptual eco-cultural paradigm whereby I started by generating information about the learners' everyday experience on lightning and thunder and by so doing identifying theories and belief systems that guide the communities practices towards lightning; allowing the learners to use their language the result of which was to promote discourse and providing them with the canonical science. However, the cross-cultural instructional approach also revealed that those traditional beliefs and practices on lightning that could not be directly explained using scientific conceptions remained problematic. Such beliefs and practices include witchcraft and belief in the ancestors.

Although Onwu (2004) and Odora-Hoppers (2002) warn against using processes from another system of knowledge to measure the worth of knowledge claims in the other, this study has shown that if the knowledge systems are integrated, i.e. co-presented', integration militates against this warning. The learners will continue to assess claims within the supernatural world using the processes that obtain in the scientifically explainable natural world. The on-going dialogues (inter- and intra) that take place within and between individuals mediate this behaviour.

7.2 Recommendations and implications

7.2.1 Teachers

Teachers

It has been found that teachers are for integration. They accept some traditional practices and at the same time accept scientific worldview. The teachers reflect some cognitive dissonance as a result of the two worldviews.

It is important therefore that before Lesotho embarks on the integration of indigenous knowledge system and school science, teachers need to be instructed in the nature of both knowledge systems. They have to know how to access the knowledge that learners bring to school and how this knowledge impacts on the school science. There is need for them to conceptualise what the integration means to them and how they should deal with the learners. In-service training will need to be strengthened and organized for teachers who are already in the field. It is very important to teach science in such a manner that learners will understand the conventional scientific view of the topic under discussion. To achieve this, strategies such as exposure to real life experiences, demonstrations, productive participation, group-work, practical work and collaborative learning have proven to be useful. More importantly, we live in the world whose economy is technological driven. It is critical therefore to relate what is taught to its technological use in everyday experience.

Cross-cultural teaching strategies suggest that teaching should be situated within the everyday experiences of the learner, which may include cultural and traditional practices. Let the same topic be presented and discussed from the cultural perspective as well. If need arises that comparisons are made and contradictions are discovered, it is but sensible to discuss them. For an example saying that lightning lays eggs contradicts science that says that birds lay eggs. I concur with Norris and Korpan (2000) who claim that respect for a plurality of ideas can be achieved by addressing reasons and explanations for beliefs and actions. Norris & Korpan proposed that where the propositions of science and tradition overlap, and where they conflict, the science teacher – culture broker (Aikenhead, 2000) should take this opportunity to help the learners understand the conflict, discuss it, and to seek to resolve it. Thus teachers will be making use of the inter-dialogue and intra-dialogue as expounded by Ogunniyi (2005). It should be recalled that one purpose of science learning is to develop critical thinking in the learners.

7.2.2 Removing prior-conceptions

As mentioned previously, the learners' conceptions of lightning and thunder are the consequences of the structural couplings between the learners and their community. It may not be wise therefore, to try to remove these dispositions. To do so, would amount to alienating the learners from their community. In these lessons, nothing was said about the importance of understanding lightning from the traditional perspective. However, learners were made aware of the protective measures they could adopt to safeguard themselves against lightning. It is therefore recommended that integration should consider the applicability of a traditional scientific and traditional knowledge that has to be taught at school. It is not enough to argue that the traditional knowledge has sustained the lives of our ancestors for centuries. Learners in this study do not see the relevance of such an argument since they live in an increasingly scientifically and technologically driven world.

It has been observed that learners mix scientific and traditional conceptions. There is need to explore the implications of cognitive preference, cognitive entrenchment and cognitive confluence on each knowledge system. For instance, it could be easily argued that cognitive confluence is dangerous in that it dilutes the qualities of both knowledge systems. Some people would see it as a confused amalgamation that undermines the authenticity and purity of the knowledge systems.

7.2.3 Effect of the exemplary cross-cultural instructional approach on conceptions of L&T

Using the instructional material, the researcher identified some overlaps between the scientific interpretation of lightning and the traditional one. These are areas where the two systems of knowledge harmonize in the sense that the traditional concepts are not in conflict with, and might even be explained by scientific evidence and concepts (Jegede and Aikenhead, 1999). If a traditional understanding and interpretation concurs with the scientific one, then both systems of knowledge benefit. For an example, traditional knowledge about the effect of tall trees and *moroeroe* (tall loner in an open space) on lightning overlaps with the scientific one and learners were seen to makes sense of the scientific conceptions. This was reflected in the learners’ response to PAT (Physics Ability Test). It is recommended that science teachers should know these harmonizing regions and develop them in such a manner that they mediate enculturation. By so doing, both systems of knowledge are might benefit. This implies that the science teacher should be conversant in both systems of knowledge. If the teacher is not conversant in both, particularly in the traditional cosmologies about lightning, she/he should seek expertise from the community.

7.2.4 Effect of the exemplary instruction approach on attitude towards science

It is incumbent upon the science teacher to use those pedagogical strategies that enhance positive attitude towards science. It has been noted learners in this study were positively inclined towards science. It is recommended that teachers should use those strategies that enhance positive attitude. The strategies identified and applied in this study include relying on cultural mode of instruction, situating content within the experiential life of the learners, practical work, allowing learners to articulate their conceptions, discussions, and plenary sessions, and applying the scientific processes.

During the scientific lessons, the following were seen to be effective in helping the learners to critically review their pre-explanations about a phenomenon: Individual articulation of explanations, discussion, handling apparatus, diagrammatic models, allowing learners to try their own ideas. However, the scientific lessons took more time than had previously been anticipated.

7.2.5 Custodians of IKS

The custodians of traditional knowledge include traditional doctors and healers, parents and other relevant members of the community. There is need to consult with these groups of people to resource this knowledge and rationalize with them about the importance and consequences of the integration. Other Basotho have already done some groundwork on how to access this knowledge. Mokuku (2004) has already identified the role of indigenous knowledge in biodiversity conservation. In his opinion, Basotho have relied on mythology to conserve fauna and flora. Mokuku recommends that myths could be of real value in the protection of fauna and flora and the consequence of believing in them should be discussed in learning contexts such as schools. Mokuku made this recommendation having undertaken a study, which amongst others, showed that it is not only fear that is associated with natural phenomena (the current study might give someone such a wrong impression). There are plants and animals that are allied with good-luck in the Basotho mythology. There are plants that are associated with peace, rain and prosperity (*Khotso, Pula, Nala*). Lesotho is currently plagued with poverty. Maybe time has come for us to see the extent to which Lesotho has harmed and destroyed plants and animals that are mythologically linked. Integrating such ideas to the extent that such animals and plants are conserved and protected has the potential of reversing the intensity of poverty in Lesotho.

7.2.6 Learners

Constructivist accounts of learning abounds that claim that learners are not empty vessels ready to be filled with propositions from the substantive content of science. They come to science classes with information from their traditional worldview. The learners should be allowed to expose this knowledge through discussions amongst themselves and with the science teacher in a welcoming atmosphere.

7.2.7 Curriculum developers

These are key people to the development and implementation of changes in the science policy of any country. The integration is a mammoth task that requires research to form a critical component built within it. The South African Department of Education (2002) reiterates this by stating that:

> *Science curriculum development which takes account of world-views and indigenous knowledge systems is in its early stages and will be addressed with enthusiasm by many educators. The Revised Curriculum Statement creates an invitation for such research and development, and in this way it is an enabling document rather an a prescriptive (p.12).*

There is need to have a more informed understanding of the nature of indigenous knowledge and how this nature compares or otherwise with the nature of the scientific knowledge. For example, the Basotho knowledge system is mainly anecdotal in nature (Wikipedia, 2006). It consists of information passed from parents and others by word-of-mouth, reports of experiences based in individual cases and information that is not based on careful study (Wikipedia, 2006). The Basotho knowledge, like most African traditional knowledge systems, does not exclude witchcraft, supernaturalism and metaphysics whereas the claims of the substantive content of science rely on empiricism, objectivity, reason and reality (Sankey, 2000; Norris & Korpan, 2000). This study has shown that learners believe that lightning urinates, some traditional doctors have the power to invoke lightning, it can be angry, it lays eggs etc. All these are unacceptable in the scientific knowledge system, which thrives, amongst others, on observation, empiricism, falsification/confirmation, replication and measurable evidence.

In the development of the current Lesotho science curriculum, the developers seem to have adopted the topical approach, where the focus is placed on acquiring content and achieving the stated objectives expressed in behavioural terms that require learners to memorize scientific facts, principles and laws. Integration will require a thematic approach with content-process focus where the themes are anchored within the values and needs of the Basotho.

7.2.8 Science Teacher Education

Basotho teacher trainers in Lesotho are the products of the scientific worldview in terms of schooling and traditional worldview in terms of their cultural upbringing. One cannot argue with the notion that obtaining graduate degree in content knowledge contributes to higher learner achievement (Duschl et al., 2006). It is important therefore to ensure that people entrusted with the teaching of science are adequately equipped with high level content. If teachers are also required to integrate science with indigenous knowledge, similarly they need to ensure that they have this knowledge. Teachers have to crate forums where they debate issues pertaining to the rationale for integrating the two incompatible knowledge systems and what has to be left out and why. Moreover, cross-cultural approach needs to be researched further from the epistemological and anthropological perspectives. Teacher trainers are better positioned to undertake such a research.

7.3 Limitations of the study

The most critical limitation of this study is that it is a qualitative one as such it is not possible to make general claims beyond itself. The claims made are about this particular group of learners only. The study focused on one grade at one particular school and one specific topic and context. The population for the study is much less than 120. This implies that the conclusions of the study limit it to grade 9 of this particular school. Subsequently the study would score low on population validity as well as ecological validity (McMillan, 1992). Further still, a limited number of beliefs about lightning and thunder were used. The Hawthorne effect could not be overruled in this study, the consequence of which was to reduce the validity of the study. Control group C_1 somehow found out that I was undertaking a research and a traditional doctor would be coming to teach the traditional conception of lightning. They further noticed that the groups that I was working with were often in the laboratory. They somehow saw some of the worksheets that we were using and subsequently some of them came to me asking why they were not provided the opportunity to work with me. This was a manifestation that an intervention was being added to the normal way of teaching science at the school which was different from the way science had been taught (McMillan, 1992; Fraenkel & Wallen, 1996). Time for the intervention was rather too short. This limitation is well elaborated by Duschl et al., (2006). They argue that for many researches the time scale for most innovative teaching interventions has typically been of two to three months for a particular topic. This time is not adequate.

However, although the context of this study is unique, other contexts might have similar characteristics. Awareness of the characteristics of the contexts of this study, including the instructional approach, the learners and the school context, makes it possible for readers of study to make analysis enabling them to judge the possible relevance for possible future contexts. The possibility of making such analytical generalization implies that qualitative studies can inform action in new context, although it is not possible to make statistical generalization.

However, looking at the interest of all the learners (experimental and control groups) towards science and their culture, all the groups had a positive attitude towards science, which they maintained throughout the intervention. The other threats to internal validity, which could not be totally overruled, include location and implementation. Location has to do, amongst others, with human and material resources (Fraenkel & Wallen, 1996). As mentioned above, the experimental group and treatment group 2 were exposed to more experimentation using resources from the university and the nearby school. Moreover, a traditional doctor came to talk to these groups.

However, the effective use of laboratory facilities and the talk by users of traditional knowledge was a key feature of the cross-cultural pedagogical instructional approach. Nevertheless, in this study several pedagogical approaches were tested in a bundle, and the relative effects of the different approaches cannot be stated. It might well be that the total effects is due to the combination of the different pedagogical approaches. As all approaches are based on recommendations in the literature, it is nevertheless possible to recommend the combination of approaches for future curricular integration.

Implementation is concerned, amongst others, with the person who administered instruments. I did the administration of all the instruments. During the administration of all these instruments, all groups were treated equally except on the administration of the instructional material. It was critical that I administered the intervention so as to ensure the teaching as prescribed by the material. Also, this gave me a chance to interrogate the learners' written and narrated responses. Furthermore, I had to be in touch with the classroom discourses throughout the research period.

Another major limitation had to do with determining reliability of the instruments. It was on a later stage that the items were subjected to Cronbach Alpha coefficient and some items did not hang together, they had a low alpha. In general, these issues limit the results to the sample school.

7.4 Suggestions for further studies

It is recommended that longitudinal study that looks into the extent to which the learners hold on to the traditional conceptions should be undertaken in integrating and con-integrating science classrooms. A topic that appears in the scientific and traditional worldview and covered in the secondary science syllabus could be selected and individual learners followed over a period of five years. In addition, it would be valuable with similar studies to this one focusing on their topics and age-groups. With several qualitative studies from different contexts we will get a fuller picture of different effects of integration on different kinds of learners.

We may want to know the extent to which traditional doctors integrate scientific issues in their everyday practice. The findings of such a study could be taken as examples of how science is benefiting and enhancing traditional practices.

What practices and values are encouraged by the scientific worldview and discouraged by the traditional worldview? For an example, traditionally, girls are discouraged from eating eggs. However, in the scientific worldview, eggs are said to contain proteins, which everybody needs for health reasons. This study found some ways in which learners resolved the possible conflict between worldviews. However, we obviously need more knowledge of learners, teachers and parents deal with conflicts so created.

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Appendices

Appendix 1: Junior Secondary Science Syllabus (New syllabus)

Content	Learning Outcome Candidates should be able to:
8.0 Electrostatics (Form B)	
Positive and negative charges; positive (+) and negative (-) signs used to represent charges. Charging by friction. Electrical conductors and insulators. Charging by induction. **9.0 Current Electricity (Form B)** Circuit symbols: switch, ammeter, bulb, voltmeter. Unit of: current – amperes (A), voltage – volts (V) Circuit diagrams: draw and interpret simple circuit connections, reading of ammeter and voltmeter.	Describe how to detect charges using an electroscope. Describe charging by friction. Distinguish between electrical conductors and insulators. Describe charging by induction. Describe how to connect voltmeter and ammeter in a circuit. Describe how to connect a simple circuit, bulbs, cells, ammeter and voltmeter. Measure current and voltage in a circuit containing bulbs, cells, switch, ammeter and voltmeter. State the SI units of current and voltage. Illustrate simple circuit diagrams containing bulbs, cells, switch, ammeter and voltmeter. Interpret simple circuit diagrams containing bulbs, cells, switch, ammeter and voltmeter.

8. Electrostatics (Form C) Effects of charge. Lightning: causes, importance – nitrogen cycle. Safety measures – earthing. Lightning conductor. Application of electrostatic. Local practices about lightning, e.g. *thakhisa.*	Describe effects of charge. Describe how lightning is caused. Describe the hazardous nature of lightning. Describe the importance of lightning. Describe safety measures against lightning. Identify everyday examples where the phenomenon of electrostatics is evident. Analyse some local practices and beliefs regarding lightning. (Notes: effects of electrostatics – dry hair & synthetic hair, feeling shock, seeing sparks; discuss some myths, beliefs about lightning)
9.0 Current Electricity (Form C) Series and parallel connection of circuits. Effects of series and parallel connections. Applications and everyday examples of circuits: torch, wall-watch.	Illustrate a series connection of bulbs in a circuit. Illustrate a series connection of cells in a cicuit. Represent a parallel connection of bulbs in a circuit. Represent a parallel connection of cells in a circuit. Illustrate parallel and series connection of circuits using symbols. Describe the effect of series and parallel connection on brightness. Identify everyday examples of electrical appliances. State examples of devices in which simple circuits are used.

Appendix 2: Junior Secondary Science Syllabus (old version – 1986)

Topic	Objectives	Content	Notes
Electricity **(i) static;**	Learners should be able to: • Recall that electric charges are separated when certain materials are rubbed against one another. • Use correctly the terms positive and negative charges; • State and demonstrate that oppositely charged objects attract, and that objects carrying the same charge repel each other; • Demonstrate an awareness of static electricity in everyday life; • Explain thunderstorms in terms of electrostatic charges.	Electrostatics: frictional charging of plastic rods to demonstrate positive and negative charge. Attraction and repulsion. Static electricity in everyday life. Thunderstorms as frictional charging between air currents and clouds, which discharge to the ground.	Charging by use of plastic rods Reference to everyday experience of static electricity in clothes; sparks and shocks. Discharge an electroscope through wire.

Appendix 3: Unit on static electricity

Background

This unit is based Constructivism, an epistemology that explains how learners acquire knowledge and understanding of nature. Constructivism assumes that humans construct understanding through the interaction of what they already know and believe. Through everyday experiences, people interact with ideas, events and various forms of activities. The strategies used in this unit are based among others, on the findings of Jegede O, and Okebukola O (1991). Their findings reveal that instruction through the use of socio-cultural modes has some significant effect on students' attitude towards the learning of science. This unit provides the pupils a chance to go through a reflective experience whereby they experience a concept and critically try to think through their observations and explanations. It is hoped that this will afford the pupils a deeper understanding of the concept being taught (Halloun, 2004). The teacher's role, among others, includes providing immediate feedback to students with the intention of allowing them to reconsider their ideas. Moreover, the unit encourages students to work together (collaborative learning). The assumption is that when students brainstorm and actively exchange ideas and views, they will engage in critical thinking and clarify their ideas. If in a group one student happens to have a viable explanation, that success will benefit the rest of the group. This particular unit attempts to find out whether this mode would have any effect in improving performance in science learning.

How to use this guide

This guide offers you a rough scheme of work and detailed lesson plans. The Lesson plans are meant as a guide only, which you can change according to your needs and circumstances. The users of this guide are encouraged to take note of the message at the top of each lesson plan. Important features of this guide are activity sheets. These are designed in such a manner that pupils experiment and make observations. They are expected to think through their answers individually and discuss their explanations in a group. Finally, they have to agree on one explanation. During plenary sessions, group leaders present group explanations. The teacher is expected to identify misconceptions and find ways of rectifying them.

University of the Western Cape, 2008

Appendix 4: Scheme of Work

Topic: Static Electricity

Lesson 1 Topic: Creating Static Electricity by **friction**. (80min)	**Learning outcomes:** Pupils should be able to: - State that static electricity is created when objects/materials are rubbed together; - State that charges are separated when certain materials are rubbed against one another; - State that like charges repel and unlike charges attract. -	**Materials needed:** Plastic pens, woollen cloth, thin stream of running water, polythene strips, paper stirrup, plastic threat, cellulose acetate strips, tiny pieces of paper, stand.
Lesson 2 Plenary on the previous lesson. (40min).	**Learning outcomes:** Pupils share ideas and views. They are exposed to the scientific explanations of their observations.	**Materials needed:** Plastic pens, woollen cloth, thin stream of running water, polythene strips, paper stirrup, plastic threat, cellulose acetate strips, tiny pieces of paper, stand.
Lesson 3 Charging by induction. (80min)	**Learning outcomes:** Pupils should be able to: - Describe the process of charging by induction; - Identify the type of charges induced on the surface of the electroscope and on the leaves; - Explain the process of earthing.	**Materials needed:** Electroscope, charged plastic strip, charged polythene strip.
Lesson 4 Plenary for lesson 3	**Learning outcomes:** Pupils share ideas and views. They are exposed to the scientific explanations of their observations.	
Lesson 5 Charging by contact. (40min)	**Lesson outcomes:** Pupils should be able to: - Describe the process of charging by contact; - Identify the types of charges on the surface of the electroscope and leave after contact.	**Materials needed:** Electroscope, charged plastic strip, charged polythene strip.

Lesson 6 Van de Graaff generator: Connecting lightning and static electricity). (80min).	**Lesson outcomes:** Pupils should be able to: - Note that charge accumulates on the outside of the dome; - Note that charge accumulates on sharp points.	**Materials needed:** Van de Graaff generator, pin, fur, wooden stand.
Lesson 7 Lightning and Thunder – Scientific understanding. (40min).	**Lesson outcomes:** Pupils should be able to: - Appreciate how lightning and thunder are produced; - Note dangers of lightning; - Note safety precautions against lightning.	**Materials needed:**
Lesson 8 Lightning and Thunder – Traditional understanding. (80min). Note: It would be wise for the teacher to invite a traditional doctor to teach this lesson. The presence of a traditional doctor is likely to create some commotion. Some people might think that she/he is going to teach witchcraft. It is critical therefore to discuss the purpose of his/her presence with the school administration.	**Lesson outcomes:** - Appreciate Basotho beliefs and customs about lightning and thunder; - Identify differences between traditional knowledge systems and scientific knowledge systems; - Identify scientific knowledge within traditional knowledge.	**Materials needed:**
Lesson 9 Importance of lightning in the fixation of nitrogen (Nitrogen Cycle).	**Lesson outcomes:** - Appreciate the importance of lightning in nitrogen cycle.	

Appendix 5: Lesson Plan 1

Creating Static Electricity

For this lesson, the teacher needs to use the worksheet provided (WSE 1). The purpose of this worksheet is to encourage pupils to think and consider their answers through. The lesson is to be conducted in a laboratory that has running water.

Lesson Outcomes:

At the end of the lesson, pupils should be able to:

- Observe that rubbing plastics creates charges;
- State that static electricity is created when objects/materials are rubbed together;
- State that charges are separated when certain materials are rubbed against one another;
- State that like charges repel and unlike charges attract.

Time	Activity		Remarks
	Teacher Activity	Pupils Activity	
10 minutes	Distributes WSE 1 handouts and explains the activity. Organizes pupils into groups.	Get into groups	It is necessary for the teacher to explain what individual and group activity mean.
60 minutes	The teacher moves between groups mediating learning and ensuring that pupils are on task.	Perform the activities as given in WSSE 1.	Each pupil is expected to write down his/her ideas first and share them with the other members of the group.
10 minutes	Teacher collects the pupils' work at the end of the lesson.	Pupils hand back the activity sheets.	The teacher should create time to study the pupils' work with the intention of identifying their misconceptions and preparing for plenary session during the next period.

Appendix 6: WSE 1: Static Electricity – Charging by Friction (Rubbing)

Pupil's Name: ______________________________

Group: ______________________________

Materials needed:

Plastic pen, thin stream of running water, 2 polythene strips, woollen cloth, paper stirrup, plastic threat, 2 cellulose acetate strips, tiny pieces of paper, stand.

Instructions:

Follow the instructions step by step.

The (a) question you do on your own and the (b) question you discuss your answer with the other members of your group and write the explanation that your group finds to be more appropriate.

1. Rub your plastic pen on your sleeve and hold it near some tiny pieces of paper.

What do you observe?

____

____

____

(a) Individually, explain your observation.

____

____

____

(b) In your group, discuss and explain why this happens.

____

____

2. Rub a strip of polythene (grey plastic) on a woollen cloth and hang it in a paper stirrup using a string

Rub another polythene strip with the same dry woollen cloth and bring it near the hang one without touching.

What do you observe?

(a) Individually explain your observation.

(b) In your group, discuss and explain your observation.

3. Rub a strip of cellulose acetate strip (clear plastic) with the cloth and bring it near the hang polythene strip as in 2 above.

What do you observe?

(a) Individually explain why this happens.

(b) In your group, explain why this happens.

3. Rub the cellulose strip with the woollen cloth and hold (without touching) near a thin stream of running tap water.

What do you observe?

(a) Individually explain your observation.

(b) In your group, discuss and explain why this happens.

Appendix 7: Lesson Plan 2

Plenary for Lesson 1

In a plenary session, group representatives are expected to present their explanations from the previous activity sheet. This discussion is to be facilitated by the teacher. It would be best if this plenary were conducted in the laboratory where apparatus for the previous lesson are also available.

The lesson Processes:

Pupils share ideas and views. They are exposed to the scientific explanations of their observations. The teacher mediates learning in such a manner that finally, through feedback; pupils come to the viable scientific explanations of their observations.

Time	**Activity**		**Remarks**
	Teacher activity	Pupils activity	
20 minutes	Facilitates group presentations.	Group representatives report on their group explanations.	Apparatus should be ready in case there is need to demonstrate a particular activity.
20 minutes	Provides scientific explanations of the observations and discusses these with the pupils. Teacher should summarize the lesson.	May take brief notes.	The taking of notes will depend on the philosophy of the school towards giving notes.

Appendix 8: Lesson Plan 3

Charging by Induction

For this lesson, the teacher needs to use worksheet (WSE 3). Once again, pupils are expected to explain their observations first individually and then in a group.

Lesson Outcomes:

At the end of the lesson, pupils should be able to:

- Describe the process of charging by induction;
- Identify the type of charges induced on the surface of the electroscope and on the leaves
- Explain the process of earthing.

Time	Activity		Remarks
	Teacher activity	**Pupils Activity**	
10 minutes	Distributes WSSE 2 and explains the activity.	Sit in a normal classroom setting.	
20 minutes	Introduces important features of an electroscope (cap, metal rod, gold leaves).	May take notes.	
45 minutes	Supervises groups to ensure that pupils are on task.	Form groups and work on the activity sheet.	
5 minutes	Collects pupils' activity sheets		Once again the teacher should collect the pupils' work to identify their misconceptions so as to prepare for plenary session.

Appendix 9: WSE 3: Static Electricity: Charging by Induction

Pupil's Name: ____

Group: ____

Materials:

Electroscope, polythene strip and woollen cloth.

Instructions:

Follow the instructions step by step.

1. Rub the polythene strip on the woollen cloth and bring it (without touching), near the cap of the electroscope.
   What happens to the leaf?

   ____

   ____

   ____

   (a) Individually explain why this happens.

   ____

   ____

   ____

   (b) In your group, discuss and explain why this happens.

2. Slowly move the strip away from the cap of the electroscope.

What happens to the leaf?

(a) Individually, explain why this happens.

(b) In your group, explain why this happens.

2. Bring a charged polythene strip next to the cap of the electroscope as in 1 above.

With the strip still near the cap, touch the cap with your finger.

What happens to the leaf?

(a) Individually explain why this happens.

(b) In your group, explain why this happens.

4. Perform the experiment as in 3 above. Without removing the charged strip, remove your finger from the cap and then slowly remove the strip.

What happens to the leaf?

(a) Individually, explain your observation.

(b) In your group, discuss and explain your observations.

Appendix 10: Lesson plan 4

Plenary for lesson plan 3

In a plenary session, group representatives are expected to present their explanations from the previous activity sheet. This discussion is to be facilitated by the teacher. It would be best if this plenary were conducted in the laboratory where apparatus for the previous lesson are also available.

The lesson Processes:

Pupils share ideas and views. They are exposed to the scientific explanations of their observations. The teacher mediates learning in such a manner that finally, through feedback; pupils come to the viable scientific explanations of their observations.

Time	**Activity**		**Remarks**
	Teacher activity	Pupils activity	
20 minutes	Facilitates group presentations.	Group representatives report on their group explanations.	Apparatus should be ready in case there is need to demonstrate a particular activity.
20 minutes	Provides scientific explanations of the observations and discusses these with the pupils. Teacher should summarize the lesson.	May take brief notes.	The taking of notes will depend on the philosophy of the school towards giving notes. Key concepts and phrases include converge, diverge, flow of electrons, earthing, etc.

Appendix 11: Lesson Plan 5

Charging by Contact

The worksheet for this lesson is WSE 5.

Lesson Outcomes:

- Describe the process of charging by contact;
- Identify the types of charges on the surface of the electroscope and leave after contact.

Time	**Activity**		**Remarks**
	Teacher activity	**Pupils' activity**	
5 minutes	Distributes WSSE 4	Form groups.	
10 minutes	Explains the activity; moves from group to group to ensure that pupils are on task.	Performs the activity as in WSSE 4	
15 minutes	Facilitates whole class plenary discussions. Gives notes.		

Appendix 12: WSE 5: Charging by Contact

Pupil's Name: ____

Group: ____

Materials needed:

Electroscope, polythene strip, and woollen cloth

Instructions:

Follow the instructions step by step.

1. Charge the polythene strip and then slide it firmly across the surface of the metal cap of the electroscope.

What happens to the gold-leaf?

____

____

____

(a) Individually explain your observations.

____

____

____

(b) In your group, discuss and explain your observations.

____

____

____

2. What charge does the electroscope have?

(a) Individual answer.

(b) Group answer.

(c) Why do you think the electroscope has this type of charge?

Appendix 13: TDWS: Connecting Lightning and Static Electricity

Pupil's Name: ____

Group: ____

Materials needed:

Van de Graaff Generator, woollen cloth and a candle.

Instructions:

Follow the instructions step by step.

1. Place a piece of fur on the dome and start the machine running.
   What do you observe?

   ____

   ____

   (a) Individually explain your observations

   ____

   ____

   ____

   (b) Discuss and explain your observations with someone sitting next to you.

   ____

   ____

   ____

2. Standing on an insulated mat, or on a thick piece of wood, bring your finger slowly next to the doom of the Van de Graaf Generator while running.

   What do you observe?

   ____

   ____

   ____

   (a) Individually explain your observations.

(b) With someone sitting next to you, discuss and explain your observations.

Appendix 14: Lesson Plan 7

Lightning and Thunder – Scientific understanding

The presentation of this lesson should be in a form of teacher-led discussion, teacher exposition and note taking. In teacher-led discussions, the questions must be such that pupils are made to create models of how a cloud becomes charged using ideas and concepts developed during the previous lessons as well as their own constructions. It is important for the teacher to make pupils aware that scientists are yet to understand fully how lightning and thunder are created.

Lesson Outcomes:

At the end of the lesson, pupils should be able to:

Appreciate how lightning and thunder are produced;

Note dangers of lightning;

Note safety precautions against lightning.

Time	Activity		Remarks
	Teacher Activity	**Pupil Activity**	
10 minutes.	Asks questions requiring pupils to recall that: charges can be created by friction; charges can be created by induction.	Respond to the questions through discussions.	
20 minutes	Asks questions that will help pupils to apply concepts they have learned from the previous lessons to explain the accumulation of electrons on the cloud and the subsequent flow from the cloud to the ground.		
50 minutes.	Gives notes on creation of charges on the cloud by rubbing of clouds, creation of opposite charges on the ground by induction, and how thunder is produced. Teacher asks questions relating to what lightning can do (dangers of lightning). Questions should be related to the everyday experiences of the pupils. Teacher asks questions relating to how people protect themselves and their property against lightning. (Pupils will also come up with the traditional ways of protection, which should not be ignored by the teacher).	Take notes; respond to questions (they may even discuss their answers).	It may be necessary at this stage for the teacher to have the Van de Graaff generator ready. It may help the teacher to explain the rubbing (Belt, doom etc.)

Appendix 15: Lesson Plan 8

Lightning and Thunder – Traditional understanding

It would be best if this lesson is presented by a local traditional doctor who has some knowledge about lightning and thunder as well as the traditional ways of protection against lightning. It is very important to brief the doctor about the lesson outcomes.

Lesson Outcomes:

At the end of the lesson, pupils should be able to:

Appreciate Basotho beliefs and customs about the nature of lighting and thunder;

Identify plants and animals associated with lightning;

Appreciate traditional ways of protection against lightning;

Identify differences and similarities between traditional knowledge and scientific knowledge relating to lightning and thunder.

Time	Activity		Remarks
	Teacher/doctor Activity	**Pupil Activity**	
10 minutes	The doctor and the topic are introduced to the class.	Listen.	The teacher should be present throughout the lesson.
50 minutes	Doctor presents the lesson.	Listen and take notes.	
20 minutes	Responds to questions.	Ask questions.	Teacher can also ask guiding questions.

Appendix 16: Lesson Plan 9

Importance of Lightning - Nitrogen Cycle

This lesson should be linked with fertilization of soil for plants. Pupils should be asked questions on types of fertilizers they use at home. Important terms like fixation and denitrification should be taught.

Lesson Outcomes:

At the end of the lesson, pupils should be able to:

Appreciate the importance of lightning during nitrogen fixation.

Time	**Activity**		**Remarks**
	Teacher Activity	**Pupil Activity**	
10 minutes	Teacher asks questions about types of fertilizers used; Components of the fertilizers; importance of nitrogen to plants.	Respond to questions.	
30 minutes	Teacher presents a lecture on nitrogen fixation by lightning; and denitrification by bacteria. (Teacher may also discuss with pupils why grass is greener at a place that had been struck by lightning).	Listen and take notes. Discuss why the grass is greener at lephakatlali).	

Appendix 17: My Ideas about Lightning and Thunder (MILT)

Form: ______________________________

Name: ____________________________________

Sex: M ( ) F ( )

Age:

Read the stories below and tick to show whether you strongly agree **(SA),** agree **(A)**, do not know **(DK),** disagree **(D)** or strongly disagree **(SD),** with the following statements.

Story 1

During a thunderstorm, Mr. Ngakamatsetsela, a well-known traditional doctor, went out of his house holding his metal spear and pointing it in all directions. He was suddenly struck by lightning. People say that:

	SA	**A**	**DK**	**D**	**SD**
(a) He was not a qualified traditional doctor *(ke ngakana ka hetla)*					
(b) He has been bewitched by other stronger doctors					
(c) His spear conducted charges through him.					

What do you say? ____

____

____

Story 2

During a thunderstorm, lightning struck one hut. After the storm, people came to inspect the hut. There was a pool of water at one place in the hut. Some people said that:

	SA	A	DK	D	SD
(a) This was not water but urine of lightning.					
(b) It was possible that indeed this was water.					
(c) The owner of the hut should call a traditional doctor to come and throw the divining bones *(a tl'o laola)*.					

What do you say?

Story 3

Molisana killed a hammerhead *('Mamasianoke)*. The following day Molisana was struck by lightning killing him. People say that:

	SA	A	DK	D	SD
(a) Lightning was angry with him because he had killed the hammerhead.					
(b) He could have been standing on the *lephakatlali* (place where lightning always strikes).					
(c) This happened by accident.					

What do you say could be the reason for his death?

____

____

____

Story 4

Lightning struck Mofokeng's house three times in one year, destroying his radio, television set and telephone. To protect his house, Mofokeng should:

	SA	A	DK	D	SD
(a) See a traditional doctor to strengthen himself and his house.					
(b) Fix a copper strip from the top of his house to the ground.					
(c) Make a prayer feast for his ancestors *(Balimo).*					

What do you say he should do: ____

____

____

Story 5

Motebang was on his way from a supermarket. He had two donkeys carrying bags of maize meal. It started to rain and he covered the bags with plastic and entered one house for protection against the rain. While he was in the house, there was a huge clap of thunder. After the rain had stopped, he found one donkey dead and the three bags of maize meal missing. Maybe:

	SA	A	DK	D	SD
(a) The bags were taken by lightning.					
(b) People came and stole the bags while he was inside the house.					
(c) Nobody really knows how the bags disappeared.					

What is your explanation? ____

____

____

Story 6

During a thunderstorm, people are discouraged from handling water. The explanation for this is that:

	SA	**A**	**DK**	**D**	**SD**
(a) Lightning likes water.					
(b) Water is a good conductor of lightning.					
(c) Lighting lives in water.					

What is your own explanation?

Story 7

Mr. Moshoeshoe was struck by lighting and killed instantly. He had huge wounds on the forehead, mouth and chin. People came to inspect the wounds. They said that:

	SA	**A**	**DK**	**D**	**SD**
(a) The wounds were scratches of the bird of lightning *(tlalimothoana).*					
(b) A witch hit him with a sharp axe or a sword *(sabole)*					
(c) Lightning kills people in a strange way.					

What do you say? ____

____

____

Story 8

Our parents tell us not to stand under a willow tree *(moluoane)* during a thunderstorm. The explanation(s) for this could be that:

	SA	**A**	**DK**	**D**	**SD**
(a) A willow tree attracts lightning.					
(b) Tall trees attract lightning.					
(c) Lightning lays eggs on willow trees.					

What is your own explanation?

Appendix 18: Physics Ability Test (PAT)

MARCH 2004 MARKS: 34 TIME: 2 HOURS

Instructions:

Write your name here: ____

Answer all questions.

---

1. Thabo rubbed his plastic pen on the sleeves of his jersey. He then brought the rubbed pen close to small pieces of paper.

   (a) What will happen to the pieces of paper?

   (The pieces of paper will be attracted to the pen) (2)

   Explain why this happens.

   Rubbing induces a charge on the pen and when the pen is brought near the pieces of paper, a different /opposite charge is induced on the papers. (3)

   (b) Explain what happened to the pen during rubbing?

   The pen gained electrons. (2)

2. Two freely suspended strips, which carry the same charge, are brought close to each other. What will happen to the strips?

   The strips will repel each other (2)

   Explain your answer.

   Like charges repel (2)

3. Two freely suspended strips, which carry different charges, are brought close to each other. What will happen to the strips?

The strips will attract each other. *(2)*

Explain your answer.

Unlike charges attract (2)

4. Two balloons are brought close to each other. If one balloon is positively charged and the other one is not charged, what charge will be induced on the uncharged balloon?

Negative charge *(1)*

Explain your answer.

The negative charges of the uncharged balloon will be attracted towards the positively charged balloon. (3)

5. A positively charged strip is brought near a positively charged gold-leaf electroscope. What will happen to the charged gold-leaf?

It will diverge more (1)

Explain your answer.

Charge on the leaves increases (2)

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

(a) The sparks. *Flow of electrons / charges* *(2)*

(b) The thunder? *Ionisation of air /* *(2)*

7. Explain how a cloud becomes charged.

Water droplets in a cloud rub against each other; the under-part becomes negatively charged and the upper part becomes positively charged. *(4)*

8. Church buildings have a strip of copper fixed to the side of the church. This strip extends high to the church spike. What is the purpose of the copper strip? *(It is a lightning conductor, it conducts charges from the cloud to the earth)*

(4)

9. Write three things that you should not do during a thunderstorm.

Do not touch water; do not touch telephone; do not play outside; do not stand under tall trees *(3)*

Appendix 19: Science and Culture Attitude Scale Questionnaire (SCASQ)

School of Science and Mathematics Education

University of the Western Cape

Science and Culture Attitude Scale Questionnaire (SCASQ)

Instruction: Please respond to all the items with honesty. **All responses will be treated with utmost confidence.**

Section A

Please fill information about yourself.

NAME OF THE SCHOOL: …………………………………………………………………

NAME OF THE STUDENT: ……………………………………………………………….

SEX: …………………………………………………………………………………………..

AGE:

……………………………………………………………………………………………...

(Please turn the page over)

Section B

Below are statements about your feelings towards science and culture. Indicate by marking **X** in the appropriate column, the extent to which you **Strongly Agree (SA), Agree (A), Undecided (UN), Disagree (Dis), Strongly Disagree (SDis)** with each statement.

No.	Items	SA	A	UN	Dis	SDis
1	Science is a very interesting subject.					
2	I like science practical lessons.					
3	I feel quite happy when it is time for science lessons.					
4	I enjoy reading science textbooks.					
5	Science experiments are very interesting.					
6	Doing science experiments is a waste of time.					
7	Doing science experiments makes me understand science.					
8	I really enjoy study science.					
9	I like explaining science observations.					
10	There are too many things to be learnt in science.					
11	Science will be very useful in my future life.					
12	I study science just to pass examinations.					
13	Science knowledge is very useful.					
14	Use of knowledge from science makes science interesting.					
15	I think everybody should be forced to study science.					
16	It is better for me to sleep rather than study science.					
17	Science helps me to understand how things are in nature.					
18	Because of science I love my culture.					
19	Science has nothing to do with my traditional beliefs.					

20	Science confuses me.					
21	Science makes me to hate my culture.					
22	My culture (customs) is more important than science.					
23	Traditional beliefs are confusing.					
24	Studying science and traditional beliefs help me understand better.					
25	I like the way science is taught.					
26	My culture is more interesting than science.					
27	I enjoy listening to stories about my culture.					
28	My culture is easier to understand than science.					
29	Science is not part of my life.					
30	Science is not good for my culture.					
31	I need to know more about my culture.					
32	I need to protect my culture against science.					
33	My culture helps me to love nature (environment)					
34	It is impossible to love both my culture and science.					
35	My culture helps me to live well with other people.					
36	I like learning science.					
37	Science is very difficult for me to understand.					
38	No matter how well I study science, I cannot understand it.					
39	I feel happy when it is time for science.					