Muthi, Science and Lightning - Teaching and Assessing Natural Sciences LO3 at Grade Level 9

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Natural Sciences Learning Outcome 3 (i.e. NS3) for Grade 7 to 9 is amplified by an Assessment Standard, namely that learners should understand science ". . . as a human endeavour in cultural contexts". Teachers are skipping over this outcome, partly because the methodology it requires is new, calls for managing debate on unfamiliar topics, and asks for clarification of world-views rather than single correct answers.

Western science seeks and offers explanations for the material, physical world only in terms of physical relationships, and so other frames of reference are usually not recognised in science classrooms. Yet the majority of South African learners in science grow up within a world-view which accepts that life is not only material but also full of spiritual meanings. The NCS has created an opportunity in NS3 for curriculum development that allows multiple explanations to be discussed in school.

This paper discusses research into learners' and teachers' views of lightning, and gives an example of how the *Science for all* project has this turned into mainstream curriculum material, with guidance for its assessment.

Introduction

The NCS for Natural Sciences, in explaining what Learning Outcome 3 (NS3) means, sets out four possible areas in which learners should show that they . . . "understand the relationships between science, society, technology and the environment." These four areas are

- Learning Outcome 3 calls for the learner to become a scientific problem solver in the context of South African society
- Indigenous or traditional technologies and practices in South Africa were not just ways of working; they were ways of knowing and thinking
- The values of people are seen in the ways they choose to deal with problems, and even in the choice of issues which they want to define as problems
- One of the underlying differences between modern science and technology on the one hand, and traditional and indigenous knowledge systems on the other hand, is the existence of different world-views.

The NCS continues, to say,

> These South African issues create interesting challenges for curriculum policy, design, materials and assessment. 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. This [ ] National Curriculum Statement creates an invitation for such research and development, and in this way it is an enabling document rather than a prescriptive one (p.12)

Thus the NCS is consistent with the principle that some science content should be nationally mandated, and that other content should be left open for development by a variety of educators, such as teachers, advisers, SAASTE groups, examiners, textbook writers, university researchers and curriculum developers.

The main part of this paper is about how the Science for all project has taken up the invitation. But before we go there, it is good to acknowledge the sources of the NS3 content in the NCS.

An influence in the group was a paper by Ivy N Goduka (2000) in which she uses a quotation:

> *The traditional African view of the universe is a spiritual whole in which all beings are organically interrelated and interdependent . . . The cosmos is sacred and cannot be objectified, nature is spirit, not to be exploited . . . All beings exist in reciprocal relationship to one another; we cannot take without giving . . . The mode of harmony (rather than control) which prevails does not preclude the ability to struggle. Spirit is primary, yet manifest in material being.*

This poetic expression captures some of the ideas expressed differently by Aikenhead (1996) in a much-quoted paper where he writes about the difficulty for learners who have to "cross the border" daily between the culture of the science classroom and the other cultures in which they live. Jim Cobern, who presented at the SAARMSE conference in 1994, *Thinking about alternative constructions of science and Science Education*, pointed out in a similar paper (Cobern, 1994) that many learners do not go further with science because " .. the concepts [of science] are either not credible or significant" (p.15). For these students ". . . it is aesthetic, religious, pragmatic and emotional concepts that have scope and force with regard to nature" (p.12)

Those were some of the roots of NS3 in the NCS for Natural Sciences. In South Africa, the working group was aware, the majority of science learners grow up in a culture which may be materialistic in many ways but is constantly aware of an unseen spiritual realm.

The authors of this paper were aware of the importance of the unseen world, especially after the research on lightning conducted by teachers of the Science Education Project (SEP) in the Durban area in 1988. This research took place through the leadership of the second author and was published by SEP under the title "Muthi, Science and Lightning – A source book for science teachers" (Ndlalane, Moodie, Cain et al, 1988). The SEP teachers faced the problem of dealing with a topic that has great importance to their learners, and their learners ultimately asking them to declare their own beliefs about the causes and prevention of lightning.

Science for all, one of the Setlhare Science Curriculum Trust projects, took this research and expressed it in terms of Learning Outcome NS3. This Learning Outcome at Grade 7-9 has an Assessment Standard that asks whether learners understand that science is a human endeavour to make sense of nature, that brings with it cultural ways of dealing with knowledge between people.

Progression in this second Assessment Standard goes as follows:

Grade Level 7: Learner compares differing interpretations of events (this is followed by examples in the document)

Grade Level 8: Learner identifies ways in which people build confidence in their knowledge systems (then examples follow)

Grade Level 9: Learner recognises differences in explanations offered by Natural Sciences and other systems of explanation (then examples follow).

The Grade 9 *Science for all* curriculum material for NS3, Assessment Standard: *Science as a human endeavour in cultural contexts*

Curriculum writers and teachers who want to engage with the worlds of the learners know that their offerings will not excite all learners; the best we can do is create activities which will stimulate debate and fresh thinking in most learners.

This learner material then, is based on the data provided by the inyanga and the electric engineer in the "Muthi, Science and Lightning" documents. It begins with an activity, "Why did the lightning strike that one house?"

It leads toward a position where learners must show that they *understand* how the inyanga and the electrical engineer handle knowledge, each within their own framework of knowing. This stays close to the Assessment Standard and it does not put either teachers or learners in a position where they have to make a choice between the view of the scientist and the view of the inyanga. Such choices lie outside the realm of the science lesson; however, what we **did** want to show is that the views of the inyanga are not taboo; they can be meaningfully discussed in a science lesson. In other words, when learners "cross the border" into the culture of the science classroom, they find some familiar franchises where they know what is on the menu.

The actual learner pages are reproduced at the end of this paper.

What follows is the teachers' guide:

Teachers' Notes for Activity 3 Why did the lightning strike that one house?

Outcomes focus: NS LO3 (AS1 Science as a human endeavour in cultural contexts). At Grade Level 9, the Assessment Standard asks "Can learners recognise differences in explanations offered by Natural Sciences and other systems of explanation?"

Develop their process skills: **interpret** information that the teacher provides **make hypotheses** about why lightning strikes in particular places or why people have certain beliefs about lightning **communicate** their understanding of science views and other worldviews.

Knowledge focus: Lightning is a transfer of energy that was stored in the cloud by the action of wind.

Note 1: Keep the Learning Outcome focus in this activity. Focus on the learners' ability to see the differences between explanations – we use lightning as the subject matter because many people have strong feelings about the phenomenon, and the discussions can bring out debates, which can be quite intense and interesting if you have learners from different cultural backgrounds.

Note 2: World-views, belief and assessment

Many people have strong beliefs about lightning, and we must be aware that people who live exposed in rural areas face real danger of lightning strikes, and some of them have developed their own theories of lightning. So from a science education point of view, it is not wise to say "Science gives the true explanation of lightning and the other ideas are just superstition."

This attitude is also unsound for another reason. It could result in a kind of mental split, where our learners say "Inside school we learn just the science explanation, because that is what we need to pass the exam, but out of school we use the other explanation, because that is what we really believe".

Therefore, in this lesson, we raise two kinds of explanations (the scientists' explanation and a traditional explanation) and make the learners aware of the differences. But note this: we cannot force them to believe one or the other. However, **we can expect them to show how well they understand each explanation**. In assessment then, our question is "Can the learners describe the differences between the two explanations?" They may see those differences in quite simple ways or they may look deeper and see that people have different views about the way that the world works.

Note 3:World-views

To illustrate the different views that people have about the world, consider this: for many people, the world is a spiritual world. Behind all the rocks, weather, machines and living things, there are spirits with laws for living, which should be respected. Physical and mental events that happen to a person (such as depression, sickness, regaining health, accidents) are the result of conflict or regaining harmony in that person's relationships with other people, with God or with the ancestors' spirits. In this world-view, events have meanings; they happen for a reason, they do not happen by pure chance. For other people, the world is really like a big machine. It is very complex, but it does not have a soul or a spirit; nor is there any spirit guiding it. Things happen because of blind forces. If something physical or mental happens to a person, we can explain it by ideas of pure chance combined with laws of biology, physics or chemistry.We can know the world scientifically, and we should be clever in how we use it, but we do not need ideas of spiritual forces. Of course, these two world-views ("behind all things or events is a spiritual meaning", versus "the Earth is a huge machine") are extremes, and people often use bits of both world-views, as it suits them. In this activity, we acknowledge that people (like our learners and their parents) have different world-views, and we give space for them to be discussed in class.

We choose lightning as an exciting topic for classroom debate, which may bring out those views.

Assessment notes and answers

This activity does not end in a vote or a forced choice, e.g. "Now choose which side you are on – do you believe in the *abafana bezulu* (muthi sticks in the thatch) or in lightning rods?"

The learners may ask you which you believe in. Sometimes, as in the sexuality education chapter, as a teacher you should reserve your right to your private life. In this case, a direct honest answer to these teenagers is probably the best. (Scientists **do** think that lightning rods save lives.)

Answers to questions

Q1 This question brings out the learners' ideas and experiences of lightning. Let learners from several groups tell their stories, because these stories are what hold the interest of the class.

Q2 Your teaching should have encouraged the learners to ask questions and to be curious about things in the natural world (this is part of LO1). Try to keep their questions focused on the shared stories.

Q3 The purpose of this question is to make the learners think, "What counts as an explanation?" Their stories have described what happened, but describing is not the same as explaining why it happened.

Q4 Each explanation can give reason(s) why lightning struck that particular house, but the reasons are very different. Let the learners say what reasons they can see. They will discuss the differences in Question 5.

Q5 Focus your assessment on the answers to questions 5 and 6.

Q5.1 Methods for staying safe

- **Scientist**: Stay away from tall, isolated trees and poles. Use a conducting rod to get rid of the electrical charge on the house. Build a wire mesh into grass huts. Stay inside a house or inside a metal shell structure like a car or bus.

- **Inyanga**: Know and use certain plants that provide protection. Cover bright shiny objects. Check the house and yard for stones that may have evil muthi on them, which will attract lightning. Avoid gum trees (perhaps because they are tall trees).

Difference: A scientist uses the concepts of metals, charges and conductors. An inyanga uses the concepts of plants that counteract evil, or which are safe against lightning.

Q5.2 Is any person responsible for the lightning strike?

- **Scientist**: No person is responsible; this was just a "blind chance" natural event. If all the houses in the street are the same, then each house has an equal probability of being struck. This is like rolling dice; any number may come up.

However, houses that have lightning rods have a lower probability of being struck.

- **Inyanga**: Yes, somebody may have a grudge against the house-owner, and this person could have paid a witch to send lightning on that particular house. We need to ask about reasons why someone might hate the house-owner. Or the lightning could simply be an accident in a storm.

Difference: A scientist says that people do not direct lightning. An inyanga says that some people can direct lightning.

Q5.3 How do you find information about lightning and staying safe?

- **Scientist**: A part of a scientist's work is to write down his or her findings and make them public. Therefore anyone can read the information in books. Anyone who has learned enough science can understand what happened in the lightning strike and can understand the reasons.

- **Inyanga**: Normally, people do not get this information about lightning. The knowledge of traditional medicine is shared only among *inyangas, sangomas* and other traditional healers. The knowledge is in the inyanga, not in books.

Difference: A scientist says that science information is written down and available to everyone who wants to learn. An inyanga says that the information is not made public – it is either secret or dangerous.

Q5.4 How can the ideas be tested?

-- **Scientists**: It's difficult to do experiments with lightning because lightning usually does not happen at the time or the place that we want it. But we can test many of the ideas, using very high voltages in the laboratory. We can keep thousands of records of real lightning strikes to see how well we can predict what happens.

-- **Inyanga**: The traditional healer knows. You are not allowed to ask how he or she tested the ideas, because this would be disrespectful. He or she received this gift of learning from the ancestors. These ideas are agreed after discussion amongst *inyangas* and others with traditional knowledge.

Difference: A scientist says that the ideas can and should be tested by anyone with the skills. An inyanga says that these ideas are not open for testing by people outside the circles of traditional knowledge.

Q6 Which explanation will satisfy most people you know? Why will it satisfy them?

Here the learners can differ; for assessment, listen to their reasons. Answers may be "People where I live prefer the inyanga's explanation because they know about plants/ this is what they always heard from their parents/ there is fighting in that community."

Other answers may be "People where I live prefer the science explanation because they are used to these ideas from school and university education/ they don't like superstition/ they have moved to the city and they want to get away from the ideas that rural people have about witches / they believe the scientists because they have never really been frightened by lightning."

As yet, we do not have detailed information on the responses of learners and teachers to this most recent form of the material. The evaluation still needs to be done. Such ongoing work is still part of the invitation in the NCS to develop new curriculum. References

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Appendix – The learners pages

Activity 3 Why did the lightning strike that one house?

Let us imagine this: Lightning strikes a house, very close to your house. You see the flash, you hear the thunderclap and you see the house begin to burn.

Figure 21: *A lightning strike can do tremendous damage to buildings, animals and people.*

Questions for discussion (Teachers: See *Teacher's Book*)

1 Why is this lightning strike frightening and interesting? Tell about similar events where lightning has struck a place, an animal or a person.

2 What questions do you have about these events?

3 Is there a way to explain what happened? In an explanation you say, "It happened because ..."

Read the scientist's explanation of how lightning happens, below. Also read the *inyanga's* explanation on page 16.

4 Do either of the explanations give you a reason why lightning struck that particular house (and not your house)?

5 List the **differences** between the scientist's explanation and the *inyanga's* explanation. In the two explanations:

5.1 What methods can you use to stay safe from lightning?

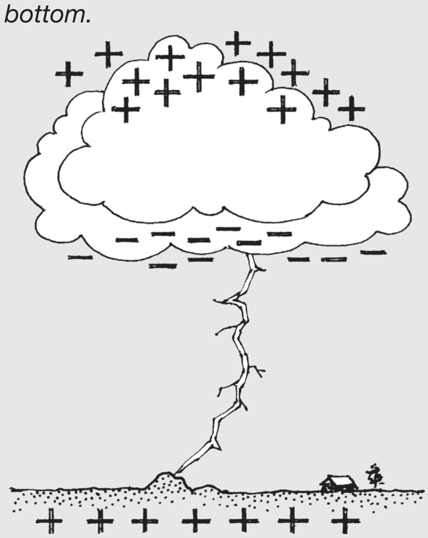
5.2 Is any person responsible for the lightning strike?

5.3 How do you find information about lightning and staying safe?

5.4 How can the ideas be tested?

6 Which explanation will satisfy most people you know? Why will it satisfy them?

Figure 22: *Particles blow up and down inside the cloud. This puts positive charge on the top of the cloud and negative charge at the bottom.*



A scientist's explanation of lightning

This explanation comes from a textbook for electrical engineers.

A thunder cloud works like a very big van der Graaff generator, which you saw in **Figures 13**, **14** and **15**. Strong winds blow bits of of water, dust and hail up and down inside the cloud. This energy of movement charges up the moving particles, and so the whole cloud charges up. The **bottom** of the cloud usually gets a **negative** charge, and this causes a **positive** charge on the ground near the cloud. So there is stored energy or a voltage between the cloud and the ground. The voltage can increase to millions of volts.

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When the voltage is so high, the air molecules begin to conduct. They form a conductor, and the charges in the cloud and on the ground move towards each other. When the charges move, it all happens very fast (in about 0,000 001 second), and the current can be 250 000 amperes or more. This current heats up the air to 20 000°C (hotter than the Sun), and the air expands so fast that we hear a clap of thunder.

Lightning happens more often in KwaZulu-Natal, Mpumalanga and Gauteng, because the hot summer conditions help to form cumulus clouds.

If lightning strikes one tree in a forest of 100 trees, and there are 99 other similar trees around it, we can only say that each tree had a 1% probability (= chance) of being struck.

Lightning can strike anywhere, but the **probability** is higher that it will strike tall buildings, poles and trees. We can protect houses with lightning rods. See **Figure 23**. These are conducting rods with sharp points that stand higher than the house. The positive charge on the ground (remember **Figure 22**) leaks away from the sharp points into the air, so that the house does not collect a large amount of charge.

Grass huts can be protected with a wire cage inside the roof, as you see in **Figure 24**. Lightning will flow along the outside of any metal shape.

If you are outside during a lightning storm, stay away from isolated (= single) trees. Try to reach a building or get into a car or bus.

Figure 23: *The lightning rod lets the charge escape slowly into the air.*

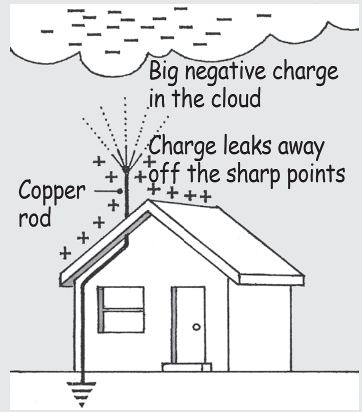
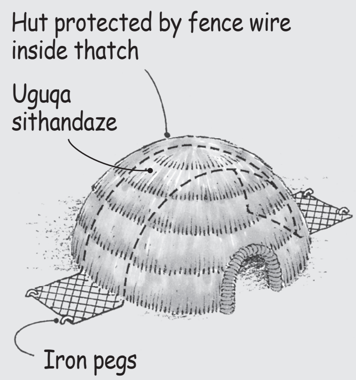


Figure 24: *Electric charge flows over the outside of a metal shape.*



How scientists handle knowledge

Scientists do investigations to test their ideas and they write reports on their investigations. These reports are printed in journals, which other scientists can read, anywhere in the world. Then the other scientists may try to repeat the investigations, to see whether they get similar results. They may make **predictions**, using the new idea. They see whether the predictions match what really happens. Then they write responses to the first scientist's report, and they may criticise his or her methods, measurements or reasoning.

After an idea has been through this debating process, the idea may be confirmed or changed or thrown away. In this way, science builds knowledge out of tested ideas.

An *inyanga's* explanation of lightning

This *inyanga* works in KwaMashu, and he is a herbalist who trains people to conserve indigenous plants. The information here comes from an interview he gave to a group of science teachers. He did not want to talk about evil people who send lightning because his business is to heal and protect people from harm.

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Here is a summary of what the *inyanga* said in the interview:

Lightning happens naturally, but it also is a sign of bad relationships between people. There are a few people who can cause lightning storms or send lightning on purpose, to strike certain places and people. Therefore you should know ways of protecting yourself against the actions of such people. You must be aware of the danger of a person who secretly wishes evil on his or her neighbour. Certain animals, such as the iguana, can control lightning. The fat of those animals is powerful *muthi* against lightning. A common method of using such *muthi* is to put it on sticks, which are then pushed into the thatch of a house, or thrown out into the yard.

The *inyanga* also advises people to do things that are opposite in nature to lightning. For example, people should cover bright, shiny objects such as mirrors, needles and buckets of water. Plants are also important – people should carry branches from particular trees (*intelezi* or *umvuthwamini*) that are never struck by lightning. However, they must not walk near gum trees because these trees attract lightning.

How the *inyanga* handles knowledge

He told the teachers that information about lightning is not given to all the children of an *inyanga*. An *inyanga* studies his or her children to decide which of them is suited to receive the knowledge of traditional medicine. Not everyone can learn this knowledge because it is not written down; only certain people may know it. If you want to know something that is difficult to understand, then you must find the right person who has that knowledge. If you ask your question respectfully, he or she will tell you what you need to know.

Lightning is not useful electricity – nobody wants to use lightning to run a TV set! We need charges that move slowly and steadily, for a long time. In the rest of this chapter we study charges that flow steadily along conductors.

Peer assessment

1 Name three ways to give energy to electric charges.

2 Must you connect a voltmeter in series or in parallel?

3 What does a voltmeter measure?

4 Why does a voltmeter show zero volts across a good conductor, for example, a connector strip?

How well did our group do?

We worked out answers to the questions	None	Some	All
We still need help with . . .			