AN INVESTIGATION AND IDENTIFICATION OF INDIGENOUS SCIENCE UNDERSTANDINGS AMONG ZULU COMMUNITY ELDERS AND THE IMPACT OF THESE UNDERSTANDINGS ON THE ZULU SECONDARY SCHOOL LEARNERS

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Dedication

This work is dedicated with all my love to my beloved husband,
Vi and our children Sindi and Zamani.

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I would like to express my sincere gratitude to the following people who all made this work reach its fruition:

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Abstract

A lot of scholars have alluded to the existence of indigenous knowledge among community elders. The purpose of this study was to explore existence of indigenous science understandings among Zulu elders and determine the impact of these understandings on the indigenous secondary school learners.

A group of elders and a group of learners from a selected rural community were interviewed on three phenomena pertaining to biology and physical science. Each phenomenon was chosen according to its relevance to the traditional African practices of the rural community studied. The data from both groups was analysed to determine understandings held by each group.

Findings of this study revealed that elders held indigenous science understandings that had an impact on the indigenous secondary school learners. Elders transmit these understandings as views that I chose to call *indigenous conceptions* and *duality explanation conceptions*. As a result of the impact of elders' views and school science, learners on the other hand held three types of conceptions, namely, *unchanged indigenous conceptions, hybridised conceptions* and *duality explanation conceptions.*

The recommendations I made are based on the findings that elders' indigenous knowledge has an impact on learners' science understandings. This then has implications to classroom practices and science education.

Declaration

I, Gugu Catherine Helen Khumalo, declare that this dissertation is my own work and has not been submitted previously for any degree in any university.

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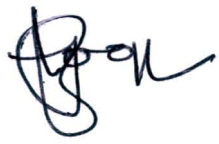
Researcher



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Supervisor

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CHAPTER 1

INTRODUCTION

This chapter provides a general overview of the events that prompted an interest in this line of investigation. This is followed by a definition of terms used, a selection of concepts studied and significance of the study. I will conclude by giving a synopsis of the chapters that follow.

1.1 Overview

I view science as all the things we do or say to make sense of the world around us. As a teacher my learners would tell me that an event occurring in our laboratory happens in the 'white man's world'. 'It does not happen at our homes' they would say. The topic on thunderstorms would generate discussion, on claims such as some learners knew people who could control lightning.

During a Matriculation Examination marking session I was involved in a similar discussion with some qualified science teachers. This discussion was prompted by an occurrence of a thunderstorm everyday around 5pm. To my amazement the teachers claimed that someone was controlling the occurrence of these storms. 'Don't you realize that it is occurring around 5 pm which is immediately after the knocking-off time of most people from work?' was their argument. Most of them also claimed that they know people who could control this phenomenon.

This made me suspect that there are some science understandings that people, especially learners, hold which are a result of their exposure to indigenous science understandings. Whether they have formed these understandings by themselves, or have heard them from peers or elders, learners do not enter the school environment empty-headed and devoid of any science knowledge. There is continuous struggle in the learners' minds to come to terms with the new knowledge they are being exposed to. This means that there is a process by which learners, who have already been exposed to indigenous science understandings, must make sense of the Western science understandings in the

classroom environment. Similarly, teachers at the marking session, knowledgeable as they are about Western science, still retained and maintained beliefs about lightning from their traditional culture.

This has generated curiosity and interest in me to find out more about the impact of indigenous knowledge on the indigenous learner. I also hope that this could give me some answers to a number of questions involving indigenous knowledge and the science curriculum.

Not many studies have been done on the impact of indigenous knowledge systems in South Africa including the rest of the world. Only recently has indigenous knowledge systems received attention from some scholars. This has been prompted by a paradigm shift, from a positivist view of science as being an enterprise of and dictated by a few, to a broader view that science is a social construction and all cultures must be in possession of some kind of science. This view acknowledges that school science is not the only way of perceiving science knowledge. School science is yet another knowledge system (Ogawa 1995). Learners do bring with them science conceptions formulated by other knowledge systems when they enter the classroom for the first time. These conceptions remain in their mental frames and affect the way they perceive new information given to them right through their school life. Thus all types of science understandings must be accorded the same merit with none being inferior to any other. This type of thinking is in line with a constructivist ideology. More discussion on these views will be tackled in Chapter 2.

The focus of my study looks at the indigenous knowledge understandings that learners bring to the classroom and how these affect the way they perceive school science. The topic of this study is:

An investigation and identification of Indigenous Science Understandings among Zulu community elders and the impact of these understandings on the Zulu secondary school learners.

There will be two critical questions asked so as to cast some light on this topic. The first

critical question is asked based on an understanding that learners come from a community where elders are seen as holders of all knowledge and wisdom in that community. Asking this question would give some explanations as to what this knowledge and wisdom is in relation to certain phenomena and concepts. Learners are exposed to the concepts held by elders right through their lives and these are the understandings that they bring to school. The second critical question would therefore find out what kind of understandings learners hold after being exposed to both elders' and school science conceptions. The critical questions are:

Critical Question1: *What are elders' indigenous science understandings on phenomena of fermentation, heat, thunderstorms and lightning?* In this case data were collected from elders through focused interview and field notes on the three concepts. Questions related to the phenomena were posed and elders discussed these and gave their descriptions and understandings.

Critical Question 2: *What are learners' science understandings on phenomena of fermentation, heat and thunderstorms?* Learners discussed and debated questions related to these phenomena and their final understandings were used as consensus understanding of the group. Again data were collected through focused interviews of a group of learners as well as field notes.

1.2 Why am I doing this study?

To be able to answer this question one must look briefly at the history of education, especially science education, in South Africa. South Africa was colonised for over three hundred years. During the years preceding apartheid indigenous people were systematically denied Western science education. This policy did not only exclude indigenous people from Western science education, but it also promoted the view that they were not good in science. It promoted an education that was only meant to enable them to read and write. This was not so very different from the rest of Africa during the colonial era (Kincheloe and Semali 1999; Ogunniyi 1986). Indigenous people's existing knowledge was never taken into consideration. This sentiment is also shared by Maurial (1999) who states that indigenous knowledge has always been associated with colonialism. She further argues that the non-conquering people or native people, as she puts it, were given the term indigenous, which was associated with being conquered,

colonized and powerless. Since knowledge goes hand in hand with power, colonizers always denied the non-conquering people's beliefs the status of being called knowledge. In addition to that, the indigenous people were denied the right to formal education, let alone science education, she concludes.

Another important aspect in education in South Africa was missionary education. Most schools for blacks during the colonial era were those built by missionaries. In the area where I grew up for example, in the 1950's and early 1960's there were only three primary schools and one secondary school in the radius of about ten kilometres. They were all built by the Roman Catholic Mission. I only attended the primary school of this area. The syllabi in these primary schools were the three languages (iSiZulu, English and. Afrikaans), arithmetic, agriculture and religious education (mainly the catechism and some stories from the Bible). All subjects were taught in the medium of IsiZulu except for the two languages English and Afrikaans. The little science learners were exposed to was a bit of agriculture which I am translating from the original IsiZulu syllabus name -*Ezemvelo neMvelo*. This agriculture syllabus was mainly about tendering gardens of the school as practical work and the theory aspect was on structure of the plant, structure of the soil and causes and prevention of soil erosion. The latter was mainly on the dangers of keeping large livestock. The emphasis of this did not make sense to us as children because most Zulu people were dispossessed of their large livestock by this time.

At secondary school level very few of these schools offered sciences. If they did, only a few students were selected to take them. The main interest in educating blacks during this era was to convert students to Christianity. The evidence for this in the area I grew up in, was the criterion for admission of learners which was used for conversion to Roman Catholicism. Those communities whose chiefs did not accept the Roman Catholicism had their children turned away (one had to submit a baptismal certificate at registration). Education was therefore used in exchange for rejecting one's ancestral and traditional faith. In this area education was therefore not administered in the interest of educating the indigenous people but mainly to convert them to the Christian Faith. This situation was found in most areas of Zululand (presently called KwaZulu-Natal) and other parts of South Africa where Christianity was practised. It was not only unique to

Roman Catholicism but could also be found with other Christian religious denominations.

Thus it can be deduced that in South Africa there was little or no science taught to blacks during the colonial era. Even when the Apartheid Nationalist Government replaced colonialism in 1948, the emphasis was still to educate the blacks to become better servants. For this reason, very few secondary schools for Africans, like in most parts of Africa, offered science (Yoloye 1995).

Even in this new millennium, the number of students taking science in secondary schools in South Africa is still very low. Science is regarded as a difficult subject by learners (Hewson and Hewson 1983). The Third International Mathematics and Science Study (TIMSS), reported in Cronje (1999), further confirmed this. In the TIMSS report South Africa is ranked last out of 41 countries, obtaining an average of 24%. Is science really difficult? Could it be that learners view learning science as learning a foreign culture? (Ogawa 1995; Aikenhead & Jegede 1999). This then means that there is a need to research whether science is really difficult or whether learning science is viewed as learning a foreign culture. If science is viewed as a foreign culture, for me, this would require research on indigenous knowledge systems and how this influences the learning of science. Science curriculum could then be designed in such a way that it takes indigenous knowledge systems into cognisance. Many scholars have indicated the importance of indigenous knowledge in learners' acquisition of concepts (Thijs 1983; Ogunniyi 1984; Prophet 1990; Kehinde 1991; Swift 1992; Jegede 1996; Ogunyemi 1969; Ogawa 1995; Addo 1996; Patel 1997; Manzini 1999). My study would investigate this indigenous science knowledge and how it impacts on indigenous learners' science understandings. It is hoped that this would make a small contribution towards research of this nature.

The second reason for this study is that I am not aware of any research that has been carried out in South Africa which traces the knowledge of elders and links it to the third generation of their offspring. Among Zulus, elders are part of an extended family. Their status is that of custodians of the family customs, norms and traditions. During their daily interactions with children and grandchildren, these customs, norms and traditions

are passed down. Any initial conceptions held by learners, be it science or otherwise, are obtained from home and would be influenced by what the elders perceive to be knowledge. This knowledge held by elders could have an impact on how learners conceptualise school science. In most literature such linkages are perceived to exist and have not actually been investigated. Doing such an investigation would actually confirm or dispute this linkage.

1.3 Definition of terms

The literatures gives descriptions of what the term **indigenous knowledge** means. Semali and Kincheloe (1999) put this as follows:

> "Indigenous knowledge reflects the dynamic way in which the residents of an area have come to understand themselves in relationship to their natural environment and how they organize that folk knowledge of flora and fauna, cultural beliefs, and history to enhance their lives." (Semali and Kincheloe 1999 –p3)

Maurial (1999) describes indigenous knowledge as people's wise and cognitive legacy, which is a result of their interactions with the environment. She further describes characteristics of indigenous knowledge as being *local, holistic* and *agrapha.* It is *local* because it is generated within the people through daily interactions. In this way it is alive, unlike knowledge, which is in archives and laboratories, as she puts it. It is *holistic* in that ideas and practices are one and partitioning of disciplines of knowledge, into law, economics, religion, arts and so on, is not found. It is *agrapha*, a term she borrowed from Hispanic anthropology, meaning it is not written down but is kept and passed on through oral tradition.

George (1999b) describes indigenous knowledge as knowledge that has evolved in a particular societal context and which is used by lay people in that context in the conduct of their lives. She stresses that it is generated to solve day-to-day problems by drawing from the existing societal wisdom and resources. It is passed on from generation to generation through oral mode.

Snively and Corsiglia (2001) also hold the same sentiment expressed by above scholars, and describe indigenous science knowledge as a way of interpreting how the local world works through a particular cultural perspective. In other words each culture sees the world in the context of its local perspectives and this is its knowledge. This does not mean that one culture is right and the other is wrong.

I accept all these definitions as they all grasp the essence of how this term is used in this study. Indigenous knowledge is the knowledge that is generated by people through their daily interactions with the environment. It helps them to make sense of the world. They pass this knowledge down from generation to generation through oral traditions, daily activities, ceremonies, rituals, customs and norms.

The term **traditional** will be used in the same context as **indigenous** described above.

Culture is a term that has various meanings for South Africans. One would hear of terms like 'cultural day' or 'culture of teaching and learning' or 'Zulu culture' and so on. Aikenhead (1996) quoting Phela et.al (1991) describes culture as the norms, values, beliefs, expectations and conventional actions of a group. A definition by Howard (1988) on cultural anthropology describes culture as the customary manner in which groups learn to organize their behaviour in relation to the environment. He goes on to describe culture as having three principal aspects – *behavioural, cognitive* and *material.* The author further elaborates that *behavioural* aspect deals with how individuals interact with each other. The *Cognitive* aspect gives the views that people have of the world. The *material* aspect deals with physical objects produced. These two definitions encompass the context of the use of this term in this study.

Cobern (1999) gives a broader view of the term **science** and describes science as an aspect of different systems of meaning that people construct so as to make sense of their worlds. This description is in agreement with Ogawa's (1995) definition of science which states that every culture has a science. Ogawa then goes further by asserting that science is a rational perceiving of reality (Snively & Corsiglia 2001 –p9). From this he deduces that every culture is capable of possessing some kind of rationality and therefore a science; if rationality means behaviour in accordance with the rules. It

therefore makes sense that there are various types of science, hence *indigenous science* as well as S*cience or school science*. In Ogawa's description of science, there will be a third dimension of science, *personal science*, which Cobern (1999) also calls the individual's science worldview (see Chapter 2). I will borrow from both Cobern's and Ogawa's views. The term science will be used in the context that every community has a science. Every community has a rational way of looking at the world so as to make sense of it.

Meaningful learning in this study would mean learning that would result in learners being able to resolve their existing knowledge with that found in school science. This would result in them understanding the science concepts and making science part of their lives. Science then would not be something that is learnt in the classroom and ending there, as was the case with my students in the opening of this chapter.

1.4 Selection of phenomena and data sources

In the selection of the data sources as well as the selection of phenomena the following were taken into account:

- Learners and elders must come from a rural Zulu background
- Learners and elders must come from the same community
- Elders should not have been exposed to secondary school science.
- Phenomena chosen should be related to common practice in the community in which the data was collected.

The phenomena chosen for this study were *fermentation, heat* and *thunderstorms*. These were chosen on the basis that most, if not all learners in rural environment, were in contact with these conceptions in their daily lives. They used heat everyday for cooking, heating and lighting at their homes and this heat could come from a variety of sources. All learners used in data collection would also have been exposed to the making of traditional beer where this process is used as an example of the fermentation concept. Thunderstorms and lightning are a naturally occurring phenomenon. The three branches of science, i.e. physics, chemistry and biology, studied at school, would be covered by the three phenomena.

The data were obtained from a rural background. It would have been fruitless to explore a phenomenon like electricity when the majority of the learners did not have electricity at their homes as well as at school. Another option would have been to choose a data source that was in urban or semi-urban environment. This would have been problematic. Firstly, most indigenous people in urban or semi-urban environment do not make traditional beer, but buy its equivalent from stores. Secondly, if elders were selected from urban or semi-urban environment, most would have been exposed to secondary school science and also practicing a culture mixed with characteristics of other cultures. If the last two points were not considered, this would have defeated the pre-requisites stated earlier, these being, knowledge of traditional beer making and understanding of uncontaminated indigenous Zulu knowledge.

1.5 Significance of this study

This study would be looking at conceptions of some science phenomena held by elders. These would be linked to those held by learners in the same community. In this way a thread would be created on the type of conceptions learners bring to school and how these affect their understandings of school science. The results of the study could then be used by educators in schools, publishers and authors of science books, and curriculum policy developers. All these aspects of our education could take into cognisance the effect of indigenous understandings learners bring into the science classroom. It is hoped that this research would contribute and also act as a resource in this regard.

1.6 Summary and sequence of work

In this Chapter I outlined what prompted interest in this study and followed this by defining the terms used in the study. The reason behind selecting the specific phenomena was given. I also stated how this study contributes and could be used as a resource by various sectors in our education system. I will now outline how this research is organised.

The next chapter, Chapter 2 will survey literature of studies that have been undertaken by various scholars. In this chapter I will examine various theories as well as studies that link indigenous science understandings with school science. The review of this literature anchors this study into a theoretical framework that learners bring to school indigenous science understandings and school science is yet another science understanding. Chapter 3 will elaborate on the methodology used and the instruments employed. Chapter 4 provides data presentation and analysis. The last chapter, Chapter 5, gives a synthesis of the study, its limitations as well as recommendations.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

In recent years Indigenous Knowledge Systems have received a lot of scholarly attention throughout both of the developing and developed world. The work of scholars like Ogawa (1995), Cobern (1991), Aikenhead & Jegede (1999), Ogunniyi (1997) and George (1999a), to name a few, gives testimony to this. In spite of the emerging examination of the social, cultural and political issues of indigeneity across the world, the same attention to the study of indigenous knowledge has been lacking in South Africa (Moore, 1994). This was due to the apartheid legacy that did not find this aspect of scholarship as being of any significant importance. For this reason, therefore, this section offers a review of literature that highlights inquiry from many corners of the world, but offers very little insight from the South African perspective. None-the-less, a few studies in South Africa have started trickling in and hence, this study has reviewed those as well.

This chapter is divided into three parts. The first part describes types of science knowledge Zulu learners, who are the focus of this study, are exposed to. The types of science knowledge looked at are indigenous science knowledge at home and school science knowledge outside home. This is followed by a review of indigenous knowledge and learning in general. This then, leads to the viewpoint of this study – the theoretical framework.

2.2 Exposure of Zulu learners to two types of science knowledge

Zulu learners are exposed to two types of science understandings – the indigenous science knowledge found at home and their local communities, and the school science knowledge. These are understandings that the child accrues as s/he tries to make sense of all experiences around her/him. The two types of science knowledge systems are important to look at since they will have a great impact in this study.

2.2.1 Indigenous Science at Home

The indigenous science knowledge a Zulu child is exposed to has its foundation in the culture of the community where s/he grows up. As a Zulu child develops, s/he does so in clearly marked stages (Kriege 1950; Schapera 1956; Levitas 1983; Stoffberg 1988; Hammond-Tooke 1974; Elliott 1978). The stages that would be described are early childhood, late childhood, puberty and entry into adulthood. In each of these stages the child is socialised into becoming a responsible member of the community (Levitas 1983). Each stage comes with its own level of responsibilities. Although formal schooling starts at age seven, indigenous developmental activities are still adhered to at home even though the learner spends most of her/his time at school. It is important to look at these stages so as to be aware of the kind of knowledge, experiences, learning methodologies and values this child is exposed to and is taking to school. Teachers of this child are older siblings, other children and members of the extended family. Learning methodology is by observation, imitation and experiencing everything around her/him.

In early childhood, while still breastfeeding, the child spends most of her/his time with the mother and siblings. Both mother and older siblings teach the child about dangers and taboos (Schapera 1956). The child imitates the mother or older siblings and by coaxing and admonishing, s/he learns the rights and the wrongs. After weaning the toddler then spends most of its time with children of its own age group (Hammond 1974). These are both boys and girls, mainly of the extended family. They spend most of their time playing. Mothers play a big role in guiding the child about the values of the community and the society at large. The father does not play much role at this stage. Any science that is learnt at this stage is by observation, like being taught various names of organisms, where they live, and how they behave and which of these are dangerous.

Late childhood sees the division of sexes. At about five years old, boys leave the homestead to head the livestock and girls stay at home and help mothers with chores (Elliott 1978). Boys spend most of their time in the outside environment where their science knowledge is expanded. The main teachers are older boys. Parents and elders of

the community also come in as needs arise. This is where boys learn about various seasons and coping with their effects. They learn about heat and its effects like conduction and insulation. They explore living and non-living things by looking at different types of substances as well as different plants and animals. In this way they gain valuable knowledge about nature, which could become useful in formal schooling if utilised by the schooling system. Van Der Vliet (1974) describing what Kriege and Kriege (1943) observed in a herd boy called Lobedu writes:

> "A herd boy walking along with you will give you the name and uses of almost every tree or shrub you pass in that rich bushveld environment, and once a boy of fifteen astonished us by being able to name over 200 specimens of plants from that area" (Kriege and Kriege 1943 -p108).

Boys find out about edible and non-edible foods and how these can be extracted. It is interesting to note that young boys spend the day in the veldt but do not carry any provisions with them. They provide themselves with food by hunting birds and other small animals as well as gathering wild fruits for their meals. Boys also learn which plants are useful for various ailments. This is early training for survival and self-sufficiency. Co-operation with peers is also instilled. (Van Der Vliet 1974). The young boy's life is full of adventure and is abundant with available knowledge from nature.

Girls, on the other hand, are also learning from older girls, their mothers and older females of the extended family as apprentices (Stoffberg 1988). They are taught intricacies of taking care of a home. They are taught how to cook, tend fields, collect water and firewood and tending minor ailments. In short, girls are taught at a very early age how to keep the members of the family alive. Women act as custodians of the family's survival and values. They are not, though, accorded this status by the Zulu society (Derwent 1998). A woman is always considered to be a minor. Girls at this stage come across a number of science concepts, which are learnt by imitation and trial and error. They learn how to make beer (fermentation, filtration), make fire and cook (heat, boiling, evaporation, condensation, conduction and so on), collect clean water, grow food crops (germination and growth of organisms) and many other concepts that are not the focus of this study.

Late childhood in a young Zulu child is full of adventure and is carefree. What is learnt during the day is also augmented by folk-tales narrated by older members of the family at night. Passage of information occurs this way from older generations to younger generations. During these teachings the young are allowed to make mistakes while learning.

Traditional education is much different from school education. In traditional education there is no threat of an examination at the end of the lessons. There is sharing of ideas with your peers. Learning skills is mainly by apprenticeship where the learner emulates those who are older than s/he is (Hammond-Tooke 1974). Children observe how adults perform tasks and at first, they imitate them, then they assist in the performance of these tasks and finally perform the tasks on their own (Howard 1989). This will be different when this child arrives at school. At home things learnt have a bearing to everyday life needs and survival of the society.

At school there will be little or limited tolerance for mistakes. There will be a limited time frame during which all the material should be learnt, therefore repeating lessons would not be the norm. Learning from your peer will be generally prohibited; hence it is called *copying* and is a punishable offence. In school the teacher instructs and the learner must assimilate the instruction. There is no trial and error for perfecting learning, but once-off lessons. Non-formal schooling at home is the whole community's responsibility as opposed to the school's one instructor per lesson format. All this is in direct conflict to the method of learning the child has been exposed to earlier in life. These are some of the hurdles the learner comes across as s/he enters the school environment. The next stages of development occur during the schooling period.

During late childhood Zulu children undergo another developmental stage called piercing of the ears - *ukuqhumbuza*. A boy or girl who has pierced ears is accorded extra responsibilities. It is viewed as another higher level of development – a first stage of adulthood (Elliott 1978; Kriege 1950). There is not much marked difference in what is learnt at this stage except that the child now enters another stage of being a teacher to younger siblings and is accountable to elders for any wrong doings that may occur in the age group. As it is seen here, accountability and being given responsibility occur

quite early in a Zulu child growing in such a community. This status would not be recognised when this learner arrives at school.

Puberty is the final stage before entering adulthood. The onset of this stage in girls is signalled by the first menstruation and in boys by nocturnal emissions (Hammond-Tooke 1974; Kriege 1950; Elliot 1978; Mwamwenda 1995). Both a girl and a boy, on onset of puberty are isolated and kept in the mother's hut (a girl) and the father's hut (a boy) for several days. During this period they are taught about etiquette, values and systems of their family and community at large and how to become responsible members of the society. They are taught that family (extended family included) comes first. Teachers in this case are parents and other older members of the family. This stage occurs when the young men and women are in early secondary school years, or even in primary school as this might be the case with girls.

2.2.2 School science

When the child enters school s/he has already acquired a wealth of indigenous knowledge and values. S/he arrives in the science classroom to find various kinds of science and values. There is the teacher's version of science, textbook version of science, and to crown it all, there is a different language called science language in which science to be learnt is conveyed in.

Most of the time the teacher tries to convey ideas and concepts to the class. The class might not draw the intended meaning of teacher's version of understanding. Every individual constructs meaning differently from available information. Osborne puts this into perspective as follows:

> "There is often a severe problem of lack of communication between teacher and pupils. When two people communicate, what passes between them are the words and gestures they use to attempt to convey meaning, not the meaning itself. So a teacher has some ideas which he or she hopes to convey by putting them into words, diagrams or symbols. The child may take note of the words, and so on, but from these has to build up a meaning for them. There is clearly a possibility that this meaning created by the child is not the meaning intended by the teacher. This is very high if the type of language used by the teacher, or work

> card, or textbook writer, is not familiar to the child." (Osborne 1985 –p81). (My emphasis)

The teacher, being human, has constructed meaning from what s/he has been taught as well as from textbooks. The teacher's constructed meaning is conveyed to the learner. As observed from the above description, the Zulu learner has had very little or no contact with the knowledge and values of the classroom environment. The teacher interacting with this learner is often not aware of children's 'non-scientific' ideas, even if aware would not acknowledge them; often makes unfounded assumptions about teaching and learning and is unable to communicate with the learner (Osborne 1985; Hills 1989).

Often teachers ignore learners' ideas brought into class and pass them off as being unscientific. Even when these are acknowledged, it is merely to extract what is felt to be acceptable in classroom scientific terms. In most cases there is a manual, a syllabus or a textbook that the teacher uses as a basis of his or her lessons. Anything that does not fit into these will be discarded. In most cases there is a time factor to consider, listening to and extracting ideas that might not conform to the stipulated concepts can cause problems when time has become a scarce commodity. "Teachers do not have time to analyse what is happening in their own classrooms; they are busy teaching and managing them" (Krugly-Smolska 1995 – p56). The syllabus needs to be completed. Children in such an environment quickly learn that the knowledge they bring from home and community is of no value at school. Ogunniyi puts this as follows:

> "Pupils' knowledge and image of the world are, to a large extent, determined by the recognition of what their teachers imply to be valid; and this, of course, may have little to do with reality in the sense that it reflects a scientifically accurate picture." (Ogunniyi 1988 –p6)

Deducing from the way many science curricula are written and most science teachers teach, an assumption is created that learners come to school with no significant science knowledge. The duty of the school is to fill up the empty heads (Osborne and Freyberg 1985). This is confirmed by curricula that accord no recognition to learners' prior knowledge as seen when viewing biology and physical science syllabi of Standard 8 – 10 (Kwa-Zulu Natal Department of Education and Culture 1995). It is again recognised

in the manner in which teachers compile and deliver their lessons by not accommodating learners' existing understandings

When it comes to textbooks they provide information that does not build on the already existing indigenous concepts. This shows that authors of textbooks could also be holding a perception that learners do not possess significant science knowledge when arriving at school. When one reads such books one notices that authors simply give school science explanations with no reference to indigenous knowledge. The language of the textbooks is not an everyday language for the learners, that is, language that can be used when talking to peers. It requires mastering of certain terms and vocabulary. For example, terms like *animal, consumer* and *producer* mean something else in science when compared to daily use of the words (Bell and Freyberg 1985). A human being would not be considered an *animal,* while in school science this would be the case since higher organisms can either be *plants* or *animals*. *Consumers* in science are organisms that cannot produce their own food through the process of photosynthesis, but everyday understanding of this term can also mean plants since they consume water. A *Producer* in everyday understanding is anything that makes something. People could be termed producers since they can produce milk in their breasts, but in science they are not producers because they cannot manufacture food through photosynthesis. In addition the learner has to master the second language the book is written in, for example English in the case of Zulu speaking learners. Another aspect is the use of unfamiliar examples which are often not found in immediate community of the learners. These are examples familiar to the author. If the author is not familiar with, for example, a Zulu background, s/he will not be able to use relevant examples.

Language used in the science classroom is problematic to the learner in two ways. Firstly, learners are taught in a second language - English, since Zulu learners have only used iSiZulu right through their lives until arriving at school. Secondly, learners have to master a third language – science language that has its own terms and vocabulary. Let alone that science language is also problematic to English speaking learners. Using English as a medium of instruction disadvantages a Zulu learner. S/he might not succeed in understanding science concepts, not due to being intellectually deficient, but due to artificially created linguistic problems (Mwamwenda 1995; Prophet 1990;

Dzama and Osborne 1999). Prophet (1990) citing Bamgbose (1976) explains that the use of Yoruba (mother tongue of these learners) by an experimental group in West Africa over a period of six years had profound results. Not only was there an improvement in subjects by the experimental group, but also their written English performance was just as good as the control group and their verbal performance in English superior. Bamgbose then concluded that the likely reason for the achievement in understanding of concepts by the experimental groups was the use of Yoruba as the medium of instruction. A conclusion of this experiment was that the use of a second language as a medium of instruction does hinder the performance of learners. Dzama and Osborne (1999) further argue that the low performance due to language is not only peculiar to African learners, but a similar problem is found everywhere when teachers do not use learners' mother tongue as medium of instruction in general. Dlodlo (1999) also asserts that learners in their first introduction to science are taught about science through words which have no relation to existing knowledge that they possess. These words are borrowed words from Western languages. Instead one can use an example of the success of Christianity in Africa which he alleges could be due to the translation of the Bible to indigenous languages for teaching purposes. He further argues that failure of science and technology to take root in Africa even after 150 years of its existence could be due to the use of non-indigenous languages as media of instruction in schools.

Dzama and Osborne (1999) citing Lemke (1990) describe learning science as similar to learning a foreign language. Learners find science language to be a third language that they have to grapple with. If iSiZulu is used as a medium of instruction, this burden can be lessened and performance of learners could be improved. Dlodlo (1999) also supports the use of mother tongue by stating that if mother tongue is used, performance of learners in acquiring Physics concepts could improve. He went on to show that Nguni Physics vocabulary could be developed and this would facilitate teaching of Physics in Nguni.

This kind of school science environment that the learner encounters results in what Aikenhead calls 'the subculture of school science'. Science is viewed as a foreign culture not only by African students, but also by students from the Western background. The situation creates a feeling of not belonging in school and the school is then viewed

as a foreign culture. Learners then find themselves having to move from their indigenous science culture into the school subculture resulting into border crossing (Aikenhead 1996,1997). This will be discussed in the next section.

When contrasting school science and knowledge acquired at home one observes that the two are in direct conflict. Most knowledge acquired by the child has occurred by observation and emulating elders and older siblings but at school there is only one teacher. S/he would be expected to remember all that is taught without making mistakes. There is no allowance for improving oneself by emulating older members. At home questioning elders is never done; at school the learner is expected to do this. The information given at home has been accepted as being the truth; at school one is expected to challenge what is taught. S/he has had a number of teachers at home; only one teacher at a time would be there at school. At home there are no time frames for learning and one can make as many mistakes as one wishes; there will be a timetable and a bell at school. The environment is the classroom; at school four walls would be a classroom. This is the level the learner is at when entering a school environment. A cultural shock is awaiting her/him.

2.3 Indigenous Knowledge and Learning

Many scholars and educators agree that learners' prior knowledge must be taken into consideration for a meaningful learning process to take place at school. This sentiment is also the view of the new national education policy in South Africa – Curriculum 2005 (National Department of Education: South Africa. 1997). Some suggestions made by some scholars on how this can be achieved are looked at in this section. I have selected these suggestions because of their relevance to this study. These are: (a) Generative Learning Model, (b) Border Crossing, (c) Collateral Learning, (d) Multi-Science Perspective, (e) Contiguity Hypothesis, (f) Science Worldview, (g) Conceptual Change Model

2.3.1 Generative Learning Model

There have been many attempts to present models of constructivist learning and teaching. This model, as described in Osborne and Freyberg (1985) was one of the first and that is why it is presented here. It uses the idea about learning proposed by Wittrock (1974,1977). The model stipulates that learners themselves construct new ideas when they generate meaning from two sources. These sources are the sensory inputs received from the environment, and the existing ideas in the memory store of the learner. The Osborne and Freyberg model can be summarised as follows:

- There is interaction between the memory store of the learner and the sensory inputs from the environment. The learner uses selected inputs and rejects other inputs.
- The selected input does not necessarily have any meaning.
- Learners generate links between the selected inputs with memory store knowledge felt to be relevant. These links might not be the ones intended by the teacher.
- The learner accommodates these constructed new ideas into memory with other already existing ones or as completely new ideas.
- The learner will unconsciously attach a certain status to these newly constructed ideas. With passage of time, these newly acquired ideas may increase or decrease in status as opposed to the older ones.
  (Freyberg and Osborne 1985 – p83)

The implications of this model are that it takes into cognisance the existence of prior knowledge in memory store of a learner. This will be indigenous knowledge in the case of a Zulu learner. From this one can deduce that the new ideas are constructed through generating meaning from sensory inputs by actually using indigenous science knowledge in memory store. This has serious implications to learning by the learner if the teacher chooses to ignore learners' existing information. This is echoed across in all of the following learning models.

The generative learning model shares its concept with collateral learning below in that learners construct their own concepts using already existing indigenous knowledge as well as school science. I see all three stages in development of a Zulu child/learner playing an important role here. Existing knowledge about environment and how to behave as a member of the society would be used in generating new concepts.

2.3.2 Border Crossing

This model was put forward by Aikenhead (1996,1997) and is also cited in Aikenhead and Jegede (1999) and in Jegede and Aikenhead (1999). Aikenhead explained that in border crossing an assumption is made that every community has a culture and sub-cultures. Culture is taken to be norms, values, beliefs, expectations and conventional actions of a particular group or community; for example learners' home community and school community. Learners cross a border as they move from home science culture to the school science culture. This is called border crossing. Border crossing can be *smooth* if concepts learnt at home agree with concepts at school. It will be *manageable* if there is a small difference between the two. For large differences, border crossing will be *hazardous*. Finally it will be *impossible* if they are completely diverse.

When the school science harmonises with the learner's science concepts, Aikenhead calls this *enculturation* and is characterised as smooth border crossing. In enculturation the school science views support the learner's existing ones and appear as one view. When school science is at odds with that of the learner's, disruption of the learner's science views occurs and these views can be replaced by the school ones. This he calls *assimilation.* In some cases learners resist assimilation and protect themselves by adopting other methods of dealing with foreign views. They can play Fatima's Rule which is a technique discovered by Larson (1995). In this technique a student simply memorised terms and processes, and made it appear as if meaningful learning has occurred; just to be able to go through an examination or a test. After the test or an examination is passed, the student reverts to her/his initial stand. On the extreme side some students completely drop out of school science as a way of avoiding assimilation.

For meaningful learning to take place, school science should be presented to students in such a way that it does not pose a threat of *assimilation.* The only way to achieve this is by taking into consideration their indigenous knowledge so as allow *smooth* border crossing and *enculturation.* Curriculum 2005 (National Department of Education: South Africa.. 1997) also takes this view that the curriculum and teaching methods must change, so that the science classroom is more inclusive, where more people/cultures can

participate. Aikenhead suggests that the teacher must act as a *broker* that takes learners from their life-world culture into the culture of school science. I agree with this notion.

2.3.3 Collateral Learning

After border crossing learning must now take place. This can be facilitated by a model that was proposed by Jegede (1996,1997) also cited in Aikenhead and Jegede (1999) and in Jegede and Aikenhead (1999) called *collateral learning*. This is an explanation of how learners deal with cognitive conflicts between the indigenous culture and the school culture. It occurs with learners that simultaneously hold two or more conflicting understandings or concepts emanating from differences in cultures. They reconcile these differences in a number of ways so as to arrive at a new meaningful concept. Just as in constructivism and the generative learning model, collateral learning states that learners construct scientific concepts using their already existing ones (indigenous knowledge) by interacting these with school science concepts. Students not interacting their indigenous knowledge with the science concepts do not construct new ones (as those playing Fatima's Rule above), therefore collateral learning would not apply.

There are three types of collateral learning – *parallel, dependant* and *secured.* In *parallel* collateral learning the two understandings held by the learners do not interact, but are used independently as and when a relevant context arises. In *dependant* collateral learning the learners modify both their existing science views and the school ones resulting in a mixture of the two. Finally, in *secured* collateral learning, the two different views are held separately but are found to be reinforcing each other. Jegede suggests that, for meaningful learning to occur the three types of collateral learning will take place and the background of the learner should be taken into consideration.

This theory explains how a learner deals with the information that s/he receives. I agree with Jegede that the background of the learner should be taken into consideration for learning to occur.

2.3.4 Multi-Science Perspective

Multi-Science Perspective is a view proposed by Ogawa (1995,1997,1999). He views science as a foreign culture to non-Westerners and also suggests that other communities also have their own kind of science (indigenous science), which should be taken into consideration. Multi-science perspective views science as divided into three types – *indigenous science, personal science* and *Western modern science.*

Indigenous science is a science existing in a particular cultural group. An individual does not hold it. The individual might not even be aware of its existence nor be aware of being governed by it. It is passed on from generation to generation through daily social and cultural events. This is similar to the passing down of knowledge from elders to the child described in 'Indigenous science at home' above.

Ogawa describes *Personal science* as the science held by the individual. Each individual perceives and views the environment differently, within the frameworks of her/his background, in this case indigenous social background. As one does this, s/he will construct science concepts as perceived. This again supports constructivism and generative learning model. The learner will construct concepts unique to him or her derived from the inputs from the environment and the already existing knowledge. The knowledge in the indigenous learner is also shaped by her/his social background. This actually makes sense in that not all people in a given community construct science understandings in the same way (Kyle 1999).

Ogawa describes *Western modern science* as the science shared and authorised by the scientific community. It is the only community that justifies it and has a say on it, although the impression is of it being open to everybody. Other institutions or individuals are excluded from critiquing or doubting it. They are expected to accept it as given. It pertains to a materialistic and theoretical world in sharp contrast to the former two.

He further states that there is a marked difference between the Western science and the indigenous and personal science. The former two treat everyday life and its happenings.

It is not divorced from the people. Western science is even foreign to the Westerners themselves (Aikenhead and Jegede 1999). Ogawa proposes that differences in the three sciences can have merits in that these can benefit from each other. Western science can utilise aspects of indigenous and personal science, and the reverse is also true. For this reason school science must mix the three in formulation of science curricula.

In my view, this does make sense in that every community has its own science understanding. The community's science should not be devalued and relegated in favour of a foreign science understanding as this creates conflicts within the individual. Reaching a point of give and take within Western and indigenous understandings would create stability within the learner. Multi-science perspective recognises the existence of different concepts but does not necessarily say that new ones are built. It proposes freedom of existence of the three. The model also recognises existence of indigenous science which is the knowledge the Zulu learner has acquired from his/her community.

2.3.5 Worldview and Scientific Worldview

Researchers, as explained by Cobern (1994), are divided into two camps when it comes to perceiving how learners view the world. There are researchers, although few in number, who believe that learners have misconceptions and/or alternative conceptions. On the other hand there is a growing number that believes that there are no misconceptions but these can be termed as *untutored beliefs* and are part of *commonsense theory*. Common sense theory is a collection of beliefs, values and concepts that people share in order to make sense of the world around them. Interaction of common sense and scientific theories yields a *worldview* or what the individual perceives the world to be. Cobern puts this as follows:

> "From this theoretical point of view, each person can be seen as having a fundamental, epistemological macrostructure which forms the basis for his or her view of reality. The more common term is *worldview.* Commonsense theories and scientific theories are different ways in which one makes sense of the world. Both ways, however, rest on the fundamental assumptions (presuppositions) of one's worldview... It is not necessary, however to view commonsense and scientific theory as being mutually exclusive alternatives.... It is more appropriate to see

> scientific theories as being two distinctive but overlapping frameworks and as involved in activities animated by distinctive but overlapping purposes". (Cobern 1994 - p4).

I support the notion that learners do not have misconceptions but that they view the world differently from what Western science projects the world to be. Cobern (1994,1999) further suggests that untutored beliefs are socio-culturally influenced and it is inappropriate for the educator to label these as misconceptions. Even more so when one takes into account that scientific theory is far removed from day to day activities and commonsense theories are part of people's culture. *Worldview* is described as 'a totality concept referring to one's total outlook on reality' (Cobern 1994 – p6). Why then opt for one in expense of the other? Cobern uses Kearney's (1984) seven universal attributes which each individual interacts with, so as to arrive at a worldview. The seven attributes are self, non-self, classification, relationship, causality, time and space.

Since the environment is dynamic and knowledge changes, it follows that *worldview* can undergo variations depending on the day-to-day feedback the individual receives through the seven attributes. Variations are very small, since, for change to occur, new information has to be seen to be superior to, or has linkages to, foundational information that has been laid down over a period of time. There is similarity in this to the Generative Theory described above.

I am of the opinion that school science aims at eradicating or displacing commonsense theory and developing a one-sided *worldview*. It is not surprising that student's attitude and achievements in school science become negatively disposed; especially when one realises that learners come to classes with already existing and embedded worldviews, including those of science.

What is *scientific worldview*? Cobern suggests that to hold a notion that there is 'a scientific world view' is problematic. He argues that different people have different conceptions of what should be a scientific worldview, based on how they use the seven universal attributes. If this is the case, which scientific worldview should be taken as *the*

scientific worldview? Even scientists themselves belong to differing camps in this argument. He further suggests that there can be differing worldviews which can be scientifically compatible, but this does not yield *a* or *the* scientific worldview that can encompass all people's understandings.

2.3.6 Contiguity Hypothesis

Ogunniyi (1997) in describing his Contiguity Hypothesis acknowledges Collateral Learning Hypothesis as depicted by Jegede (1995) but further contends that this hypothesis does not explain how the learner maintains the balance proposed between school science and traditional science. To explain this he proposes *contiguity hypothesis* as a way of bridging two differing mental states or understandings. He proposes that they depend on worldview, worldview in this case being influenced by the cultural background of the learner, and Western science understandings. Contiguity Hypothesis is a mechanism of resolving and accommodating two or more conflicting ideas. He puts this as follows:

> "The Contiguity Hypothesis is a bridge principle depicting the dynamics of integrative reconciliation between school science and alternative worldviews held by pupils... A world view in this regard is the **cultural Hegelian dialectic** which transforms apparently contradictory or anomalous ideas to a higher form of understanding...within a given context an individual exhibits only the dominant world view." Ogunniyi (1997 -p52). (**My emphasis**.)

To do this, Contiguity Hypothesis takes into cognisance that various conditions must be conducive for it to be successful. Some of these conditions that should be considered are that:

- learners hold ideas or world views quite distinct from science;
- scientific knowledge does not always accord with sense observations – understanding comes by negotiation of meanings rather than by imposition.
- there is a need to develop science curricula which will be culturally relevant and compatible in terms of instruction, resources, values, and daily experiences of the learner.

This again emphasises the importance of taking the learners indigenous understandings when designing science curricula.

2.3.7 Conceptual Change Model

The conceptual change model cited in Hewson and Hewson (1983) suggests that there are three conditions which should be satisfied by a new conception before it can be integrated with the existing knowledge. The new conception must be *intelligible, plausible* and *fruitful*. If it is *intelligible* it means the person considering it knows what it means without necessarily believing in it. S/he can make a coherent presentation of it. For it to be *plausible* the person must find it to be intelligible and believe it to be true. In this case the new conception can be reconciled with the existing knowledge. A *fruitful* conception can be used to solve problems and suggest new approaches. This model takes into account that learning is not just an addition of new knowledge into an empty vessel but involves interaction of new knowledge with existing one. This may also involve rejection of some conceptions. Knowledge is intelligible, plausible and fruitful within the culture and context in which it is used. Again in this model indigenous knowledge has to be taken into account since it is the existing knowledge in the Zulu learner.

2.4. Bridging the Gap Between Indigenous Science and School Science: Theoretical Framework

Modern Western science and indigenous science are found at school and at home respectively. Looking at the above suggestions about indigenous science and learning, it is clear that Zulu learners' indigenous science understandings and Western science understandings should be given equal status for meaningful learning of science to take place. Each should be accorded a status of being of value. No one understanding should be replacing the other. All suggestions show that learners construct new concepts using already existing knowledge, which in this case is indigenous knowledge. Figure 2.1 represents a pictorial explanation showing the linkage between the seven models and indigenous knowledge. Indigenous knowledge is in the centre of the diagram because in

this case I am looking at a Zulu learner's existing knowledge. The seven models depict existing knowledge to be important for any of them to succeed.

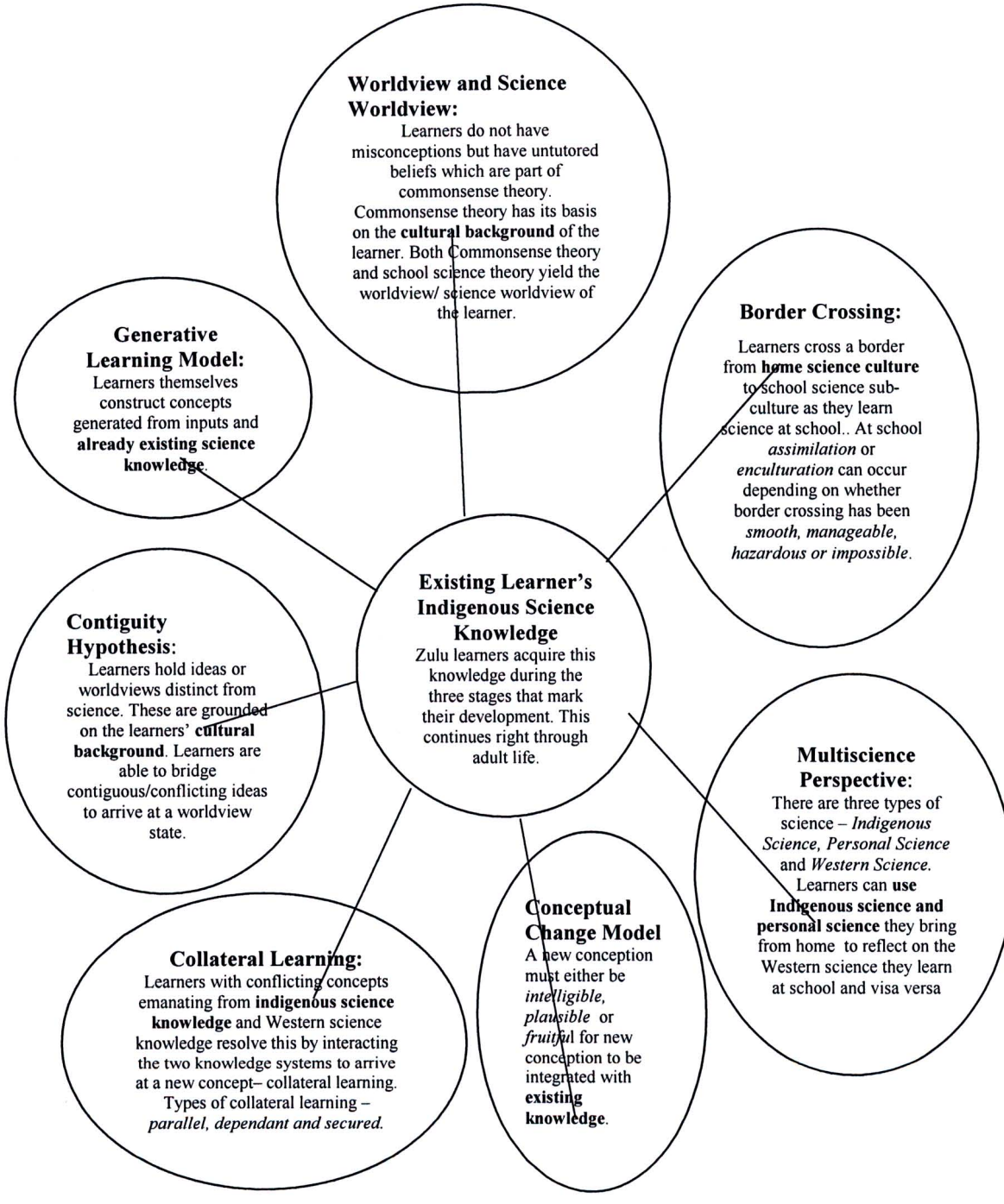

Figure 2.1: Relationship between existing knowledge of the learner and seven views on learning

2.5 Conclusion of Chapter 2

This study is anchored on the theoretical framework that learners come to class with already existing understandings or knowledge – indigenous science understandings. School science is yet another form of understanding which the learner comes into contact with. A number of scholars' views were discussed in this chapter concerning this issue. In this study I will explore the impact of these understandings on the secondary school learner. The methodology of this study is described in the next chapter.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction.

Chapter 2 described how Zulu children develop their understanding of some science phenomena and also developed a theoretical framework for this study. This chapter will highlight the methodology used in conducting the research, the choice of subjects interviewed, the concepts used in generating answers to the critical questions and data analysis.

3.2 Search for an approach

As I indicated in the previous chapters, this study seeks to identify, explore and understand indigenous knowledge embedded in the community's culture and in day-to-day activities of a Zulu child. I am also determining the impact of this knowledge when this child becomes a learner at school. I have already pointed out that indigenous knowledge is passed down from generation to generation through oral medium as well as through observing various activities occurring in the community. Traditionally, this is not documented in books or found in museums, or archives, as would be the case with other knowledge systems (Marial 1999).

In my opinion the ideal method for obtaining information should be similar to the way knowledge is passed down in the community. Colen, Manion and Morrison (2000) view interviews as interchange of views between two or more subjects and in this way have centrality in human interaction for knowledge production. In short, interviews are a tool that can help us to understand our fellow human beings. I was attempting to understand the conceptions of the elders and how these have impacted on the learners' understanding of school science. Adopting other methods of research like paper and pencil method might yield only a peripheral thinking, without giving me the underlying thoughts that produced such understandings. Thus I needed to interact with the subjects that possess the information through interviews.

The site I chose was Lower Msinga Village where both learners and elders reside. The reason for choosing this field has already been discussed in Chapter 1. Looking at all these I find myself positioned in an interpretative/phenomenological paradigm as opposed to a positivist paradigm. This then means that I am carrying out a qualitative research.

Why qualitative research and not quantitative research? To start with, as stated by Schurink (2000), quantitative research takes the following stances:

1. Questions and hypothesis posed by the researcher are subjected to empirical testing so as to verify them.
2. The researcher sees herself/himself as detached from the object/situation s/he is studying.
3. The researcher believes in an objective reality and that this reality can be explained, controlled and predicted using natural laws/rules.

On the first point, although in qualitative research there are no pre-determined answers that are to be proven, there is a presupposition in this case that indigenous knowledge has an impact on learners. It is the nature of this impact that is being determined. It is therefore impossible to go through a process of testing and verification, as this nature is still unknown.

On the second point, the nature of the answers I want from subjects would not give me the full outlook of what is actually happening if I am completely detached from the subjects. Interacting with the subjects would paint a more vivid picture of what is taking place. In other words interpretative research would explicate meaning from data that is enigmatic from the surface (Cobern 1993).

Lastly, Schurink (2000) argues that reality be looked at as pertaining to objects, which can be manipulated so as to follow rules – like rats in a laboratory or chemicals in a test tube. In this case the nature of the study requires human contact so as to arrive at a conclusive goal. This cannot be achieved when one has completely detached him/herself from the subjects studied. Ogunniyi (1984) puts this into perspective as follows:

> "Although statistical techniques have added the dimension of objectivity and generalizability to field-data, they are likely to remain of secondary importance. This is because human behaviours are quite complex and difficult to quantify. For example, a study might select only variables with precise measures while neglecting qualitative variables which might ultimately turn out to be more important characteristics of the culture under investigation."(Ogunniyi 1984 –p4)

In this research I would actually be doing the opposite of all the three above points stated by Schurink (2000).

Going further in qualitative research, De Vos and Fouche (2000) show phenomenology and ethnomenology as some of the strategies or tools that can be employed when doing this kind of research. They describe these strategies as follows:

> "These approaches aim to understand and interpret the meaning that subjects give to their everyday lives. In order to accomplish this the researcher should be able to enter the subject's life world and place himself in the shoes of the subject. This is mainly done by means of naturalistic methods of study, analysing the conversation and interaction that the researchers have with the subjects. Researchers using this strategy of interpretative enquiry will mainly utilise participant observation and interviewing as methods of data collection. Data are systematically collected and analysed within a specific context." (De Vos and Fouche 2000 -p80)

This description encapsulates strategies embarked on in this research. In this study I will interview, observe and analyse conversations of the subjects. This will take place in the subjects' life situations.

3.3 Choice of subjects

Basing the study on an assumption that all cultures have indigenous science understandings (Ogawa 1995), a further assumption was made that such understandings should exist in a selected community. The first step was to identify such a community. Thereafter I had to select the subjects that I assumed would possess this indigenous knowledge. Finally I selected subjects that I assumed would show the impact of this knowledge on their learning. These will be described below.

3.3.1 Selection of a community

I first assumed that indigenous knowledge would lie in those individuals who still lead a very basic rural life. I eliminated all other habitats like urban or semi-urban. Urban or semi-urban communities have a mixture of various indigenous knowledge systems. It would be difficult to actually trace one of these and would yield a lot of variables to consider when pursuing the study.

The community selected for the main study was Lower Msinga village. This village is situated at about 100 kilometres from the nearest city and about 40 km from the nearest town. Because of this proximity from urban environment, an assumption was made that the influence of Western culture would not be so profound as could be the case with the pilot study. In addition, the village was targeted because it was close to the school where the learners were based. The lifestyle of individuals in this area is divided into two – those that still follow strictly the traditional lifestyle and those who have imbibed the Christian living into their traditional lifestyles. The traditional-lifestyle group still wears traditional clothes -men wear *amabheshu* and women wear *amabhayi nezidwaba. Amabheshu* are loin skins covering the front and back of the lower body. *Izidwaba* are skirt-like skins worn by married women. *Amabhayi* are pieces of cloths rapped around the lower and upper body and are mainly worn by unmarried women. The Christian-Traditional group wore mainly Western clothes. Access was only possible into the Christian-Traditional group since parents of the broker belonged into this group (see definition of broker in section 3.6). All elders and most learners lived in this village.

3.3.2 Elders

The group interviewed was a combination of female and male – three females and two males were interviewed in this study. They were all above the age of sixty-five and this would put them at the age of being grandparents to the learners. This group was chosen for the following reasons:

1. they have lived longer and hence could trace traditional customs, norms and values that have lasted for decades;

2. they were chosen because they had not received secondary school education. I assumed that their indigenous knowledge would not have been contaminated with Western or school influences as it could have been the case in urban areas. This was important so as to make comparisons with the learners' understandings when analysing data; and

3. the community holds elders in high regard as custodians of traditional customs, norms and values (Jegede & Okebukola 1988). This transpired in my interaction with the broker, who comes from the same community and who played a biggest role in identifying the subjects for the research. Such practices were also observed by Waldrip and Taylor (1999) in their study of elders and learners in The Pacific Island of Kantri in Melanesia. They said:

> "Parents of students were not interviewed as planned because villagers wished to show respect by making available for interview their village elders. Village elders are perceived to be source of all wisdom and are the recognised authority on tribal knowledge." Waldrip and Taylor (1999 – p292).

The same practice was also found to exist in the community I studied.

3.3.3 Learners

The learners interviewed had no direct relation to any of the elders except that they came from the same community. Learners chosen were in grade twelve. They were all doing physical science and biology. The gender ratio was one to one i.e. four girls and four boys. It was important to get both views of girls as well as boys. They all belonged to the same class, as there was only one physical science class in this school. Their ages ranged between seventeen and twenty-one. They all came from Lower Msinga village with the exception of one boy.

This group was chosen because they had already received school science at its optimum level as they were in their final year. In addition, being older they might have been freer to discuss with me what they were doing in school as compared to the younger learners.

I also assumed that, since they were young adults, some of them could already be participating in community activities. The criteria of doing the two subjects, namely biology and physical science, was chosen on the basis that the concepts that would be used as vehicle of determining impact, would be grounded on the work done in these subjects.

3.4 Choice of language

All interviews were conducted in iSiZulu since all elders did not speak English and iSiZulu was their medium of communication. As mentioned above in this chapter, only those elders who did not have secondary school education were chosen. It was felt that they would have had less Western influence in their understanding of the concepts. In the case of learners I felt that they would also be more comfortable in their mother tongue, even though they spoke English as their second language. In addition they have acquired this knowledge in the mother tongue, which is iSiZulu.

3.5 Administering of instruments

All interviews were recorded in audiotape and field notes written on a notebook. Permission was first sought to use audiotape and write down field notes during the discussion. Subjects were asked whether they had any objections to being audio taped or to my writing down of what was being discussed. None of the groups or individuals objected. In the beginning, most subjects were self-conscious of the audiotape's existence, but later got used to it and behaved as if it was not there. As iSiZulu is my first language, I translated all the tape-recorded data from iSiZulu to English (see Appendix 2).

I used focus-group interviews because these allow freedom to discuss among subjects. The discussion was allowed to take its own course, but only redirected when it was felt that it was moving away from the scope of the research.

3.6 Entry into sites.

Brokers facilitated entry into sites. These are people who are well known to the data sources as well as the researcher. They act as go-betweens between the two parties. They facilitated the acceptance of the researcher by the data sources. The broker for the pilot was a colleague, who took me to his village where I did the pilot study.

I used two brokers for the main study. The first broker was the principal of a school who had been a biology teacher in a region where I work as a science subject adviser. He gave his school as a venue for interviews as well as giving me learners who were to be the subjects for the study. He also introduced me to a teacher who comes from the village of Lower Msinga and was to be my broker for the elders. The teacher introduced me to his parents who then gathered other elders of the community to be the subjects for the study.

3.7 Pilot study

The community selected for the pilot study was Mashingeni Village. Mashingeni is a rural village mainly inhabited by a Zuma clan. This village is situated about 40 kilometres from the nearest city. The type of lifestyle in this area is a mixture of traditional Zulu and Christian. Members of the community practice Christianity but still adhere to their traditional customs. The dress code in the community was both Western and traditional. Most women were observed to be wearing their traditional clothes as opposed to men. This community was chosen because of its proximity to where I work. It became easier to travel to this place several times within a short space of time, even after working hours. Secondly, although this community is close to town, it was found to be unique in that its members still adhered to Zulu traditional customs.

Originally, the pilot study was to be conducted on a group of six elders. *Induna* / headman was to set up the meeting with the rest of the group, but on both occasions no other elder came to his homestead. He insisted that whatever I needed to know from other participants he would be able to cover. As a result of this, he was the only person

interviewed for the pilot. The information received from this pilot was valuable and hence helped me to improve on the instruments.

The interview was conducted in iSiZulu since the elder did not speak English. As mentioned above, this was done so as to obtain the information in the language in which the knowledge is transmitted. Permission was also sought to tape record and take field notes. Questions asked were based on the two critical questions (see appendix 1).

Questions asked were mainly based on two concepts – **Fermentation** and **Heat.** The other concepts, **Thunderstorms** and **Lightning**, were linked to the discussion of the heat concept. It is important to note here that both thunderstorms and rain are given the same name in iSiZulu i.e. '*izulu*'. A thunderstorm is distinguished by qualifying the rain namely - '*ukuduma kwezulu*' -directly translated to mean - rumbling rain.

3.7.1 Results of the pilot study

The pilot study revealed that other related concepts had to be included in the main study. The necessary adjustments were made in instruments, bearing in mind the findings obtained. Adjustment on the concept of fermentation was made by including the concept of microorganisms. Discussing the concept of heat revealed other related concepts like – heat transfer, cloud formation and the states of matter; and these were then included. After these adjustments the main study concepts were as follows:

- Fermentation and Microorganisms
- Heat and its related concepts - heat transfer, cloud formation and changes of state
- Thunderstorms and Lightning

The pilot study also revealed that I had to be sensitive to certain taboo questions, protocol and other customs pertaining Zulu culture.

3.8 Data Collection and Analysis Process

The interviews were conducted in the environment where each subject was based, with

the exception of the elders. Learners were interviewed at school. Elders were an exception in that the first interview was conducted at school and the second interview was conducted in one of the subject's homestead. This was out of their choice. It could be that they did not want to bring a stranger to their homes on the onset. They wanted to know me first before they could open up.

A number of questions were asked for each concept for both the pilot and the main study. I made adjustment of the pilot study concepts and questions and then used them for the main study. These additions came out during the discussions in the pilot and were found to be casting more light on answers of the critical questions (see Appendix 1).

I used Miles and Huberman (1994: 428-444) method of 'data reduction, data display and conclusion drawing and verification' cited in Poggenpoel (2000) in working with the data. This was done for each group of the data sources.

In data reduction meanings are drawn from each interview and collapsed into explanations of each of the questions being answered. This was done by first typing the whole translated interview into a document. Annotations were made along each page. The annotations denoted the concept being highlighted in each phrase or phrases. In this way the whole document ended up showing each phrase with its related concept. An example of this is shown below:

Changes of state – liquid to solid	Researcher – Where does frost come from? Elders– Frost is like dew but comes in winter. The dew comes during the night and when you wake up in the morning you will find it on top of the grass. In winter because it is cold, the dew is cooled and turns to frost. This only takes place during the night when it is cold. Researcher – What happens to the dew or frost during the day? Elders – The frost melts and forms water which wets the ground.
Changes of state – liquid to gas	Researcher – What happens to the water? Elders – Water goes down the ground. Another – The sun takes it. If you pour water in a bowl, it disappears when left in the sun.

Only those concepts and answers that were related to the questions were used in the

discussion.

Data display is presentation of explanations of each of the questions. Meaning was drawn from highlighted data (shown above) by grouping together concepts being discussed. These meanings were then summarised and displayed as answers to questions.

Conclusion and verification is interpretation I drew from the displayed data. Each explanation of a concept from elders was compared to that of learners. Points of departure or convergence were highlighted and conclusion drawn. Where new concepts or ideas emerged, these were also discussed and presented.

3.9 Limitations

With face-to-face interviews the problem was that subjects could tell me what they thought I wanted to hear. In the case of learners, they could have viewed me as a 'teacher' who would give marks at the end of the research. I tried to overcome this by stressing to the learners that the data was only for my own use and the school played no part in it. I encouraged them to be open and only tell me what they believed to be true.

When it came to elders, an element of suspicion could have come in. As a stranger in the community, I was not sure whether some of the information was withheld from me, especially when we were discussing thunderstorms. Thunderstorms are linked to witchcraft in these rural communities. To alleviate their fears I allowed the subjects to tell me only what they wished. I also mentioned that the information was confidential and only for my own use. Names of the subjects would not be used in the research if they were uncomfortable about this.

In view of these circumstances, generalisability of the study might be difficult. Poggenpoel (2000) also holds the notion of the difficulty of generalisabity in qualitative research.

Another limitation was translation of the data from iSiZulu to English. The richness of

the information is usually lost during translation. In some instances I had to search for the right expression to use and try not to distort the meaning. In some cases there were no words in English that could explain fully what was meant. In such cases an equivalent term in English was used. For example, in iSiZulu there is one term for both heat and temperature and also for thunderstorms and rain. These have been explained where relevant in this study.

3.10 Conclusion

This chapter has detailed the choices made in the selection of site, subjects, concepts and method of conducting the research. The community, subjects and type of concepts selected were all influenced by indigenous knowledge practices. In this case I assumed that rural areas still have indigenous knowledge practices which are not so highly influenced by Western cultures. The method chosen for extracting this data was qualitative phenomenological research using interviews. In the next chapter I will present and analyse the data.

CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

4.1 Introduction

In Chapter 3, I discussed the methods used in doing this study and how the data would be presented. This chapter would present and analyse this data obtained chronologically according to their relevant critical question and selected phenomena. Questions leading to the explanation of concepts surrounding each phenomenon were asked so as to facilitate the discussion. A summary of answers to these questions is also presented here. In some cases more than one question would be answered by one explanation. Discussion and analysis of each question and its answers would be linked to its critical question and hence, the research topic. I will discuss each concept and its answers one at a time.

4.2 Critical Question 1:

What are the elders Indigenous Science Understandings on selected phenomena?

To get answers to this critical question it was necessary to first identify selected phenomena. The selected phenomena were *Fermentation and Micro-organism*, *Heat and its related concepts,* and *Thunderstorms and Lightning.* Questions were formulated around these concepts as shown in Appendix 2. In Chapter 1 I explained why each of these phenomena were chosen instead of others. The following answers to the questions were given by all elders during the interview.

4.2.1 Fermentation and Microorganisms

To get the answers to these concepts it was necessary to first get a description of how traditional beer is made. I assumed that if elders entered into a discussion with me of what they normally do rather then answering verbatim questions, this might facilitate easy flow of conversation and information. They were all familiar with the making of

beer. Asking them about baking bread for example would have been far remote from their routine activities. Making beer is a common activity among rural Zulu communities. I therefore asked them the question: (a) *How is traditional beer made?* The description given by elders was as follows:

> Ground sorghum, sorghum malt and maize malt are used. Boiling water is added into a mixture of ground sorghum and sorghum malt. This is left overnight to ferment. The following day this mixture is cooked into porridge. The porridge is allowed to cool overnight. When it is cool, a mixture of ground maize malt and ground sorghum malt are added into the cooled porridge. This then ferments into beer by keeping it in warm place. The fermented mixture is sieved to remove spent grain from the liquid.

The reason for asking this question was merely to use it as a vehicle to arrive at underlying concepts in beer making i.e. fermentation and microorganisms.

(b) What causes fermentation in traditional beer?

The cause of fermentation in the description of the process above was given as being ground sorghum and ground sorghum malt. When asked whether the porridge would ferment if malt was not added, the explanation was that it would ferment but not as beer and would not be suitable for drinking. It was clear in this explanation that microorganisms did not play any part during fermentation.

I found logic in this explanation. It showed the steps that had been followed over generations and explanation of why each step was taken. When I asked for the explanation of boiling, it was explained that boiling makes the sorghum and sorghum malt soft.

> Researcher: Why do we add boiling water?
> Elders: Boiling water makes the mixture to ferment. It does not ferment if cold water is added. Boiling water also softens the sorghum-malt mixture. The following day we scoop the liquid part of the mixture and add into another pot. Mix it with cold water and add it into another pot. Allow this to boil and add the remaining mixture. Cook it. Cool it overnight and add malt to let it to ferment.

Elders also explained that heat triggers the initial fermentation. A concept of a catalyst was also introduced during the discussion. The catalyst was a substance called *inhlese* (this is a sediment of previously fermented beer that is dried and kept for this use). I was told that *inhlese* is used to start off and speed up fermentation. If it was not there, fermentation would take place but at a slower rate. *Inhlese* is added directly into the beer. Since it is a sediment of previously fermented beer, it is edible and therefore is incorporated into the fermenting beer. In other words *inhlese* is spent sorghum and sorghum malt. This was the response given when they were asked to explain what *inhlese* is:

> Elders: This is a sediment of previously fermented beer. The sediment is filtered out of the liquid part and is allowed to dry. It is used to starting the process of fermentation. The sediment can also be eaten as food by first cooking it.

(c) Do microorganisms exist?

I followed up the idea of mould explained to me as forming in the granary where malt is kept. I asked whether mould is a kind of an organism. The existence of microorganisms as agents of fermentation was vehemently disputed. It was explained to me that it was impossible for organisms to enter into the sorghum. Sorghum is kept in a specially designed granary with no access to any creatures (see Appendix 3 for the structure of a granary). They explained that mould comes from the granary because it is warm. When the idea that mould could be an organism was suggested, this was vehemently rejected as they felt that the granary is very clean. This was part of their argument:

> Researcher: It is believed that some of these organisms cannot be seen with our naked eye. They are in air so they can go in with air.
> Elders: No such organism goes in there. This is a sacred place and it is very clean.

When asked why some of the grain rotted if nothing went in, the response was that the warmth is the cause of rotting and production of mould; not organisms. Elders felt that if there are any organisms, these must have been brought in with foreign foods. This is how they put it:

Researcher: It is believed that we are not able to see these organisms. They are there in the air we breathe, even there in the beer we drink. They cause the beer to ferment.
Elders: Not at all. These organisms were never there from time immemorial. If they are there now, they are new arrivals. We have only had things like, weevils and beetles that fly in air. We are hearing about these organisms for the first time. They were never there during our times. They must have been only brought in with the European things. You now have things like onions, tomatoes, potatoes and all these have come with these organisms you are talking about.

It was clear to me that the idea of microorganisms and their existence is a concept not known in this indigenous knowledge. Fermentation as such is caused by ground sorghum and ground sorghum malt. The reason for this could be that microorganisms cannot be seen with the naked eye.

When I compared school science and indigenous knowledge explanations, the explanation given by elders equates quite well with school science. They have given sorghum as the cause of fermentation. They have discovered that fermentation does not yield the type of beer expected if one does not use sorghum. They mentioned that in such a case fermentation occurs, but the beer produced is not suitable for drinking. If one looks at school science, yeast is a cause of fermentation and this can be equated to the use of *inhlese* in indigenous knowledge. The difference lies in that indigenous knowledge takes *inhlese* as a catalyst (something speeding up the reaction) although *inhlese* actually contains yeast since it is spent sorghum malt from previous fermentation. This difference was due to the fact that indigenous knowledge of these elders does not acknowledge the existence of microorganisms – hence *inhlese* containing yeast as microorganisms.

(d) What are factors influencing fermentation?

In both school science and indigenous knowledge explanations, the mixture must be kept in a warm place and too much heat can spoil the beer. In school science learners are taught that one of the factors influencing fermentation is temperature. Temperatures around 40°C would speed up fermentation while lower temperatures would slow down the reaction. This is in agreement with elders' view as seen in the following extract.

> Elders: Boiling water makes the mixture to ferment. It does not ferment if cold water is added. Boiling water also softens the sorghum-malt mixture... Cool it overnight and add malt to let it to ferment. Let it stand in a warm place.

Also in both cases one can trigger fermentation by addition of an agent –one can add commercial yeast in school science and *inhlese* in indigenous knowledge.

(e) Second explanation of fermentation

During the course of the discussion another explanation surfaced on the cause of fermentation. Elders explained that different people make the different qualities of beer. Some people have an ability of making quite potent beer which can make one very drunk. Even if other people try to imitate them, they still do not produce the same kind of beer. The elders told me that such people 'have *isandla'* (directly translated to mean 'have a hand'). This, they explained, as a gift a person is born with. They explained this as follows:

> Researcher: Do all people make the same type of beer?
> Elders: No. Others have *'isandla'* and their beer can make you very drunk.
> Researcher: Why is this so?
> Elders: This is a gift they are born with. It is a gift from the ancestors.
> Researcher: Can't other people learn from the person with a gift to make the same kind of beer?
> Elders: No. Even if they use the same ingredients the beer would not be the same. If you have a gift, it is yours. Other people cannot use it.

This means that, according to elders' explanation, the cause of fermentation is determined by two factors – the natural factor – sorghum, *inhlese* and warmth - and the supernatural factor – powers a person is born with *(isandla)*. The two factors do not oppose one another but can exist side-by-side. This concept also surfaced in other explanations that follow. It will be discussed further on in this chapter how learners deal with it.

4.2.2 Heat and its related concepts

There were a number of questions I asked elders to find out about concepts held in relation to heat. I will discuss these one at a time.

(a) Where does heat come from?

This question was asked so as to find out what indigenous knowledge considers to be sources of heat. The source of heat given by elders was from burning matter. In this case it was wood. This is the explanation given by one of the elders, Mr Gonyela Ndlela (pseudonym) who was a member of the panel. Mr Gonyela Ndlela happened to be the only one in the group who had produced fire the traditional way. He did this as young boy while herding his father's cattle.

> Researcher: Did any of you ever used this method of starting the fire.
> Elders: Only those before us. Only Mr Gonyela Ndlela used this method as a young boy while heading cattle.

Mr Ndlela explained this as follows:

> You use an axe to cut and chop '*umthanti*' tree. Two pieces of wood from this tree are rubbed together at an angle (He demonstrates how the two pieces of wood are positioned.) Sparks come off.
> Researcher – Where do the sparks come from?
> Ndlela: From the two because of the rubbing. You can actually feel the heat as you rub.
> Researcher: Is this tree still available?
> Ndlela: Yes, but we do not use it anymore.
> Researcher: How long does it take before you can produce a flame?
> Ndlela: A very long time.

From this explanation it was clear that heat could be produced when two specific types of pieces of wood from a specific tree were rubbed together. From heat a spark was formed and produced a flame. Elders showed that substances like wood burn producing more heat. Comparing this to school science, one sees similarities where a matchstick head releases sparks and a flame from rubbing it against a rough surface of a matchbox. Again a matchstick and a surface of a matchbox are special kinds of chemicals; just like with elders in the case of a special tree, the *umthanti* tree, that gives these results.

(b) Heat Transfer and Effects of Heat:

How does heat travel and where does it go, when in contact with a substance?

To get answers to this question I asked questions surrounding the cooking of food.

> Researcher: How does food get cooked?

Elders: Water makes it soft.
Researcher: What if we barbecue *(ukuyosa)* it and not use water?
Elders: Still it is cooked. The heat passes from the fire through the pots into the water into the food. Air is blocked from entering the food.
Researcher: Is it the heat or the water that cooks the food?
Elders: The heat cooks the food. It travels from the fire to the water and to the food. The air is stopped from entering the food because it can cool the food and stop it from cooking.

From their explanation it was clear that heat cooks the food. For this to happen heat travels from its source through other substances until it reaches food. The food changes and becomes cooked. This heat can also be lost if air is allowed to be in contact with cooking food. In other words heat can be transmitted from food to air. Looking at these explanations a conclusion can be drawn that heat is transmitted through all states of matter. From fire to the pot, indicates transmission of heat from the fire to the solid. The solid, in this case being the pot, transmits the heat to the liquid, in this case water. Water transmits the heat to food and the food can either be a solid or a liquid. Finally heat can travel from solid or liquid to air, if the food is in contact with air. All these show conduction of heat as mode of heat transfer.

This is in line with the school science concept of heat transmission, which states that heat travels through substances. In this way heat can be gained or lost by solids, liquids or gases. When elders were asked what happens to hot substances when they are left exposed, their answer was that the wind takes their heat. This is similar to school science explanation that, exposed hot substances lose their heat to the environment. When I compare school science explanations and indigenous knowledge explanations about heat, I find few differences. Elders view heat as an entity, that is, the fattening notion as opposed to energy version. It is seen as something that moves from one point to the other. Air is seen as something that carries this heat entity away during the loss of heat by a substance. Another difference I see is that indigenous knowledge does not attach names or terms to transfer of heat. It does not go to the point of differentiating between various types of heat transfer such as conduction, convection and radiation. But, still, indigenous knowledge concepts about heat transfer are not contradicting the school science ones. School science uses both caloric notion and energy version; for example the calorific content of substances and the energy transfer from one point to the

other. The concept of heat as a form of energy does not exist in the elders' view. This does not create a problem. Explanations can still be made without using this version.

Elders associate heat loss with air or wind. (Please note that there is only one word for both air and wind in iSiZulu, that is *umoya*). Since heat is considered to be an entity, it is taken away by air or wind when it is lost. Air can also cool things it gets into contact with. These explanations are shown in the extracts above and below.

> Researcher: Where does the heat go to? If you leave hot food on a table, it gets cold.
> Elders: The wind takes it. The heat is then gone with it.

I see close relation to school science here which states that moving air can speed up cooling – which is the loss of heat. The difference lies only in that indigenous knowledge takes heat as an entity that can be lost, while this loss of heat is associated with energy of particles in school science. Still, there is no contradiction in the two concepts.

(c) Source of body heat: Where do our bodies get the heat?

I wanted to see whether there were linkages of heat and the food eaten. In this way there could be similarities between school science and indigenous knowledge. In school science food is a source of energy and this energy is stored as chemical potential energy. During body metabolic reactions, this energy is converted from chemical potential energy to heat energy. This is the explanation that was given by elders:

> Researcher: What about heat in our bodies? How can we explain this heat?
> Elders: Breath makes you alive. It warms your blood. Your blood then moves. When your breath is gone, your body gets cold. It is the breath that makes you warm. When you are wet, you become cold and you get warm because your breath warms you up.
> Researcher: Is the body heat similar to the heat from the fire?
> Elders: No. No one is heating your body. The breath is holding the heat. You were born with it. When you die the heat will leave your body with the breath.

In this explanation, body heat is something one is born with and it will leave the body when one dies. There is also mention of blood being warmed by breath and a correlation that when one has breath, the blood gets warm and it moves. When one dies the body gets cold because one has stopped breathing. The theory of body heat of elders is developed and confined to the context of living and death. This is different from the explanation in school science where body heat is generated all the time through respiration process. Breathing is just another process that keeps one alive but not the sole controlling process as viewed by elders. Contrary to school science, elders did not mention the central nervous system as the controlling aspect of various body functions, including body heat and breathing. This is one concept completely different to that of school science. In Chapter 5 it will be seen how this affects learners.

(d) Changes of state: How do three states of matter occur?

To answer this question we discussed frost, dew, water, clouds and mist and I tried to see whether they made any linkages in these phenomena. Elders made linkages within some of them but not all, as seen in the following discussions.

Elders explained that dew is formed at night. If it is cold, like in winter, dew is cooled and it becomes frost.

> Elders: Frost is like dew but comes in winter. The dew comes during the night and when you wake up in the morning you will find it on top of the grass. In winter because it is cold, the dew is cooled and turns to frost. This only takes place during the night when it is cold.

This explanation is based on their observation of what actually takes place in nature. They see drops of water remaining as a liquid – dew - in warm weather but in cold weather these change into a solid – frost. Here there is logic developed from observations. This logical explanation is also prevalent in their description of other changes of states. They explained that during the day when it is warm the frost melts and forms water. Some of the water goes into the ground while part of it disappears and is taken by the sun.

> Elders: The frost melts and forms water which wets the ground.
> Researcher: What happens to the water?

Elders: Water goes down the ground.
Another elder: The sun takes it. If you pour water in a bowl, it disappears when left in the sun.
Researcher: Where does it go to when it disappears?
Elders: Water burns up and just disappears. We are not sure where it disappears to.

I think here there is quite a quantum leap in their deductions in that they associate some of the water as being taken by the sun even though they do not see this happening. They were not sure where the sun burns and takes this water to. The elders showed a linkage between water in the ground, mist and clouds. They explained that water in the ground comes up as mist, which can also form clouds. Again here there is an association between liquid water, moisture, mist and clouds, even though moisture is invisible. Moisture according to them comes from the ground. It is not everywhere as is taught in school science. Elders further explain that clouds collect rain from the sky and rain falls as water into the ground.

Elders: When it is warm, the clouds come from the mist in the ground. The mist rises to the sky and forms clouds. Clouds collect rain from the sky and rain falls down. The same mist forms the dew on the ground. It can form clouds and also dew. It comes from the moisture in the ground.

There is no association made between clouds and rain in terms of clouds cooling and forming rain. Their understanding is that rain is already in the sky and the clouds collect it and bring it down. This is a different theory from that learnt at school where clouds cool down and form large droplets that become heavy and fall down as rain. Again the elders' theory could be based on observations in that the sky is transparent just like water and therefore water must be there. Also rain only falls when there have been clouds. It is only logical to them that the clouds must have brought this rain down.

A diagrammatic presentation of these processes can be in summarised figure 4.1 as follows:

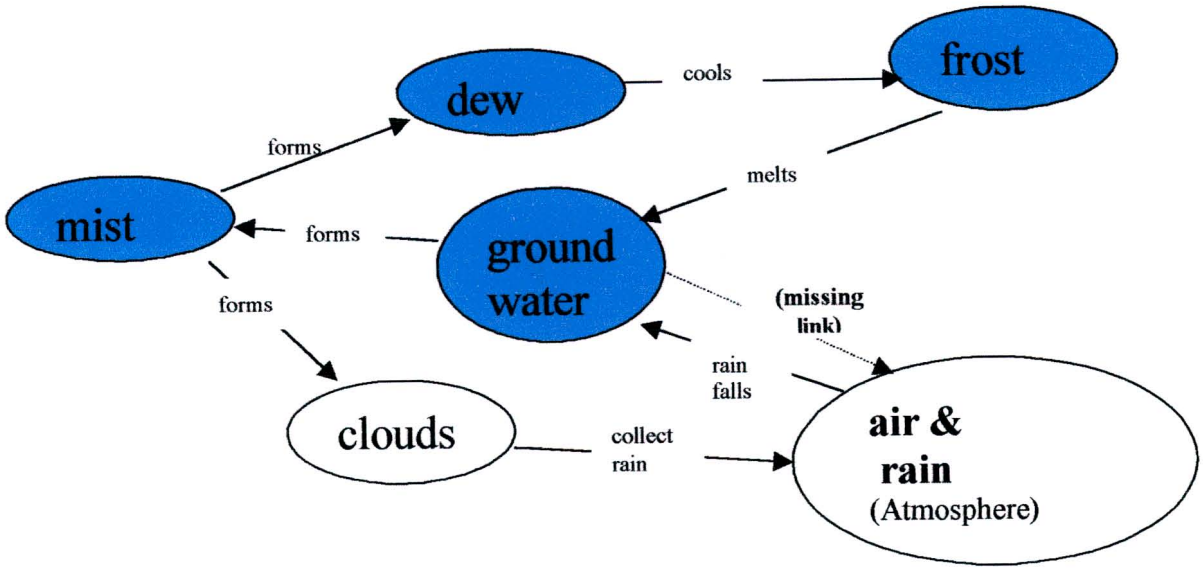

Figure 4.1:Changes of states of water – Elders Explanation

The diagram figure 4.2 below is a summary of the school-based description of changes of states of water.

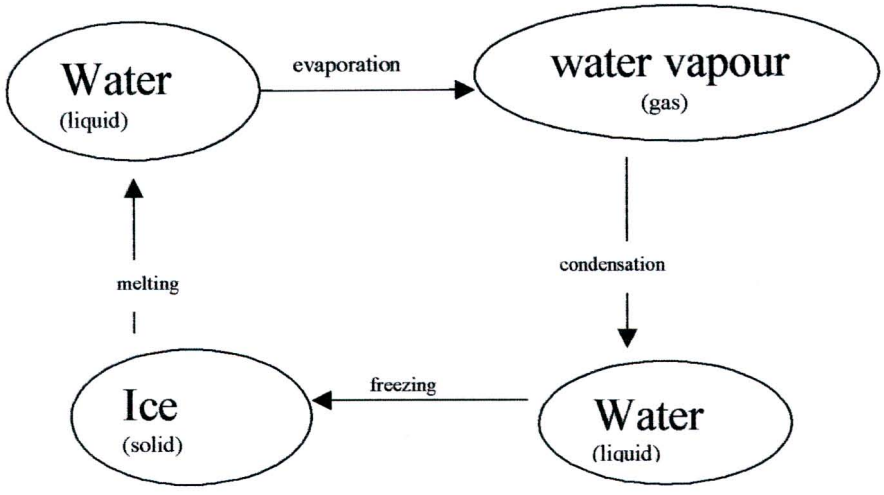

Figure 4.2 Changes of states of water - School Science Explanation

Comparing elders' explanation to school science, I see a relationship between the three states of matter - gas, liquid and solid – as explained by both school science and elders. In elders' description in fig. 4.1 shaded parts of the diagram, mist (close to gas state) changes to dew (liquid state) and changes to frost (solid state). Again frost (solid state) melts and changes to ground water (liquid state) and then forms mist (close to gas state). The water cycle is complete and is similar to that in fig.4.2 which is taught in school. In school science a liquid changes to a gas and elders describe the moisture becoming mist and clouds. A change of a solid (frost) to a liquid (water) is identical in both school science and elders' explanation. The problem only arises in elders when a liquid has to change to a gas or a gas has to change to a liquid. This explanation requires description of an invisible entity – water vapour.

The elders' theory on changes of state is based on the visible aspect of matter while in school science the explanation is based on particle theory which can accommodate invisible aspect of some matter like gases. Particle theory allows the linkage between water vapour in the sky changing to a liquid which is rain. Invisible particles of a gas – water vapour – come close together due to their kinetic energy being low. When the kinetic energy is low and the distance between particles is small, the state of these particles is now that of a liquid. On the other hand, since elders' theory is based on what can be seen, this explanation cannot be attained.

Also elders could not explain what happens to water when the sun 'burns' and takes it. They can only explain that it disappears and the disappearance is linked to the sun and burning. Water does not only disappear to the ground but some of it is 'taken' by the sun.

I find this to be a plausible explanation. The explanation is given to those things that can be seen. Since water vapour is invisible to the naked eye, it makes sense that its existence is difficult to explain. Elders have also observed that when water is poured on the ground it disappears. When one digs the ground the soil underground would be found to be moist. This observable aspect of water then forms the basis of their explanation. The need has not arisen to require formulation of a theory like particle

theory; hence elders have not seen the need to find out where the sun takes the water to. This has not affected their daily lives and activities.

It is also important to note that elders' explanation linked heat/temperature to changes of state. For frost to form, dew had to be cooled by cold winter nights. For water to disappear, the sun had to heat it. (Please note that there is one root word for both heat and temperature in iSiZulu - ***shisa***. Heat is *ukushisa* and temperature is *izinga lokushisa.)* This idea of temperature linked to changes of states also exists in school science. Learners are taught that for one state to convert to the other, energy is either released or absorbed and this energy can be in the form of heat. In indigenous knowledge explanation, heat is the cause of changes of states. They mention that frost occurs in winter when it is cold and mist forms clouds on a warm day. The sun 'burns' the water and it disappears (see above extracts). They associate these changes of state with temperature changes.

4.2.3 Thunderstorms and Lightning

(a) What is lightning and where does it come from?

Thunderstorms and lightning are a phenomenon that all elders are exposed to. Asking this question would elucidate views held by elders on this occurrence and then these views could be compared to the school explanation. The panel found this question very difficult to answer. They explained lightning as a ball of fire that comes down from the sky. This led to the explanation of how traditional healers use their medicines to protect the homestead from this occurrence.

> Elders: Lightning comes down like a lump of fire. A traditional healer would smear medicine on some sticks and the father of the home would stick these on the houses to protect the homestead.

As explained in indigenous knowledge, there are two types of thunderstorms and lightning, God made and man made. Elders could not explain how a thunderstorm or lightning occurs. Their explanation is that it is God's creation. Elders explained that, besides the Maker, witches also could create lightning. This is what elders said:

Elders: That is quite a difficult question. That is for God to know what actually happens; except if people who are witches made it.

I realised that since the topic is linked to witchcraft, no one would volunteer to give an explanation. What I can deduce from their answers is that there are two ways of explaining the concept of a thunderstorm. The first one is that it is a natural phenomenon which is explained as God made. The second one is linked to supernatural powers. Here again thunderstorms are explained in two ways – the supernatural form and the natural form. I explored this idea further with the elders.

Researcher: This means that there are two types of lightning – God made and man-made.
Elders: Yes there is also lightning which is witchcraft. It is the lightning which is made by a person when that person just wants to 'play' in your house.
Researcher: So there is lightning made by people? Can it really work?
Elders: Oh yes. It really works. This type of lightning can also be stopped from coming into the homestead. It can be driven away so that it strikes the trees instead of the homestead. The natural one is from the Maker and usually does not strike the homestead.

This also explains why most of them did not want to discuss this topic further. From my understanding of Zulu culture, no one wants to be labelled a witch. In olden days, witches were killed and burnt in their huts. This stigma of being a witch is still viewed with fear even today. I think that if one appears to be knowledgeable on how a thunderstorm or lightning occurs, the feeling could be that one is actually practising witchcraft. They fear becoming victims of witchcraft if they are suspected of knowing something about this. The belief among Zulus is that a witch could test the powers of another witch to see how 'strong' s/he is. This could have been the reason for refusing to discuss the matter further. There was no mention of this being a gift from ancestors.

After exploring the indigenous knowledge held by the community of Msinga, I will now look at science understandings held by learners of the same community. As I have already explained, these learners have been exposed to both school science and this indigenous knowledge.

4.3 Critical Question 2:

What are science understandings held by learners of Lower Msinga community?

This question will uncover learners' views after being exposed to both indigenous knowledge and school science. It will show which of the two views learners hold. Or do learners come out with a view of their own? For this critical question I also followed the same procedure as in critical question one. I used the same phenomena so as to identify whether there are any similarities or differences between learners' and elders' views. The phenomena were still *Fermentation and Microorganism*, *Heat and its related concepts,* and *Thunderstorms* (see appendix 1). In the beginning of each interview I asked learners to give me their own explanation of each concept. In other words, I wanted them to tell me what they actually believed to be the truth. I insisted that they should not give me what they thought was someone else's explanation, but that it should be their own understanding. Learners were interviewed in a group without the questions being directed to individuals. The group's answers would be its understanding. When members in the group did not agree with the answer they would discuss until they reach a consensus. All answers given below are views of the whole group. I will now discuss each concept and its answers one at a time.

4.3.1 Fermentation and Microorganisms

When I initially interviewed the learners in connection with this section, I discovered that they had not yet covered the topic on fermentation in their school science. They were going to learn this in subsequent weeks. I therefore decided to schedule a second interview after two months. This was to be done when they had covered the work. Extracts of their explanation are from both first and second interviews, that is, before and after they were taught the section on fermentation in school.

(a) How is traditional beer made?

This question will bring out views held by learners on the concept of fermentation. I decided to go this route to create a dialogue rather then going through a question-and-

answer route. Learners' explanation on how traditional beer is made can be summarised as follows:

> Sorghum malt or maize malt is ground into a powder. You put water in a pot and boil it. Make a paste with maize and sorghum malt and maize meal. Add this to the boiling water. Leave it overnight to ferment. The following day you cook this like porridge. It is called *umncindo.*
> Then it is cooled. After cooling you add sorghum malt. It changes and looks watery. You then allow it to stand for some days. Then it ferments again.

The method described by learners was identical to that given by elders. Both elders and learners mentioned that fermentation has to occur twice. The first fermentation is described as that which makes the mixture sour. The second fermentation produces alcohol in the mixture. There is agreement in procedures used by both learners and elders. School science in this case has not altered indigenous knowledge possessed by learners.

(b) What causes fermentation in traditional beer?

(c) Do microorganisms exist?

Both these questions will elucidate whether learners link fermentation with microorganisms or a different view is actually held by them. In this case both questions would be discussed simultaneously because the data answers both. During the initial interview learners described the cause of fermentation as being due to sorghum malt. Their description fits that of the elders.

> Researcher: What is *umncindo* and how is it different from ordinary porridge?

I asked about *umncindo* because learners had mentioned that the mixture ferments into a substance called *umncindo*, meaning that this mixture is different from the original substance. Their description indicates that this is a sign of fermentation.

> Learners: *Umncindo* is sour.
> Researcher: What makes it sour?
> Learners: Because it was prepared the previous day.

Researcher: If I cook *uphuthu* the previous day will it be sour the following day?

Uphuthu is crumbled porridge made with maize meal. Their explanation indicated that it is sorghum that causes fermentation and not only just leaving the mixture overnight. Their explanation was as follows:

> Learners: *Umncindo* is made sour by maize meal and sorghum malt but *uphuthu* is just maize meal alone. That is why it is not sour. *Umncindo* has fermented.
> Researcher: What has caused fermentation?
> Learners: Sorghum malt and warmth. When it is cold you use *inhlese* to make it ferment.

Learners described the first and second processes of fermentation as being caused by sorghum malt. This description is identical to that of elders whose explanation also indicated that sorghum is the cause of fermentation. During the second interview when the learners had had exposure to school science explanation, their explanation altered slightly. On the onset, they still believed that malt is the cause of fermentation and later on in the discussion they mentioned bacteria as the cause.

> Researcher: What makes the mixture ferment?
> Learners: Sorghum makes it ferment. (One learner explained that they always use a mixture of maize and sorghum malt.)

The above explanation was given in the beginning of the discussion. They still believed that malt is the cause. I then asked them how they described fermentation in school science.

> Researcher: What about fermentation? What do you say about fermentation at school?
> Learners: In plants when there is shortage of oxygen, like in yeast, glucose is broken down into alcohol.
> Researcher: Is it similar to traditional beer making?
> Learners: We are not sure.

From the description there is no linkage being made between school science and existing knowledge. Some of the learners gave another explanation as being bacteria.

> Learners: I think it is the bacteria that make the beer ferment.

Researcher: That is different from the explanation you gave me before. You told me that sorghum malt makes the mixture ferment and produce alcohol.
Learners: I think malt has the bacteria. The bacteria make the mixture sour.

During the second interview after exposure to the school version of fermentation learners were making linkages between indigenous knowledge and school science. Malt is thought of having bacteria in it and thereby being the cause of fermentation. At the same time learners did not want to abandon their existing knowledge of malt being the cause, for the new one of bacteria. They used the school science to enrich and not to abandon their initial conceptions. This is in agreement with studies carried out with black high school students in South Africa by Hewson and Hewson (1983). They discovered that students who were taught by linking their existing knowledge with new concepts, showed better progress in acquisition of these new concepts. Those who were taught without using existing knowledge showed poor acquisition of new concepts. They deduced that poor progress of the control students in acquiring scientific conceptions lay with the continued presence of the alternative conceptions in their conceptual frameworks. Hewson and Hewson (1983) findings can be used to explain why learners still believe that malt is the main cause of fermentation and that organisms must be attached to the malt for the process to take place. There is continued presence of indigenous knowledge in learners' conceptual frameworks.

Similar findings were identified in a study carried out by Waldrip and Taylor (1999). The study was carried out using elders and high school students in South Pacific Island of Kantri. They discovered that students perceive that the agricultural science methods they learn in school are not superior to their traditional methods. Students still held their traditional methods in agricultural science even after years of schooling. In my study learners still hold the concept that fermentation is caused by malt even after exposure to the school science notion that organisms are the cause.

In the interviews it also surfaced that learners do believe that microorganisms exist. Their existence though, is still associated to sorghum malt. They mentioned the existence of yeast and bacteria attached to sorghum, being agents of the fermentation process. This explanation is different from that given by the elders who vehemently

denied the existence of microorganisms. Learners must be finding some sense in this new explanation and hence not abandoning it completely.

(d) What are factors influencing fermentation of beer?

This question would indicate whether learners hold the school view, elders' view or a different view on factors influencing fermentation. Learners identified these factors to be temperature (warmth) and the use of *inhlese* as a catalyst. This is identical to the elders' view on the same aspect. In their explanation it is clear that they are aware that temperature plays a part in the rate of fermentation. This was their assertion.

> Researcher: In your last explanation you told me that it is the sorghum malt that causes fermentation. Also last time you said the warmth is a catalyst. Now you tell me warmth also causes fermentation. Which is true?
> Learners: No, the warmth makes it ferment faster.

When it came to the addition of an agent – *inhlese* – the feeling was that it is used when one wants to increase the rate of the process. Their explanation was that on a cold day this agent is used for this purpose.

> Researcher: What has caused fermentation?
> Learners: Sorghum malt and warmth. When it is cold you use *inhlese* to make it ferment faster.

Learners also explained yeast as being a catalyst and not an organism. They equated yeast to *inhlese* in that they believed that they both speeded up the reaction.

> Learners: Yeast is the catalyst.
>
> And
>
> Learners: ... But what we know is that *inhlese* or even a carton of packaged beer can actually make your beer ferment faster.

Explaining yeast as catalyst and not as microorganisms could be due to the fact that learners do not associate commercially produced yeast purchased from shops with

microorganisms. To them this yeast is a substance you add to the malt mixture to speed up the reaction.

In some instances, learners' explanations are in agreement with those given by elders - like malt playing a role in fermentation. In these instances indigenous knowledge in learners had not changed. The slight difference occurred where learners added another factor – attachment of microorganisms on the malt.

During the course of the discussion learners mentioned the supernatural factor as some factor that could also influence fermentation. This was also in agreement to what the elders believed. This is discussed below.

(e) A second explanation on causes of fermentation

During the course of the discussion it surfaced that learners believed that fermentation is also caused by a second factor. This was how learners explained it:

> Learners: I think malt has the bacteria. The bacteria make the mixture sour.
> Researcher: What about in the beer? Is the sourness the same?
> Learners: That differs 'according to hands' making it.
> Researcher: What does that mean?
> Learners: Old people usually say that 'one has a hand. Her beer would make you drunk quickly. She makes strong beer.'

I introduced the idea that different quantities could be playing a factor. This was disputed. They were firmly convinced that it is one's powers that determine the process. They agreed that experience can play a role but this is not the only determining factor.

> Researcher: Is it because of some quantities you use or what?
> Learners: It is because of your gift in making alcohol.
> Researcher: If we all start with the same quantities and do exactly the same thing, can't we produce the same beer?
> Learners: No. It also depends on experience. Even then, the beer would not come out the same.

They supported this by saying that even in the same household people do not make the same kind of beer. This shows a different level of thinking, that same quantities do not

yield same results. Learners are showing that one does not necessarily get the same results even when variables have been kept constant, contrary to what is expected. Here the explanation of where this power comes from was given as being a gift one is born with. This is in line with what the elders also believed.

> Researcher: Is it similar to the ability to stop lightning?
> Learners: Yes. Stopping lightning is a gift you are born with.
> Researcher: What about in the same house? Can't knowledge be exchanged?
> Learners: It looks like a gift is not the same in all people. This is similar to germinating pumpkin seeds. When some people plant seeds they get more pumpkin than others.

At this point learners introduced another natural process which may be explained by being born with a certain power. This, one of them claimed, had been proven in one experiment he carried out.

> Researcher: Does it not occur by coincidence?
> One Learner: I know it really happens. I tried it at my home. My brother and I were asked to plant the seeds while someone else was digging holes.
> Researcher: Was it not because you were just throwing the seeds?
> One Learner: No. At home we all help in ploughing. I wanted to prove whether my brother really 'has a hand'. My row did not give as much pumpkin as his. I really believe that he has a gift because everything else was the same.
> Learners: Even in beer, there is a gift you are born with.

Learners hold the belief that this gift comes from the ancestors. It is not exchangeable and others cannot learn it. They explained this further by introducing a linkage between God and ancestors. According to them ancestors are a link between God and people. These gifts are then channelled to people from God through ancestors.

> Researcher: How can we describe this gift? What is it like?
> Learners: It is something you are created with and it is your gift.
> Learner 2: I think it is something you dedicate yourself to at that time.
> Learner 3: Sometimes you can really show a lot of dedication but still not have the results.
> Researcher: Where does the gift come from?
> Learners: It is from the ancestors. They are closer to God. They channel these gifts from Him to the person.

What transpired in this discussion is that learners firmly believed that some processes in life are determined by two modes – the natural and extra powers possessed by some people. They maintained that these extra powers are a gift and are not transferable. The source of these gifts is ancestors who also receive them from God. There is a slight difference in explanation of where the gifts come from, from that given by elders. Elders did not mention that ancestors channel the gift from God but only upheld that they are from ancestors.

Again here I see the adherence to the indigenous beliefs by moderating them using new knowledge so as to arrive at a worldview. This is in agreement with Jegede (1991) and George (1999b). In their studies, both scholars found that learners combine their indigenous knowledge with aspects of science in the formulation of some concepts. Educators on the other hand do not promote this, but learners nevertheless, do it in their own mental framework.

4.3.2 Heat and its related concepts

I asked similar questions to those I asked elders so as to make comparison of the concepts held by learners and those found in school science and indigenous knowledge. At school learners are taught the concept of heat from primary school up to secondary school. It is covered mainly in science classes. The discussion below shows concepts held by learners.

(a) Where does heat come from?

This question was asked instead of asking what heat is. Learners found describing what heat is quite difficult. I observed this from the answers they gave when I asked the question. Instead of them not answering completely, they would rephrase the question to give some answers. This actually led the interview forward. This is the description they gave of where heat comes from:

> Researcher: How would you explain what fire is?
> Learners: I can only explain by how it is made. You burn wood and fire comes out.

From what learners said fire comes out of burning wood. This is the same description as that given by elders. Learners also incorporated the idea of energy which was absent in the elders' description. This could be the influence of school science since there was no association of heat with energy in elders' description. This association is only found in school science.

> Researcher: Where does the fire come from? Let's describe the fire versus flame.
> Learners: It is difficult to describe what fire and flame are.
> Researcher: What about heat? What is heat? How can you describe it?
> Learners: When you make fire, the heat comes out. You can feel the heat. It is something that is travelling to you; without burning flame and without the sun. It is a source of energy.

Later on in their description they incorporated a concept of energy conversions, although not accurately portrayed. This was done as follows. I added emphasis to highlight the point.

> Researcher: What has actually happened when the food cooks?
> Learners: **Heat energy** comes from **light energy**. This energy cooks the food.

This description of light energy changing to heat energy could be based on their observations. They see wood being ignited with matches and burning giving a flame. When one touches the flame it feels hot.

> Researcher: What is "*ukuphehla uzwathi*"?

Ukuphehla uzwathi was incorporated into the questioning because elders described this as a traditional method of producing fire. This process was unknown to learners. It is a tradition that has died out. Instead of explaining this concept learners reverted to energy conversion concept:

> Learners: We have never heard of that. In our understanding we have **light energy**, then **heat energy** then **kinetic energy** e.g. light of fire, to heat in the pot, and the movement of food, which is kinetic energy. Another example is when you heat water; you see it moving. You see the **light** then the **heat** and then finally the **movement.** (Emphases added)

Although these are not accurate descriptions of the energy conversion concepts, learners attempted to incorporate these into their existing knowledge. They also used their observations of seeing light and movement and feeling the heat. These observations are then linked to school terms like *energy* and *kinetic* as well as existing indigenous knowledge. Indigenous knowledge still features strongly in the descriptions compared to school science. These descriptions are similar to those given by elders.

(c) Heat transfer and its effects:

i) How does heat travel?

ii) Where does heat go to when in contact with a substance?

These questions will clarify concepts held by learners on heat transfer. Questions surrounding the cooking of food were asked to facilitate a discussion rather than question-and-answer mode. Cooking of food is also a daily experience learners are exposed to at their homes. Heat transfer was explained as follows by learners:

> Researcher: When cooking with fire how does the food get cooked?
> Learners: The heat travels from burning wood to the pot, to the food and make the food cook.

Learners do believe that heat is transmitted from one substance to the next, that is, from the pot to the food. How this happened was still a mystery to them. Their description is similar to that given by elders. Learners hold the view that heat is an entity that can move from one point to the other exactly as the elders did. There has been no change in their understanding on this concept. I would have expected them to mention concepts like conduction, convection and radiation, but this did not take place. Learners' views on this concept are grounded on their indigenous knowledge. School science influence does not come out strongly.

On the loss of heat, the understanding is slightly different from that of elders. Elders believe that air or wind takes the heat away [See previous extracts in section 4.2.2 (b)]. On the other hand learners believe that heat escapes with steam through openings as an entity. It can therefore be stopped by sealing of these openings. This was how they explained this:

Researcher: Where does the heat go to? For example, when I leave hot food outside, it becomes cold. Where has the heat gone to?
Learners: It gets out with steam because it is opened.
Researcher: What if it is completely sealed?
Learners: There will be small space for it to escape.

In the case where there is no steam learners admitted to be baffled by how heat is lost.

Researcher: What if I put an iron on top of a cloth, or metal pot on a metal stove. What happens then?
Learners: This means there is something that moves when heat is lost.
Learners: ... We only believe that heat is something that moves, but how it moves is not clear.

Learners in this case did not have an explanation of how heat is lost by substances. They believed that it moved from one point to the other during transfer as an entity. Elders on the other hand explained that heat is carried away by things like wind or air. Learners have neither acquired school nor elders' version in this concept of heat loss.

(d) Source of body heat: Where do our bodies get the heat from?

Learners also gave the source of body heat as being blood. They explained it along these lines:

Researcher: What about our bodies and heat?
Learners: We have blood in our bodies. The heat of the body is due to the heat of the blood.
Researcher: Where does the blood get the heat?
Learners: The heat is from the blood that is moving. The pumping of the heart makes the body warm.
Researcher: So the heat is from the moving blood?
Learners: As we breathe in, the heat from air outside gets in and we get this heat into our body and it heats our bodies.

The heat is thought to come from heat in the environment. This heat is absorbed by the body through breathing. Again there was no mention of respiration and the link between respiration and production of body heat. The description of heat being contained in blood and breath was similar to that given by elders in their community. The only difference was that elders said that one is born with heat and heat is kept by one's breath. Learners believed that heat comes into the body through air that one breathes in.

The school science version is abandoned in favour of the indigenous one. The reason for this could be that the latter is found to be more plausible. Learners find no reason to change their existing mental state to accommodate new information.

(e) Changes of state: How do three states of matter occur?

Learners explain the changes of state using phenomena mist, moisture, dew, frost and water. They explain that air has moisture and air collects this moisture wherever it moves.

> Learners: air which moves on the soil/ground will have moisture also air from the sea and rivers has moisture.
> Researcher: Does all air have moisture?
> Learners: When air moves it collects moisture wherever it moves.

There is already a difference in this explanation to that of elders in that learners are already using a new term *umswakama* for moisture. This term can mean moisture, dampness or water vapour depending on the context in which it is used in a sentence. In this context the term was used to mean water vapour. There is an indication of an influence of school science here where invisible moisture is acknowledged. In the case of elders they merely talked about moisture in mist which can be seen and dampness in the ground which can also be seen.

Learners' explanation goes further and links up with the formation of mist.

> Learners: At night it becomes cooler. The cold air above the ground cools the moisture above the soil/ground and forms mist.

There is an introduction of temperature playing a role here. But, there is no use of terms like energy changes or transfer. The explanation appears to be the modified elders' version with the introduction of the term *umswakama* (the invisible aspect) which was not there with the elders. Elders used a term *ubumanzi* which directly translates to *wetness* instead of *umswakama.* Elders' term implied the visible aspect of water like mist or dampness of the ground.

Learners explanation went further to link moisture to the formation of clouds and rain by mentioning that mist is formed by cooled moisture/water vapour during cool nights. This moisture can form mist and can also form clouds.

> Researcher: What about mist? Where does it come from?
> Learners: When it had rained the sun heats up the soil causing moisture which forms mist.

Their depiction went further to indicate formation of clouds and rain. This information was extracted from the description of how a thunderstorm occurs.

> Learners: ... Moisture from the ground moves to the atmosphere and makes clouds. ... It is cold up there therefore clouds can be formed when moisture reaches up and clouds can form rain.

In this description there is linking of temperature and change of state from vapour to liquid. Learners also acknowledged the temperature getting lower as altitude increases. Elders did not mention the concept of altitude and change in temperature. Learners also link this concept to changes of state. I can deduce here that this new concept must have been acquired from school science since it did not exist with elders. This is what elders said to indicate that they do not know about it:

> Elders: Water burns up and just disappears. We are not sure where it disappears.

Temperature is again seen by learners to be playing a role in changes of state from liquid to solid and solid to liquid. They explained that moisture could form dew and frost. Frost melts to form water, which sinks to the ground.

> Researcher: What about dew?
> Learners: This is caused by cooled air which settles down.

This is their explanation of how frost is formed and linking this to temperature changes:

> Learners: Frost only comes in winter.
> Researcher: Where does it come from?

> Learners: When it is hot, moisture moves into the atmosphere where it mixes with cold air. It comes down at night when it is cold and changes into frost.

In this explanation there is connection of gaseous state and solid state. The moisture is cooled to form a solid because of very low temperatures indicated by mentioning that this occurs mainly in winter. There is a distinction between dew and frost in relation to temperature. Elders also mentioned winter (see elders' extract above) indicating temperature to be playing a role in changes of state. I can deduce that learners still hold their indigenous knowledge in this aspect. Learners' account goes on to link dew to frost.

> Learners: Frost can also be formed from dew. Dew can also come from guttation at night. When this water falls down it becomes dew. The cold air freezes at night and dew becomes frost. Also when there has been a lot of rain during previous summer, during that winter the water from the soil will change to dew and then to frost. More water in summer means more frost in the coming winter.

Learners have also introduced new terms like guttation which is learnt in biology classes, showing an influence of school science. They are able to link all three states of matter like in the melting of frost and changing of dew to moisture (*umswakama)* which is then carried in the atmosphere. The cycle then becomes complete.

> Learners: When it is hot during the day, the sun heats up the frost and melts it. Dew also changes into moisture and the air carries this into the atmosphere. Moisture can become dew, clouds, mist and so on.

The cycle can be depicted as in figure 4.3

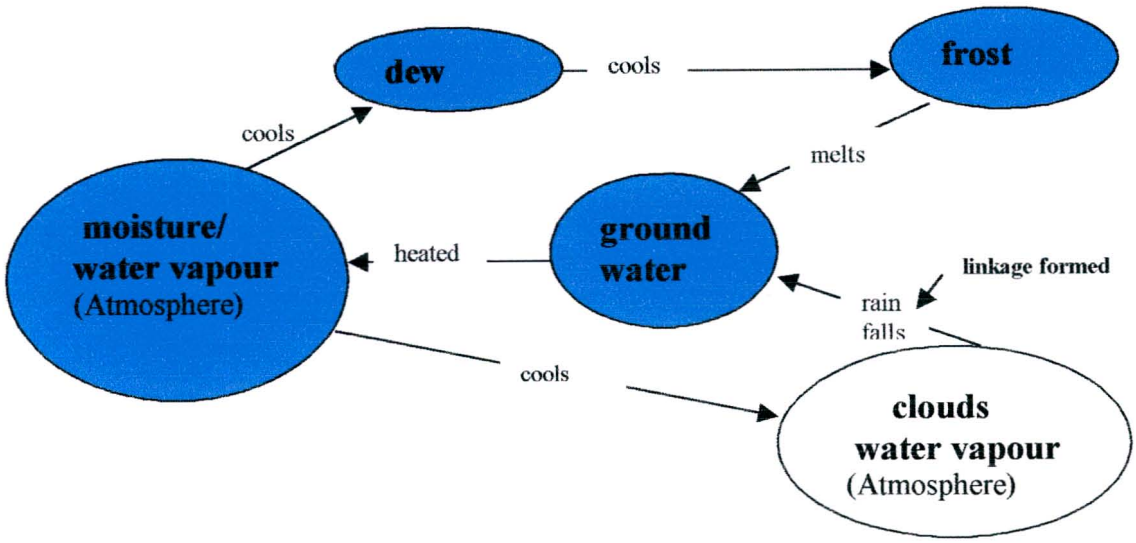

Figure 4.3:Changes of states of water – Learners Explanation

This is similar to the elders explanation but the learners have introduced another term that the elders did not use – *umswakama*. The link between ground water and clouds, and water in the atmosphere has now been bridged in the learners' view (compare fig. 4.1 and fig. 4.3).

Again a connection is made between heat from the sun and the formation of water vapour initially alluded to by elders. There is now a distinction being made of a difference between air and water vapour. Water vapour is described as arising from water – being another state of matter. Introducing the concept of moisture/water vapour has explained disappearance of ground water after being heated by the sun. They have also introduced the concept that, it is not only temperature that can cause a change of state but also another factor like moving air carrying vapour from the surface of water.

When it came to the formation of frost, it was still explained exactly as elders explained it. This is indicated in the learners' extract above.

I found that learners have used some school science to enrich their understanding of changes of state. They still adhered to the concepts learnt at home but they also augmented others to deepen their understanding. It was a bit surprising to me that their explanations did not use concepts like movement of molecules and the way these molecules are arranged in each state. There was no mention of molecules or particles during our discussion. Asking their teacher about this, I discovered that these concepts have been taught. Learners simply chose not to use them in their elucidation.

4.3.3 Thunderstorms and Lightning

What is a thunderstorm and where does it come from?

As thunderstorms and lightning are natural phenomena that learners are also exposed to, it was hoped that this question would reveal their views on this matter. Learners explanations would then be compared to the school science and elders' description. In their explanation learners described thunderstorms as coming from clouds. This was their description:

> Learners: It is a mixture of coldness and warmth. A storm only comes when it has been warm. Moisture from the ground moves to the atmosphere and makes clouds. These clouds knock each other producing lightning. It is cold up there therefore clouds can be formed when moisture reaches up.

Another explanation was as follows:

> Learners: It's when clouds knock on each other because they are pushed by the wind. The sparks then come out.

From this explanation I could conclude that some learners had tried to account how a thunderstorm occurs using school science. This was more than what elders could describe. In elders' case a thunderstorm was an occurrence, which only the Maker knew how it occurred. Some learners, though, had gone a step further. They acknowledged that it is a natural phenomenon which can be explained in terms of clouds. Others were still not sure about this. They claimed that in a geography class they were taught that when it thunders, it is when clouds knock against each other. They maintained that they

did not believe this to be true and they were still not sure what to believe. Others took this explanation as being valid. This indicated to me that learners do weigh the information given at school to that already existing in their mindset.

Just like elders, learners believed that there are two types of thunderstorms – naturally occurring and man-made. With the man-made thunderstorm only people with supernatural powers are able to make it. Their description was along these lines:

> Learners: ... We know that there are two types of thunderstorms – natural and man-made. Witches can make a thunderstorm.
> Researcher: What about traditional healers?
> Learners: When they do this they are no longer healers but witches.

This explanation suggested that only 'evil' people have these powers. This was also in line with what the elders believed. Learners also claimed that there were some traditional healers who could stop lightning from striking a homestead. They argued about this amongst themselves, as one learner was not convinced there are people who could make a thunderstorm. The discussion went on these lines:

> Learner1: We think that only man-made lightning can be prevented.
> Learner 2: Can one make lightning in winter? I do not think so. Can these people make lightning in winter?
> Other Learners: It can happen even in winter. In some cases people will threaten you that they will send lightning to you and it really happens. Do you think this is still a coincidence?
> Learner 3: I think even in winter people can send you lightning because it is caused by medicines.
> Other Learners: You just see a black cloud collecting. It strikes and quickly clears. This is usually different from the natural storm. You even hear elders saying they wonder where the damage has been done.

What transpired in this discussion was that there are two types of thunderstorms. One is man-made and is preventable and the other is natural. Man-made thunderstorm can occur during any season. It is always sent to a particular individual. Only traditional healers with a particular supernatural power are able to prevent it from striking homesteads.

In this case learners hold a second concept on the explanation of a thunderstorm. A thunderstorm can also be described, not through collision of clouds, but through powers possessed by a witch. Learners believe that a witch mixes special herbs that would yield a cloud. This means that these learners still uphold what they were taught at home. Elders also hold an identical understanding that witches can make thunderstorms. This concept does not exist in school science. Some learners did not abandon it even when the school version was given. Both concepts exist side-by-side and are used to describe one phenomenon.

4.4 Conclusion

I have shown in this data analysis some common and some differing understandings of some phenomena between elders, learners and school science. I discovered that elders were able to explain concepts surrounding a phenomenon in a plausible way through their daily observations. Their explanation came quite close to school science explanation in some cases. Learners used elders' explanation in describing certain concepts. They did not abandon their indigenous understandings in favour of the school one. In most cases they used the school science to enrich the indigenous ones. But for other cases school science explanations were abandoned in favour of the indigenous conception. The phenomena fermentation, and thunderstorms (as well as germination in the case of learners) were described using two explanations – the natural route and the super natural route. The two explanations did not appear to be clashing but existed side-by-side.

The next chapter will look at the summary of these findings and conclusion that can be drawn from them..

CHAPTER 5

SUMMARY OF FINDINGS AND CONCLUSION

5.1 Introduction

The main thrust of this study was to investigate and explore the impact of indigenous knowledge on the learner. In the previous chapter I gave an account of concepts held by elders and learners on the phenomena of fermentation, microorganisms, heat, thunderstorms and lightning. It became clear that the elders understanding of these concepts has some similarities and some differences to those found in school science. It also appeared that learners held elders' views and in some cases, juxtaposed both indigenous knowledge and school knowledge to arrive at a worldview satisfying to them. In this chapter, as a way of synthesis, I will look at elders' and learners' science understandings and the impact of indigenous knowledge on the learner. I will then make a conclusion of the findings which will then lead to some recommendations to classroom practices, science education and further studies. It is imperative that there are some limitations of this study and these will also be outlined.

5.2 Synthesis

5.2.1 Elders' indigenous science understandings

Elders were found to hold two types of conceptions on the phenomena of fermentation, microorganisms, heat, thunderstorms and lightning. These were

- Indigenous conceptions
- Duality explanation conceptions.

Indigenous conceptions are those understandings that the community holds. This knowledge has been passed down from generation to generation and is used to explain daily happenings of the world. Duality explanation conceptions are also indigenous conceptions but differ in their description of some phenomena. A phenomenon is described using two modes of explanation – the natural process and the supernatural process. The two descriptions do not contradict one another but exist side-by-side. I will

now look at the two conceptions one at a time.

(a) Indigenous conceptions

I noted in this study that indigenous knowledge held by elders on given phenomenon could be described as rational and valid when viewed in its own context (Ogunniyi 1984; Jegede 1994; Ogawa 1995). If I put this in Ogawa's (1995) words, the rationality in this case does not only mean Western modern rationality, but that it should exist in all cultures. The descriptions given of phenomena studied are in relation to day-to-day living observations, that is, in the context of the community. For example elders' description of changes of states indicated that they had made observations and drawn conclusions. The first example was the disappearance of frost. It was explained in two ways based on observations. Frost melts and goes to the ground and when there is sunlight the sun must have taken it. Both these explanations show rational thinking – making deductions from observations.

> Elders: The frost melts and forms water which wets the ground.
> Researcher: What happens to the water?
> Elders: Water goes down the ground.
> Another elder: The sun takes it. If you pour water in a bowl, it disappears when left in the sun.

When asked about frost their explanation was that frost forms in winter while dew occurs mainly in warm weather. This showed a linkage of temperature with changes of states. This was what they said:

> Elders: Frost is like dew but comes in winter. The dew comes during the night and when you wake up in the morning you will find it on top of the grass. In winter because it is cold, the dew is cooled and turns to frost. This only takes place during the night when it is cold.

The explanation is supported by daily activities and interpretations. It has been tested against time for many generations. For this reason it is embedded within the people. If this line of thinking is correct, this indigenous knowledge should therefore be rational and valid for this society. For example in the case of fermentation, beer is made for various occasions like funerals, weddings or just for consumptions. When it is made,

observations lead to interpretations and conclusions like – when it is cold, one needs *inhlese* to boost the reaction; different people make different qualities of beer even though following the same procedures.

In some cases the explanation of some concepts were very similar to those found in school science. These were concepts like transmission of heat where heat travels from the fire to the food through substances. This was what elders said:

> Elders: ... The heat passes from the fire through the pots into the water into the food.

School science also explains that heat can be transferred from heat source to solids, liquids and gases. Another example was that found in the changes of state where a liquid like water changes to a solid – frost, and frost changes to a liquid. These changes occur due to variations in temperature (see extracts in Chapter 4). School science also explains similar changes of states occurring due to temperature variations. Another similarity was that of factors affecting fermentation. In school science commercial yeast was added to boost the process while elders mentioned the use of *inhlese* to achieve the same effect. In the elders' view addition of *inhlese* was not understood to be addition of microorganisms as is the case with school science. Nevertheless the desired effect is identical irrespective of what the two substances were labelled to be. Temperature was also mentioned as a factor influencing the process of fermentation in both elders' explanation as well as in school science. (See Chapter 4 extracts for these examples). This is in agreement with George who states,

> "There are similarities between the traditional wisdom and science. They are both humanistic in that they originate from the attempts of human beings to take care of themselves and to make sense of the world, and are thus the product of the culture"(George 1999b –p92).

I therefore I agree with Ogawa (1995) when he asserts that, for better understanding, school science and indigenous science can be used as mirrors to reflect one another. In this case one should not be chosen in the detriment of the other.

Some school science concepts were unknown in indigenous knowledge. Concepts like microorganisms and water vapour were unheard of. This is understandable since these societies have not seen it necessary to use these to explain certain phenomena. In addition they tend to rely mainly on physical perceptions. These concepts involve the microscopic level of nature. The notion of matter existing at this level is non-existent in this culture. It does make sense therefore, that the community rejected outright the idea of microorganisms being the cause of fermentation. Microorganisms were even viewed as being agents brought in by 'outsiders' when alien foods were introduced. My attempt to explain this stance taken by elders is that microorganisms cannot be seen with the naked eye. Elders cannot therefore justify their existence. Explanations of concepts have been achieved without having to use the unseen. Secondly life has gone on for generations in this community without the need of the knowledge of microorganisms' existence. This then has not driven the need to develop this concept.

In the case of water vapour, it was never used in the description of the water cycle for the same reasons given for microorganisms. Elders saw no need to worry about the water that had 'disappeared' as this would not make any difference in their lives. What transpires is that the apparent differences between school science and indigenous knowledge are created by the need for that knowledge in each context. School science requires the microscopic levels to provide certain explanations of phenomena while the need for this has not arisen in indigenous science.

(b) Duality explanation conceptions

Another conception found to exist among elders was what I chose to call duality explanation conception. In this conception elders explained certain phenomena using two modes of thought. This occurred when fermentation and thunderstorms were discussed. They indicated that the two processes could be explained as being controlled by a natural process (controlled by nature or Maker) or controlled by extra powers one possesses. In the case of fermentation this was viewed as a gift from ancestors one possesses. Nature can take its cause in making the beer ferment, but the quality of the beer made by a person with a gift called 'a hand' is always better and more potent than other people's beer. Even when using identical quantities and same conditions, no one

else can make similar beer to that one brewed by a person with this gift. Fermentation is then explained as occurring through two processes – through natural process (everyone can do this) and through an extra power possessed by an individual (only a few individuals have this gift). The two extracts show the two processes:
i) nature or Maker controlled; ii) process controlled by certain individuals with a special gift – 'a hand'

> i) Elders: Beer mixture is cooked and cooled and allowed to ferment using malt. ... The traditional beer gets fermented by malt and ground sorghum.
> ii) Elders : No. Others have *isandla* and their beer can make you very drunk.

In the case of thunderstorms this power was viewed as being witchcraft and not a gift. A witch was viewed as having powers to make and control a thunderstorm. Here elders made a distinction between i) thunderstorm controlled by nature or Maker; and
ii) thunderstorms controlled by super natural powers. This is shown in the extracts below:

> i) Elders: That is quite a difficult question. That is for God to know what actually happens. Except if people who are witches made it.
> ii) Elders: Yes there is also lightning which is witchcraft. It is the lightning which is made by a person when that person just wants to 'play' in your house.

Elders hold a notion that naturally occurring thunderstorm produces lightning that seldom strikes a homestead; but will strike far from the where people live. On the contrary lightning created by witches is believed to strike a homestead it was created to target. For this reason elders believe that the latter can be prevented by traditional healers as indicated in the statement below.

> Elders: ... This type of lightning can also be stopped from coming into the homestead. It can be driven away so that it strikes the trees instead of the homestead. The natural one is from the Maker and usually does not strike the homestead.

This line of thinking yields two types of understandings of thunderstorms. One understanding is that nature or Maker produces one type of a thunderstorm and the other

is that the second type is produced by certain individuals possessing special powers.

What the duality explanations conceptions point out is that some phenomena can be explained using two processes. In this case fermentation and thunderstorms are explained in two modes – the natural or Maker mode and super natural mode. The latter type of explanation does not exist in school science. In school science only the natural process version that can be subjected into testing is given. As explained in section 5.2.1, duality explanation conceptions do not follow the Western science rational mode of thought. These cannot therefore be subjected to tests that use Western science line of rationalisation. Otherwise these conceptions will fall into a trap of being labelled as being myths or superstitions. Nevertheless this mode of thinking was part of conceptions in the community studied. It had been passed down as existent knowledge from generation to generation. For this reason it should not be ignored.

5.2.2 Learners' science understandings

Learners were found to hold three types of science conceptions and these were

- unchanged indigenous conceptions,
- hybridised indigenous knowledge and school science conceptions,
- duality explanation conceptions.

These findings differ from those of Hewson and Hewson (1983) where learners have two types of conceptions. In their study they discovered that learners either abandoned their original understandings for the new view ("gain of scientific conceptions and loss of alternative conceptions") or simply held on to the original ones. It was also surprising to me that in my observations learners did not hold a conception where they only adhere to the school science notion and completely abandon their indigenous views. I will now discuss each of the three conceptions one at a time.

a) Unchanged indigenous conceptions

In unchanged indigenous conceptions learners described the phenomena exactly as the elders had done. An example of this transfer of knowledge from elders to learners was seen in their description of fermentation. Learners did not challenge elders' information

but were using it as given. For example both learners and elders said malt is the cause of fermentation. This was what they said:

> Elders: ... Cool it (mixture) overnight and add malt to make it ferment. Let it stand in a warm place.

and

> Learners: It is the sorghum malt that allows it to ferment.

Inhlese was mention by both learners and elders as a booster for fermentation

> Elders: ... You can also use *inhlese.*
> Researcher: What is *inhlese* and what is it used for?
> Elders: This is a sediment of previously fermented beer. ... It is used to starting the process of fermentation.

This is the learners' version

> Learners: ... When it is cold you use *inhlese* to make it ferment faster.
> Researcher: What is *inhlese*?
> Learners: This is the sediment from fermented beer.

Another example was the description of heat transfer and body heat where there was also no change in learners' conception to that of elders'. Elders took heat as an entity and so did learners. Terms like conduction, convection and radiation found in the school science were never used anywhere in their explanations of heat transfer. These terms would have indicated that learners had adopted the school version rather than elders' views. See extracts below to indicate this similarity:

> Learners: The heat travels from burning wood to the pot, to the food and makes the food cook.
> Elders: The heat passes from the fire through the pots into the watter into the food.

In the case of body heat learners also believed that body heat comes from the breath, as do elders. The difference only lied in the origin of this heat. Elders believed that one is born with this heat while learners believed that the heat is absorbed through breathing.

Surprisingly a term like respiration never surfaced during this discussion. Both heat transfer and body heat were described using indigenous knowledge.

These unchanged conceptions can be explained using Hewson and Hewson (1983) clarification. They propose that lack of change of original conceptions can be attributed to the use of traditional methods of instruction which do not take into account learners' indigenous knowledge when teaching strategies are designed. In this case learners find their indigenous knowledge to be *intelligible, plausible* and *fruitful* and therefore requiring no altering. School science has to contend with well-established indigenous conceptions. In this case school science comes out as a loser. I found that elders' conceptions are identical to those of learners even though learners had been attended school for twelve years.

Other examples of unchanged indigenous conceptions were observed in some aspects of thunderstorms and changes of states. In these two phenomena learners did not only adhere to indigenous knowledge but introduced second dimensions in their explanations. These will be discussed in b) and c) of this section.

b) Hybridised indigenous knowledge and school science conceptions

I decided to use a term "hybrid" to explain the mixing of indigenous knowledge and school science. In this case it is used in the context of describing a mixture or fusion of the two understandings – namely indigenous knowledge and school science. The product can still show characteristics of the two concepts being mixed

An example of hybridisation is shown in the case of fermentation. In this case learners still believed that malt causes fermentation. With the introduction of organisms at school, they modified this by saying that organisms must be attached to the malt. This is seen when one compares the elders' views to those of learners in the following extracts:

> Elders: ... The traditional beer gets fermented by malt and ground sorghum.
>
> And

Learners: I think malt has the bacteria. The bacteria make the mixture sour.

The idea that malt plays part in the fermentation is entrenched in learners. They do not abandon it by saying that it is just the bacteria or the yeasts that actually cause this process.

In the case of changes of states of water, learners were able to explain how water changes to water vapour and again water vapour to water by adopting a concept of vapour state which was learnt from school. They used the term *umswakama* (used in the context of vapour state) which elders did not use in their explanation. Elders could not achieve this explanation as their knowledge did not include the microscopic level of things (see Chapter 4 and figures 4.1 and 4.3). I find that, although learners' descriptions start from their indigenous knowledge, school science has been used to enhance their understanding in this case. One can see elders' knowledge being enhanced with school knowledge. A build up from indigenous knowledge to hybridised conceptions is seen in the following extracts of elders and learners:

> Elders: When it is warm, the clouds come from the mist. Mist in the ground rises to the sky and forms clouds. Clouds collect rain from the sky and rain falls down. The same mist forms the dew on the ground. It can form clouds and also dew. It comes from the moisture in the ground.

and

> Learners: When it had rained the sun heats up the soil causing moisture which forms mist.

Note that learners described mist as being formed from moisture in the soil. Again, in the following extract, there is still a similarity between learners' views and elders' views.

> Learners: At night it becomes cooler. The cold air above the ground cools the moisture above the soil/ground and forms mist.

A difference of views arises at the level where rain is formed. In the following extract learners explain that rain comes from clouds. Learners go further and explain that moisture can be carried in the air which means it can be invisible and is at microscopic level. Elders could not attain this level of conception.

Learners: ... Moisture (*umswakama*) from the ground moves to the atmosphere and makes clouds...It is cold up there therefore clouds can be formed when moisture reaches up and clouds can form rain.

And

Learner: When it is hot during the day, the sun heats up the frost and melts it. Dew also changes into moisture and the air carries this into the atmosphere. Moisture can become dew, clouds, mist and so on.

In this section learners used their school science to enhance their original knowledge. The result of this is the hybridised conception.

c) Duality explanation conceptions

With the phenomena fermentation and thunderstorms learners described these using two concept routes – the natural route and supernatural route – which I chose to call **Duality explanation conceptions**. With the natural route they used either indigenous knowledge or hybridised conception in their explanation. With the supernatural route they used unchanged indigenous conceptions as way of description. This mode of holding two explanations of fermentation process and thunderstorms was also found in elders as explained in section 5.2.1 (b). The belief that other people have extra powers that enable them to produce or enhance some processes of nature is firmly grounded. The concepts are therefore defined in two modes – the natural mode and the supernatural mode. The two coexist side by side. One does not interfere with the other.

Learners give examples of fermentation, germination and thunderstorms as being controlled by two modes. This can be seen in the following extracts given by learners showing processes controlled by:

i) nature and

ii) people with special powers.

Fermentation in the first example occurs naturally. In the second example a person with a gift called 'a hand' yields a more potent beer.

i) Learners: It is the sorghum malt that allows it to ferment.
Learners: I think malt has the bacteria. The bacteria make the mixture sour
ii) Learners: Old people usually say that 'one has a hand. Her beer would make you drunk quickly. She makes strong beer.'

In germination this learner conducted an experiment to prove that his brother possesses 'a hand' and therefore could yield more pumpkin than him.

One Learner: ... At home we all help in ploughing. I wanted to prove whether my brother really 'has a hand'. My row did not give as much pumpkin as his. I really believe that he has a gift because everything else was the same.

In thunderstorms the process could be governed by processes of nature or Maker or can also be the work of witches. In this case this is not a gift but is considered to be witchcraft.

i) Learners – It is a mixture of coldness and warmth. A storm only comes when it has been warm. Moisture from the ground moves to the atmosphere and makes clouds. These clouds knock each other producing lightning.
ii) Learners – No. We know that there are two types of thunderstorms – natural and man-made. Witches can make a thunderstorm.

The three types of conceptions show persistence of indigenous knowledge. The influence of school science appears to be minimal. I will elaborate on this below.

5.2.3 Conflicts or points of convergence between elders' and learners' science understandings

In elders' and learners' science understandings no conflicts were found to exist. Instead learners' views were either identical to those of elders or where they differed, learners enriched indigenous knowledge with school science knowledge. This was observed in all the three phenomena studied.

When learners and elders used indigenous knowledge in describing the three phenomena studied, I discovered some aspects of their views to be similar to those of

school science, contrary to Hills (1989) proposition that these should not be accorded a status of being scientific. I found these to have an element of being scientific in their own context (Ogawa 1999), even though they were an indigenous conception.

I discovered that school science does not appear to have had much impact on learners' views. As a result, there was no situation where indigenous knowledge was abandoned in favour of school science knowledge, contrary to Manzini's (1999) and Hewson and Hewson (1983) findings. In my findings indigenous knowledge was resolute. The reason for this difference could be that both Manzini and Hewson and Hewson carried out studies of learners from a semi-urban environment i.e. township areas. In this study learners were from a rural background.

In a few cases learners enriched their indigenous knowledge with school science yielding *hybridised conceptions* This is contrary to Hewson and Hewson (1983) findings in that these learners did not have their original knowledge replaced by school science; instead a hybrid was formed. Comparing this type of conception to some views expressed by some scholars in Chapter 2, it might appear as if there are similarities between it and the views expressed by Cobern's (1994) Worldview theory, Freyberg &Osborne's (1985) Generative Learning Model, Ogunniyi's (1997) Contiguity Hypothesis, Jegede's (1997) Collateral Learning, but this is not entirely the case. All these views cite importance of integrating existing knowledge of the learner with school science. The difference between them and the observation I made in this study, was the nature of the understandings resulting from such integration. I observed that learners' hybridised conceptions were heavily laden with indigenous knowledge and school science was not so pronounced. The above views do not state this. My deduction from this is that learners hold on to their indigenous knowledge and only enhanced it with school science when and by how much they deem fit.

In both elders' and learners' views duality explanation conception was identified. This mode of conception follows an alternative mode of thought. Ogunniyi (1984), Ogawa (1995) and Jegede (1997) are scholars that also support the line of reasoning that traditional systems follow different patterns of explanation when compared with school

science. It is different from reasoning employed in school science, but being different does not mean that it is inferior nor invalid.

Duality conception, though following what Ogunniyi (1984) and Jegede (1994) called the African mode of thought, still bears a slight difference to their explanations. From their explanations school science can be described as dealing mainly with the technical mode of thought – the how aspect. How does fermentation occur? How does a thunderstorm occur? The causality explanation is concerned with what actually causes something to happen, that is, cause and effect – the why and what aspect. On the other hand duality explanation conceptions show one process being explained in two routes. This is not the same as cause and effect. Duality explanation conception could therefore be explained as yet another mode of African thought. I propose that this thought be called a **duality mode of thought** and not causality nor technical modes.

Duality explanation conceptions differ from hybridised conceptions in that in duality conceptions the two explanations are not fused to give rise to one understanding. Explanations exist as entities without interfering with one another. School science explanation is used to enhance the indigenous knowledge explanation and visa versa in the case of hybridised conceptions. This is not the case with duality explanations which exist as entities.

5.3 Conclusion

From this study I found that elders held indigenous science understandings and these had an impact on the indigenous learners. I further found that there was transfer of indigenous knowledge from elders to learners through views held as *indigenous conceptions* and *duality explanation conceptions*.

The impact of indigenous knowledge on learners manifested itself in three conceptions. Two of these conceptions were identical to those of elders, namely, *unchanged indigenous conceptions* and *duality explanation conceptions.* The third type, *hybridised conception*, indicated modification of indigenous knowledge after introduction of school science.

Indigenous conceptions and duality explanation conceptions are not recognised as existing in the school science system. Only the hybridised conceptions might be accorded recognition since these show some aspects of school science.

In view of these observations I propose here that indigenous science understandings be viewed as belonging to a **larger science body of knowledge** system. This system would accommodate all views from all backgrounds, be they indigenous understandings, Western understandings or any other form of understandings. All these views would then be sub-sets of this system (figure 5.1). None of the understandings would be superior or inferior to any, but their differences would enrich each other. In such a system the conceptions held by elders and learners would be a product of, or belong to, the sub-sets. In this way they will all be incorporated in the super-set – larger science body of knowledge system. At position **B** in fig. 5.1 the science view incorporates all parts of the science understandings. In this study position **B** would be the hybridised conceptions held by learners. This is because the two sub-sets (other) were not investigated and the focus was on Indigenous Science Understandings and Western Science Understandings subsets.

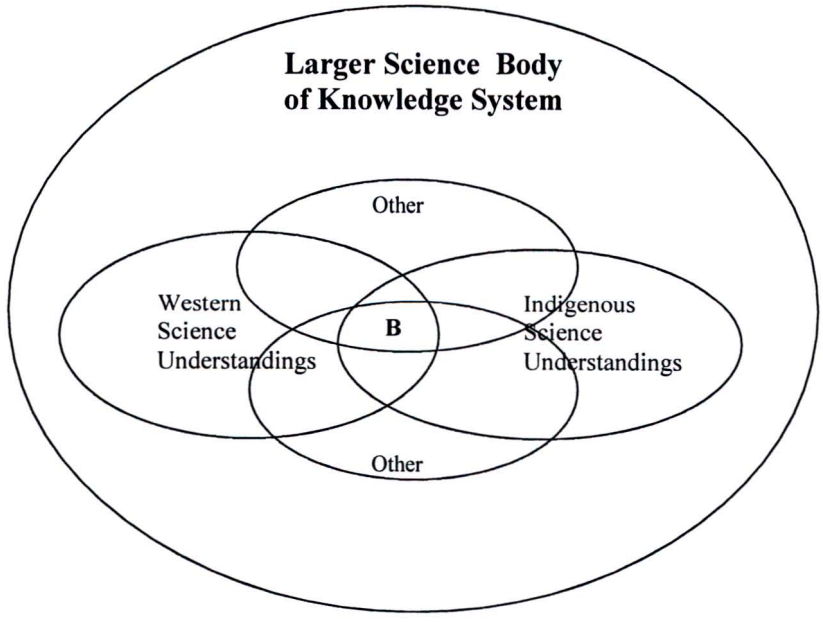

Figure 5.1: Larger Science System Body of Knowledge

This system is different from Ogawa's (1995) proposal of multiscience perspective model which alludes to all understandings to be existing as entities that should be acknowledged as bodies of knowledge. In this case all understandings would belong to one larger science body of knowledge system where interactions between them is taken to be the norm.

5.4 Implications of the study and Recommendations

In this section I will make recommendations for teachers in the classroom, for science education and finally for further studies. Classroom practices determine how the information is delivered and how learning takes place. Science education looks at what information is to be learnt. Both science education and classroom practices form the basis of science knowledge conceptualisation. Some areas which could be explored would be recommended as further study.

5.4.1 Implications to classroom practices

This study has found indigenous knowledge to be embedded in learners thought processes. School science is only used to enrich their understandings of concepts. This has serious implications for classroom practices. It will therefore be unwise not to take indigenous knowledge of the learner into cognisance. It is suggested here that this is tackled in the following way.

Firstly, during lesson design and implementation, learners' fundamental or prior understandings should be explored and used as a starting point (Osborne 1985). Points of convergence between school science and indigenous knowledge should be investigated and then merged. This can be done by first allowing learners to explain their understanding of a phenomenon being studied. Those aspects which differ should be discussed and a point of convergence be arrived at. Finally, as learning progresses learners should be encouraged to voice out their understanding of the concepts and these could be integrated into their knowledge acquisition. In this way school science would

not be viewed as something foreign, taking place outside one's life and replacing one's culture.

5.4.2 Implications to science education

The study shows that indigenous knowledge of the learners persists in their mental framework. It has also been observed with the phenomena investigated in this study that learners do not use school science in their description of some of these science concepts, even after spending most of their lives in the classroom. I would therefore make recommendations to two areas of science education which I think could help remedy this situation. The first area is science curriculum policy development and the second one is science textbook writing. Each of these has great influence on what takes place in the classroom by determining what the educator will teach.

A new science curriculum in South Africa has recently been developed and documented in Curriculum 2005 Policy Document (1997). In this document the Natural Sciences contain nine specific outcomes. Specific Outcome number 6 deals with taking the cultural background of the learner into perspective in science learning. This is a good starting point. In view of the findings of this study, I would suggest that any science curriculum policy formulated should adopt this approach. Further, taking indigenous knowledge into cognisance should not only be in one topic or section of the curriculum as is the case in this document, but should be part and parcel of all learning processes in science. If this is ignored, learners lose out on the valuable knowledge base that they can build on, as seen in this study.

In textbook writing topics discussed should have a bearing on the cultural background of the learner. This would be determined by the targeted audience the author is writing for. Use of local examples in textbooks can foster easier understanding of the topic under discussion (Osborne 1985). For example, if the topic is fermentation, traditional beer brewing can be used; and if the topic is on preservation processes, making biltong can be another local example (Ayerst, Clark, Khumalo & Ndwandwe 1999). In this way the learner is not divorced from his/her local environment during learning.

5.4.3 Implications for further study

In this study I have only observed that learners in this community hold three types of conceptions and all being the result of the impact of indigenous knowledge. These are unchanged indigenous conceptions, hybridised conceptions and duality explanation conceptions. Investigation can be pursued in following areas:

- Finding out whether these conceptions exist, differ or are absent in other communities – for example semi-urban and urban.
- On the basis of these results further studies can be done on why learners in this community did not use school science conceptions in their explanations.
- Another study could be done to validate duality concept explanation.
- In view of the fact that I chose only a limited number of phenomena, an investigation can also be done to find out whether similar results are attained in other phenomena.

5.5 Limitations of the study

Some limitations of this study are presented. The first limitation is that the sample used was of one particular community and made up of five elders and eight learners. Also, only three phenomena were selected basing them on their familiarity to the learners. The impact is not known on those phenomena which are not in the cultural background of learners, like electricity. The number is too small for generalisation. Generalisability using these results should therefore be restricted. The interview format places a limitation in that the data source could have given the information which they assumed I wanted to hear instead of telling me exactly what they believe. Translation had to be made from IsiZulu to English. Some meaning could be lost during this as no two languages are identical in the meaning they convey. One limitation of qualitative research is that it is also open to different interpretations. The results portrayed here are therefore not conclusive.

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APPENDICES

APPENDIX 1: Concepts and Questions of Interview Schedule

1. Pilot concepts and questions

Fermentation concept:

How is traditional beer made?

What makes the beer ferment?

Heat concept:

How did our forefathers produce and use fuel?

Is this process still found today?

Where does the heat come from?

Where do our bodies get the heat?

Is this heat in our bodies the same kind of heat as that found in fire?

Thunderstorms and lightning

What is a thunderstorm/lightning?

Where does it come from?

How does it occur?

2. Main Study Concepts and Questions for both Elders and Learners

Fermentation and Microorganisms

How do we make traditional beer?

What causes fermentation?

How does heat affect fermentation?

Sour milk and traditional beer are both sour. Are these processes identical?

Do microorganisms cause fermentation?

Heat and related concepts

How did our forefathers produce and use fire?

Is this process still found today?

Where does the heat come from?

How do three states of matter occur?

How does a substance like wood transmit heat into the food?

Where does the heat disappear to after it has been in contact with a substance?

What happens when food gets cold after it has been heated?

Where do our bodies get the heat?

Is this heat in our bodies the same kind of heat as that found in fire?

Thunderstorms and lightning

What is a thunderstorm/lightning?

Where does it come from?

How does it occur?

APPENDIX 2: DATA

Interview: Pilot

Fermentation

Researcher: How is the traditional beer made?

Elder: You put partially, mealed maize together with sorghum malt into a pot and add warm water. Mix the two and allow it to ferment. This will take a day or a number of days depending on whether it is a warm day or not.

Researcher: How does the mixture ferment?

Elder: You add '*inhlese*'

('*Inhlese*' is a left over mixture from previous beer and is used for starting the reaction when making beer. It acts like a catalyst)

Researcher: Why does it ferment?

Elder: *inhlese* makes it ferment. *Inhlese* comes from previously fermented beer.

Researcher.: In Western Science it is said that fermentation is caused by micro-organisms. What do you say to that?

Elder: There is no such thing in traditional beer. It is *'inhlese'* that causes the fermentation.

Researcher: But in some cases we observe that fermentation occurs without *inhlese* like in making sour porridge. What do you say to that?

Elder: Yes, sour porridge does ferment without *inhlese*. Maize and malt can reach a point where they ferment without *inhlese*. Malt is the cause of fermentation in this case. No organism causes it to ferment.

Researcher: After the mixture has been cooked how does it cause one to be **drunk?**

Elder: The malt causes it to ferment further. When it is a warm day fermentation takes place faster. I undestand that some people even use yeast to start fermentation. Not organisms. Even when we make malt we need warmth for it to germinate the sorghum.

Researcher. Why do they use yeast?

Elder: It is because it works like malt and *intlese*.

Heat

Researcher.: How did we make fire in the olden days?

Elder: We used to rub a stick and a log from a special tree called *' uvathe'*. Once this became very hot, some sparks would come out and ignite grass. This process was called *'ukuphehla uvathe'*

Researcher.: Are there some people who still use this method of producing fire?

Elder : It was only in our fore-fathers' times. It does not take place anymore.

Researcher: When we have made the fire, where does the heat come from?

Elder: The fire has a special power to release heat.

Researcher: Where does the fire get the heat?

Elder: It is because it is burning.

Researcher: How does the heat get out?

Elder: The heat is released by another heat. If we take a stick and rub it on a stone, the heat is released. This is the same way how uvathe releases the heat. When uvathe ignites its heat releases the heat of the wood and the wood would release the heat of another wood and so on. Again it was not everyone who was able to get uvathe to ignite. Others use to rub and rub and not be able to produce a flame. Others would rub and in no time be able to produce a flame.

Researcher: What used to cause this?

Elder: I really do not know. People would just differ from one another.

Researcher: Was this a gift of some sort?

Elder: In the olden days, when a king was about to be ordained, he had to start by giving the fire to the whole community. He had to *' aphehle uvathe'* If he is not really the descendent of the kingdom (*inkosi yoselo*) the flame would not be produced. If he were the king, he would be able to give fire to his subjects.

Researcher: Let me get this straight, when you rub sticks together is it called *'ukuphehla uvathe'* or is it a stick that is called *'uvathe'*?

Elder: *'Ukuphehla uvathe'* is a process – rubbing of the sticks

Researcher: Are there still people who are able to do this process?

Elder: I do not think so. This happened a long time ago – during the times of our great grand fathers.

"Fortunately Mr Ndlela of Msinga village produced fire using this process as a young boy while heading cattle. We will observe this when we look at the data of Msinga village elders."

Researcher: How did people know about this process?

Elder: People used to be observant about things. For example there is a tree that is called *unyenye*. This tree is used to stop lightning from getting into the homestead. This process is called *ukubethela.* A special medicine called *ilebetheka* is burnt and ground into a powder. Its powder is then mixed with fat of a black sheep. The mixture is then rubbed on poles of *unyenye*. The poles are then placed around the homestead as well as on roofs of houses in the homestead.

Researcher: So these are placed to stop lightning?

Elder: They stop anything bad from entering the home. There used to be real '*izinyanga'* (traditional healers) not these you find today.

" The conversation then went on to discuss the various modes of deception *izinyanga* of today do. He found these to be disturbing and needing attention."

Researcher: What about the heat we find we possess as human beings? Is this heat the same as the heat from '*ekuphehleni uvathe?"* We have heat but we do not do the same process as *uvathe*.

Elder: Heat from the fire is not the same as in that in people but is the same as that in the sun. There is heat showing that you are alive. Sometimes you become hot because you are ill.

Researcher: When you touch yourself you can feel that you are warm. As warm as in warm water. How do I get this warmth without being ignited from the inside?

Elder: What makes you hot is the blood. When the blood is still moving in your body, you will actually be warm. When you have no blood, you will be cold. If it happens that bile gets spilled, then the blood will not be well pumped. Bile controls a lot of functions in the body. If it is not released in a proper way as in making the food to rot, then one will get ill. The blood also is not properly pumped.

Researcher: What happens if too much of it is released?

Elder: You won't be well. As when you induce vomiting, some of it can be released.

Broker: If I can go back to the lightning and its protection, at home where I grew up

we used to use a tyre and place at the top of the roof to protect the house from lightning. What do you think of that?

Elder: That was just to make means because of lack of the real thing. The tyre helps a little bit, but it does not do the real thing.

Researcher: When there is thunder, where does the heat come from?

Elder: Thunder is like electricity. The West obtained electricity from lightning.

Researcher: How does lightning occur?

Elder: Lightning occurs first then rain comes after.

Researcher – What actually causes this?

Elder: No one actually knows what happens up there. Only the Maker knows what He puts together.

Broker: Are there people who can do this?

Elder: Traditional healers can do this. They can mix certain medicines and herbs. Soon thereafter you can see the clouds gathering as he mixes these. The gathering of clouds culminates into a thunderstorm and lightning. He can actually send this to you. If you are not strong enough, the lightning will strike you and you will die. If you are strong it will strike away from you. When it has struck at the right place, the storm will then pass it becomes a sunny day again as if nothing had ever happened.

Researcher: Are there any other people who can still do this?

Elder: There are '*izinyanga*' (traditional healers) who can do this. They will never part with their knowledge on how they do this. This is because they are not real healers. They are '*abathakathi*' (witches). Nowadays we do not have traditional healers. In the olden days there were specialist healers for specific needs. There were those who specialised in stopping lightning, those who specialised in making barren women fertile, those who could protect the homestead from bad spirits, and those who could treat your illnesses. Nowadays these *izinyanga* claim they could do it all. I do not think that any person can be capable of being a specialist in everything as these claims to be. They are just chancers. They just want money. Nowadays we even have Whites who claim to be *'izangoma'* (diviners). Have you ever heard of idlozi *lomlungu* (a white ancestor)?

Interview: Lower Msinga Village Elders

Fermentation

Researcher: How do we make African beer?

Elders: You mix sorghum and sorghum malt and grind these two on a stone. Boil the water in a big pot. In another pot mix the mixture with cold water. Add the boiling water into the mixture.

Researcher: Why do we add boiling water?

Elders: Boiling water makes the mixture to ferment. It does not ferment if cold water is added. Boiling water also softens the sorghum-malt mixture.

The following day we scoop the liquid part of the mixture and add into another pot. Mix it with cold water and add it into another pot. Allow this to boil and add the remaining mixture. Cook it. Cool it overnight and add malt to make it ferment. Let it stand in a warm place.

Researcher: Will it ferment if you do not add malt?

Elders: It will ferment but not for drinking.

Researcher : What will happen if you add malt without allowing it to cool?

Elders: It will be sour. The malt would burn and would not be sweet.

Researcher: How do you make malt?

Elders: You take your sorghum seeds and allow them to sprout. By soaking them in water and then leave them in a warm place. After sprouting you leave them in the sun to dry. This is then malt. Any time you need to use malt you will first grind it on a grinding stone.

(The conversation continued) – You start by taking a small quantity of cooled cooked mixture and put it in a small pot, add malt to make it to ferment. The small quantity is used to start off the main beer. You can also use *inhlese.*

Researcher: What is *inhlese* and what is it used for?

Elders: This is a sediment of previously fermented beer. The sediment is filtered out of the liquid part and is allowed to dry. It is used to starting the process of fermentation. The sediment can also be eaten as food by first cooking it.

Researcher: Sour milk taste sour light traditional beer. How are these different or similar?

Elders: Sour milk is different.

Researcher: How is it different?

Elders: In sour milk we use a calabash. Sour milk gets sour on its own. Beer gets fermented through the use of malt.

Another member: If the beer gets sour it is spoilt and is not properly fermented.

Elders: Beer mixture is cooked and cooled and allowed to ferment using malt but sour milk is not. The warmth provided by the calabash makes the sour milk to get sour. The traditional beer gets fermented by malt and ground sorghum.

Researcher: How does the heat affect fermentation?

Elders: The mixture must always be cooled to allow fermentation.

Researcher: What happens if you do not cool it but add malt while it is still hot?

Elders: The beer gets sour and does not taste nice like beer.

Researcher: Do children know how to make this traditional beer?

Elders: The method used today is no longer the same as that used when we grew up.

Most of the things are now bought. Children also use shortcuts. Some families do not teach their children. Traditionally we use to grow all our food and that is why we did not have so many diseases. We use to grind our own meal like maize meal and sorghum meal.

Mr Ndlela (Senior) to other members of the team: Tell her about women and drinking.

Researcher: Were women allowed to drink?

Elders: Oh yes. Those who wanted to used to and those who did not want to it was their choice.

Researcher: Do all people make the same type of beer?

Elders: No. Others have 'isandla' and their beer can make you very drunk.

Researcher: Why is this so?

Elders: This is a gift they are born with. It is a gift from the ancestors.

Researcher: Can't other people learn from the person with a gift to make the same kind of beer?

Elders: No. Even if they use the same ingredients the beer would not be the same. If you have a gift, it is yours. Other people cannot use it.

The conversation trickled on into other aspects of beer drinking and ended explaining how a granary is made: A large hole, wide at the bottom and narrow at the top, was

dug in the ground. The small opening at the top was closed with a stone and the edges sealed with cow dung. The grain was then poured down this hole and left safe from pests. The grain at the edges would develop mould and would be removed periodically for cooking. It was ground into a powder, cooked and eaten. This was called *isangconde*. The grain would stay unspoilt for a very long time. This was a method of preserving food.

Researcher: Nowadays it is believed that when food develops mould it is spoilt and should not be eaten because it can actually make you ill.

Elders: There was no disease in this grain because no dirt entered the granary.

Researcher: Where does the mould come from then?

Elders: It is because it is warm inside the granary.

Researcher: Western science believes that mould is caused by microorganisms.

Elders: There are no organisms that went into the granary – not even weevils.

Researcher: It is believed that some of these organisms cannot be seen with our naked eye. They are in air so they can go in with air.

Elders: No such organism goes in there. This is a sacred place and it is very clean.

Researcher: How did the outer grain rot then if nothing went in?

Elders: It is rotting due to the warmth. The food has developed moisture due to the warmth and then moulded. No organism entered.

Researcher: It is believed that we are not able to see these organisms. They are there in the air we breath, even there in the beer we drink. They cause the beer to ferment.

Elders: Not at all. These organisms were never there from time immemorial. If they are there now, they are new arrivals. We have only had things like, weevils, beetles that fly in air. We are hearing about these organisms for the first time. They were never there during our times. They have been only brought in with the European things. You now have things like onions; tomatoes; potatoes and all these have come with these organisms you are talking about.

Thunderstorms and Lightning

Researcher: I would now like us to talk about thunderstorms. How does a thunderstorm occur?

Elders: As you know now is spring, people would use certain sticks around their homes to protect their homesteads.

Researcher: Why do they protect the homestead?

Elders: To make sure that the storm does not come down

Researcher: What actually comes down?

Elders: Lightening comes down like a lump of fire. The traditional healer would smear medicine on some sticks and the father of the home would stick these on the houses to protect the homestead.

Researcher: Where does this lightning come from?

Elders: That is quite a difficult question. That is for God to know what actually happens. Except if people who are witches made it.

Researcher: This means that there are two types of lightning – God made and man-made.

Elders: Yes there is also lightning which is witchcraft. It is the lightning which is made by a person when that person just wants to 'play' in your house.

Researcher – So there is lightning made by people? Can it really work?

Elders: Oh yes. It really works. This type of lightning can also be stopped from coming into the homestead. It can be driven away so that it strikes the trees instead of the homestead. The natural one is from the Maker and usually not strike the homestead. (Another member in the panel is asked to explain to me about *uvathi.* She then explains and others also join in.) *Uvathi* is different from lightning. A special type of wood called '*umthathi*' is rubbed together until sparks come off and fall onto some grass and the grass ignites.

Researcher: Did any of you ever used this method of starting the fire.

Elders: Only those before us. Only Mr Gonyela Ndlela used this method as a young boy while heading cattle.

It turned out that Mr Gonyela Ndlela could not come to the school and we had to go to the village and carry on the discussion with him in the homestead. We arrived at the homestead and Mr Gonyela Ndlela came to the homestead. We then agreed that he should tell us how he did this. He explained this as follows:

You use an axe to cut and chop '*umthanti'* tree. Two pieces of wood from this tree are rubbed together at an angle (He demonstrates how the two pieces of wood are positioned.) Sparks come off.

Researcher: Where do the sparks come from?

Ndlela: From the two because of the rubbing. You can actually feel the heat as you rub.

Researcher – Is this tree still available?

Ndlela: Yes but we do not use it anymore.

Researcher: How long does it take before you can produce the flame?

Ndlela: A very long time.

We then went back to our conversation.

Heat and its related concepts

Researcher: How can we explain what fire is.

Elders: That's a deep question. Fire comes out of wood. We know that when we ignite wood fire comes out. It is the wood that releases the wood. That is why in the olden days we use to make sure that fire never dies out.

Researcher: Why is it that only dry wood burns.

Elders: Water in the wood stops it from burning. The natural water from the tree is stopping the burning. Water does not burn. When wood is dry water has gone.

There was a long pause and I decided to change the topic to something else related to heat:

Researcher: Where does frost come from?

Elder: Frost is like dew but comes in winter. The dew comes during the night and when you wake up in the morning you will find it on top of the grass. In winter because it is cold, the dew is cooled and turns to frost. This only takes place during the night when it is cold.

Researcher: What happens to the dew or frost during the day?

Elders: The frost melts and forms water which wets the ground.

Researcher: What happens to the water?

Elders: Water goes down the ground.

Another elder: The sun takes it. If you pour water in a bowl, it disappears when left in the sun.

Researcher: Where does it go to when it disappears?

Elders: Water burns up and just disappears. We are not sure where it disappears to.

Researcher: In the case of clouds, where do they come from?

Elders: When it is warm, the clouds come from the mist. Mist in the ground rises to the sky and forms clouds. Clouds collect rain from the sky and rain falls down. The same mist forms the dew on the ground. It can form clouds and also dew. It comes from the moisture in the ground.

I then changed the topic to discuss transmission of heat.

Researcher: How does the food get cooked?

Elders: Water makes it soft.

Researcher: What if we barbecue it *(ukuyosa)* and not use water?

Elders: Still it is cooked. The heat passes from the fire through the pots into the water into the food. Air is blocked from entering the food.

Researcher: Is it the heat or the water that cooks the food?

Elders: The heat cooks the food. It travels from the fire to the water and to the food. The air is stopped from entering the food because it can cool the food and stop it from cooking.

Researcher: What about heat in our bodies? How can we explain this heat?

Elders: Breath makes you alive. It warms your blood. Your blood then moves. When your breath is gone, then your body gets cold. It is the breath that makes you warm. When you are wet, you become cold and you get warm because your breath warms you up.

Researcher: Is the body heat similar to the heat from the fire?

Elders: No. No one is heating your body. The Breath is holding the heat. You were born with it (breath). When you die the heat will leave your body with the breath.

Researcher: Where does the heat go to? If you leave hot food on a table, it gets cold.

Elders: The wind takes it. The heat is then gone with it.

Interview 1: Lower Msinga Village Learners

Fermentation and microorganisms

Researcher: How is traditional beer made?

Learners: You put water in a pot and boil it. Make a paste with maize and sorghum malt and maize meal. Add this to the boiling water. Leave it overnight to ferment. The following day you cook this like porridge. It is called *umncindo.*

Researcher: What is *umncindo* and how is it different from ordinary porridge?

Learners: *Umncindo* is sour.

Researcher: What makes it sour?

Learners: Because it was prepared the previous day.

Researcher: If I cook *uphuthu* the previous day will it be sour the following day?

Learners: *Umncindo* is made sour by maize meal and sorghum malt but *uphuthu* is just maize meal alone. That is why it is not sour. Umncindo has fermented.

Researcher: What has caused fermentation?

Learners: Sorghum malt and warmth. When it is cold you use *inhlese* to make it ferment faster.

Researcher: What is *inhlese*?

Learners: This is the sediment from fermented beer.

Researcher: At school what do they tell you about fermentation?

Learners: They tell us that a catalyst can cause fermentation.

Researcher: What is this catalyst?

Learners: Yeast is the catalyst.

Researcher: But you did not mention yeast when you were telling me about the process of making beer.

Learners: Methods differ sometimes.

Researcher: What do you remember about this process from what you have been taught?

Learners: We have not been taught about this process yet. But what we know is that *inhlese* or even a carton of packaged beer can actually make your beer ferment faster.

Researcher: If these are not added, does it mean that fermentation would not take place?

Learners: It can take place but it will be slower. These make it fast.

Researcher: If you make sour milk, how does it take place?

Learners: Warmth makes it ferment. It also turns sour.

Researcher: Is this fermentation similar to that of beer?

Learners: No, it is different.

Researcher: We do not heat up the milk. How come it also becomes sour?

Learners: We are not sure.

It turned out that these students have not yet done respiration in their Biology class. I then decided that I would come and interview them again after two months when they are about to write their final examination. By that time they would have covered their syllabus.

Thunderstorms and Lightning

Researcher: Have you spoken about clouds, thunderstorms and lightning at school? How can you explain these to me?

Learners: It's when clouds come apart.

Researcher: How do they come apart?

Learners: It's when clouds knock on each other because they are pushed by the wind. The sparks then come out.

Researcher: Is this the only way in which a thunderstorm takes place.

Learners: No. We know that there are two types of thunderstorms – natural and man-made. Witches can make a thunderstorm.

Researcher: What about traditional healers/

Learners: When they do this they are no longer healers but witches.

Researcher: What about the natural thunderstorm, where does it come from?

Learners: It is a mixture of coldness and warmth. A storm only comes when it has been warm. Moisture (*umswakama*) from the ground moves to the atmosphere and makes clouds. These clouds knock each other producing lightning. It is cold up there therefore clouds can be formed when moisture reaches up and clouds can form rain.

Researcher: What about mist? Where does it come from?

Learners: When it had rained the sun heats up the soil causing moisture which forms mist.

Researcher: What happens during those days when there has been no rain but mist is there?

Learners: At night it becomes cooler. The cold air above the ground cools the moisture above the soil/ground and forms mist. In towns the mist can be formed from burnt products of industries.

Researcher: What about outside towns?

Learners: It can also come from burnt grass and trees. It means there are two types of mist – one from burning another from moisture in the soil.

Researcher: What about dew?

Learners: This is caused by cooled air which settles down.

Researcher: Where does this air come from?

Learners: air which moves on the soil/ground will have moisture also air from the sea and rivers has moisture.

Researcher: Does all air have moisture?

Learners: When air moves it collects moisture wherever it moves.

Researcher: What happens to dew when it disappears?

Learners: When it is hot during the day, the sun heats up the frost and melts it. Dew also changes into moisture and the air carries this into the atmosphere. Moisture can become dew, clouds, mist and so on.

Researcher: What about frost?

Learners: Frost only comes in winter.

Researcher: Where does it come from?

Learners: When it is hot , moisture moves into the atmosphere where it mixes with with cold air. It comes down at night when it is cold and changes into frost.

Researcher: Where does it start?

Learners: It starts from the soil and moves up.

Researcher: Is there only one way in which frost is formed?

Learners: Frost can also be formed from dew. Dew comes from guttation at night. When this water falls down it becomes dew. The cold air freezes at night and dew becomes frost. Also when there has been a lot of rain during previous summer, during that winter the water from the soil will change to dew and then to frost. More water in summer means more frost in the coming winter.

Heat and related concepts

Researcher: How would you explain what fire is?

Learners: I can only explain by how it is made. You burn wood and fire comes out.

Researcher: Where does the fire come from? Let's describe the fire versus flame.

Learners: It is difficult to describe what fire and flame are.

Researcher: What about heat? What is heat? How can you describe it?

Learners: When you make fire, the heat comes out. You can feel the heat. It is something that is travelling to you; without burning flame and without the sun. It is a source of energy.

Researcher: May be there is another way of describing this heat. For example, why is it that dry wood burns but if I cut wood from a live tree it does not burn, or burns with difficulty.

Learners: Wet wood has water. Water stops burning. Anything that has water would not burn well.

Researcher: When cooking with fire how does the food get cooked?

Learners: The heat travels from burning wood to the pot, to the food and make the food cook.

Researcher: What has actually happened when the food cooks?

Learners: Heat energy comes from light energy. This energy cooks the food

Researcher: Do you know how a fire was started before matches was invented?

Learners: No

Researcher: What is "*ukuphehla uzwathi*"?

Learners: We have never heard of that. In our understanding we have light energy, then heat energy then kinetic energy e.g. light of fire, to heat in the pot, and the movement of food which is kinetic energy. Another example is, when you heat water, you see it moving. You see the light then the heat and then finally the movement.

In the following discussion I wanted to find out whether learners associate heat with chemical change in a substance.

Researcher: What about braaing the meat? What has happened to the meat?

Learners: The meat received the heat and becomes soft.

Researcher: What about half cooked "*uphuthu*" – "*uphuthu olwenyele*"?

Learners: The food does not get completely cooked.

Researcher: Does this mean that when we say food is cooked, something has happened to it?

Learners: This means that intensity of heat has been enough.

Researcher: Has the food changed?

Learners: It has cooked

There was a long pause here and I decided to change the questioning to something else.

Researcher: What about our bodies and heat?

Learners: We have blood in our bodies. The heat of the body is due to the heat of the blood.

Researcher: Where does the blood get the heat?

Learners: The heat is from the blood that is moving. The pumping of the heart makes the body warm.

Researcher: So the heat is from the moving blood?

Learners: as we breathe in, the heat from air outside gets in, we get this heat into our body, and it heats our bodies.

Researcher: Is heat in our bodies the same as heat from the sun?

Learners: Not the same. We do not feel that we are hot.

Researcher: Where does the heat go to? For example, when I leave hot food outside, it becomes cold. Where has the heat gone to?

Learners: It gets out with steam because it is opened.

Researcher: What if it is completely sealed?

Learners: There will be small space for it to escape.

Researcher: What if I put an iron on top of a cloth, or metal pot on a metal stove. What happens then?

Learners: This means there is something that moves when heat is lost.

Researcher: Did you do methods of transfer of heat in class?

Learners: We did not learn that. We only believe that heat is something that moves, but how it moves is not clear.

Micro-organisms

This topic was not yet covered by the teacher during this interview. I decided to reschedule it for a later date.

Interview 2: Lower Msinga Village Learners

Fermentation and micro-organisms

Researcher: Let us start again by asking how traditional beer is made?

Learners: Sorghum malt or maize malt is ground into a powder and then warm water is added into it. This is left for some time.

Researcher: When you say 'sometime' what do you mean – hours, days or weeks?

Learners: We mean a few days.

Researcher: Why is it left for a few days?

Learners: To allow it to ferment.

Researcher: Why do we add warm water?

Learners: So that it can be warm and increase the rate of fermentation.

Researcher: What if we add cold water?

Learners: I do not think it will ferment. (another learner) Even if it ferments, it will take a longer time to do so.

Researcher: What happens after it has fermented?

Learners: You now cook it into a porridge called "*umncindo*". Then it is cooled. After cooling you add sorghum malt. It changes and looks watery. You then allow it to stand for some days. Then it ferments again.

Researcher: What makes it ferment?

Learners: It is the sorghum malt that allows it to ferment. (another learner) There are two kinds of malt – maize malt and sorghum malt.

Researcher: Which is one is used?

Learners: You start with maize. (A discussion ensued trying to come to an agreement which should be added first, maize or sorghum. They finally come to an agreement, except for one, that you start with maize malt in the first fermentation process and then sorghum malt is used in second fermentation process.

Researcher: What makes the mixture to ferment?

Learners: Sorghum makes it ferment. (One learner explained that they always use a mixture of maize and sorghum malt.)

Researcher: We now have one method that is different from the explanation. What do you make of this?

Learners: (They now started to interview this learner. They all felt that it is the sorghum that causes fermentation. The other learner also stood his ground that in his home they use a mixture of both.

Researcher: When making sour porridge what makes it to ferment?

Learners: It is the warmth that makes it ferment. If it is warm the porridge ferments because of warmth.

Researcher: In your last explanation you told me that it is the sorghum malt that causes fermentation. Also last time you said the warmth is a catalyst. Now you tell me warmth also causes fermentation. Which is true?

Learners: No, the warmth makes it ferment faster.

Researcher: What causes the porridge to ferment then if the warmth is to make it ferment quicker?

Learners: You sometimes see bubbles of air coming out when you add water.

Researcher: What about fermentation? What do you say about fermentation at school?

Learners: In plants when there is shortage of oxygen, like in yeast, glucose is broken down into alcohol.

Researcher: Is it similar to making traditional beer?

Learners: We are not sure.

Researcher: Why do we always allow the mixture to cool down before we add malt and then allowing it to ferment?

Learners: I think it is the bacteria that make the beer ferment.

Researcher: That is different from the explanation you gave me before. You told me that sorghum malt makes the mixture ferment and produce alcohol.

Learners: I think malt has the bacteria. The bacteria make the mixture sour.

Researcher: What about in the beer? Is the sourness the same?

Learners: That differs 'according to hands' making it.

Researcher: What does that mean?

Learners: Old people usually say that 'one has a hand. Her beer would make you drunk quickly. She makes strong beer.'

Researcher: Is it because of some quantities you use or what?

Learners: It is because of your gift in making alcohol.

Researcher: Is it similar to the ability to stop lightning?

Learners: Yes. Stopping lightning is a gift you are born with.

Researcher: If we all start with the same quantities and do exactly the same thing, can't we produce the same beer?

Learners: No. It also depends on experience. Even then, the beer would not come out the same.

Researcher: What about in the same house? Can't knowledge be exchanged?

Learners: It looks like a gift is not the same in all people. This is similar even in germinating pumpkin seeds. When some people plant seeds they get more pumpkin.

Researcher: Does it not occur by coincidence?

One Learner: I know it really happens. I tried it at my home. My brother and I were asked to plant the seeds while someone else was digging holes.

Researcher: Was it not because you were just throwing away the seeds?

One Learner: No. At home we all help in ploughing. I wanted to prove whether my brother really 'has a hand'. My row did not give as much pumpkin as his. I really believe that he has a gift because everything else was the same.

learners: Even in beer, there is a gift you are born with.

Researcher: How can we describe this gift? What is it like?

Learners: It is something you are created with and it is your gift.

Another Learner 2: I think it is something you dedicate yourself to at that time.

Another Learner 3: Sometimes you can really show a lot of dedication but still not have the results.

Researcher: In traditional healing, can this be learnt?

Learners: You cannot learn to be a divine healer. This is a gift you are born with.

Another Learner: You can learn other things but others are a gift.

Researcher: Where does the gift come from?

Learners: It is from the ancestors. They are closer to God. They channel these gifts from Him to the person.

(A discussion ensued on ancestors and God. It is beyond the scope of this research.)

Thunderstorms and Lightning

Researcher: What is happening when there is a thunderstorm?

One learner: In geography we learnt that when it thunders it is when clouds knock against each other. But I still don't believe that.

Researcher: What do you think is happening then?

Same learner: I am still not able to explain what is happening.

Researcher: Last time you told me there are two types of thunderstorms. You also told me that there are people who are able to prevent lightning from striking.

Learners: (one learner) We think that only man-made lightning can be prevented.

Another Learner 2: Can one make lightning in winter? I do not think so. Can these people make lightning in winter?

Learners: It can happen even in winter. In some cases people will threaten you that they will send lightning to you and it really happens. Do you think this is still coincidence?

Learner 3: I think even in winter people can send you lightning because it is caused by medicines.

Learners: You just see a black cloud collecting. It strikes and quickly clears. This is usually different from the natural storm. You even hear elders saying they wonder where the damage has been done.

Researcher: Have you ever seen this happening in this community?

Learners: Yes, we see it quite often.

Researcher: Does this mean there are people who can make lightning?

Learners: Oh Yes. We have observed that in some instances when there is a drought, young women will go and pray to *"Nomkhubulwane* – the rain maiden" on a particular mountain. They dress in leaves and sing a particular song.

Researcher: Why is it only women who go and pray?

Learners: We do not know why.

Researcher: Does it really rain after this?

Learners: Yes. A cloud gathers. By the time they come back it is already raining. In some cases it will take a few days.

Researcher: Who participate in this?

Learners: Only young maidens who have no children. In some cases even older women go. Young maidens smear clay and were leaves of "*umsenge*" tree.

APPENDIX 3: STRUCTURE OF A GRANARY