Voices from the classroom: Beliefs of Grade 11 learners about science and indigenous knowledge

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Abstract

The dismantling of apartheid in South Africa provides educational researchers with the opportunity to explore many issues in education one of which being knowledge and its epistemology. Since colonization Africa has been mainly a consumer of Western knowledge and hardly a producer of new knowledge. Generally indigenous knowledge is taken by Western scholars and then sold to its motherland dressed in Western garb. Because of colonization and subsequent apartheid rule the progress of indigenous ways of knowing was marginalized and only Western ways of knowing were promoted. Indigenous ways of knowing need to be debated not only by scholars in the main but also by the science learners in African schools. Hence this study firstly explores the beliefs of a large group of grade 11 Physical Science learners about school science and indigenous knowledge and secondly explores how these learners negotiate relationships between school science and indigenous knowledge.

DEDICATION

THIS WORK IS DEDICATED TO MY CHILDREN DIVESH AND NEELESH.

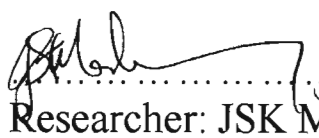
ACKNOWLEDGEMENT

- I thank you Professor Malcolm for your continued support, guidance and time during this study. Your support was beyond the call of duty.

- Thank you to Divesh and Neelesh for your understanding and love during my difficult times.

DECLARATION

I, Jayanthi Siva Kumaree Maharaj, declare that the research involved in this dissertation entitled *Voices from the classroom: Beliefs of Grade 11 learners about science and indigenous knowledge*, is my own work.



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Chapter One

Introduction and Rationale

1.1. Introduction

"We should call school *Dool,* ma" was my eight year old son's words that broke through my thoughts. I wondered what the catch was this time around, since I was used to the games he often played with my mind. "Why *Dool"* I suspiciously asked. "**D**estroyer **O**f **O**ur **L**ives" came the quick and obviously well thought out response. This was coming from a young and happy child that was excelling at school according to school reports.

Learners think about school and what it means to them, even when they are quite young. They do have important contributions to make as far as their schooling is concerned, and therefore we should *listen* to their voices. This is the starting point of this research: to listen to learners' ideas about knowledge and science and their lives. The learners involved were 194 grade 11 Physical Science students from a township in the Durban area – learners who are in that sense urban and modern. These learners, about half of them from informal settlements, are serious about their learning and they attend a school that is serious about learning. Further, they have chosen Physical science as a study at the grade 11 level.

Post apartheid South Africa is in the fortunate position of being the home of citizens of various diverse cultures who are given equal opportunities of being productive and successful citizens. The concept of the African Renaissance, which President Thabo Mbeki has often spoken to, has been my inspiration to undertake this study.

1.2. The Context

The South African classroom, in which my research was conducted, is a classroom that is emerging from a history of colonization, apartheid education, abuse, depravation, violence and political activity.

Two major economic models of exploitation that were externally derived afflicted Africa in the 20th century. These were the colonial model of exploitation and the neo-colonial models that were aimed at re-colonization (Emeagwali: 2003). These models developed an education system that promoted the dependence of Africa on the West for economic survival. A Western education system that was based on negative assumptions about race, gender, culture, colour and religion was imposed on the African child. The poor performance and lack of interest of the African child in science, and in school in general was, under colonization and apartheid, a deliberate and expected consequence of such an education system.

The Western science taught at school is often represented as tested and reliable knowledge and in that sense superior knowledge in comparison to local knowledge. According to Taylor and Cobern :

> *Local cultures are in danger of suffering erosion and loss of integrity as a powerful culture-insensitive science education, operating through the agency of local schools, delegitimates and rapidly displaces traditional ways of knowing, being and valuing (cited in Aikenhead and Jegede:1999b).*

In many developing countries Western science is a hegemonic icon of cultural imperialism that, in the process of presenting and exalting the achievements of science, marginalizes local economies and traditional knowledge. For many learners and entire communities, this has had numerous consequences, as will be explored in Chapter 2: it interferes with learning 'science', by failing to make connection with learners' experiences, and failing to acknowledge other wider ways of understanding existence and life; it uncritically suppresses 'difference' rather than critically tapping into the wealth of

traditional knowledge; it belittles, rather than affirming and expanding learners' cultures and lives.

The dismantling of apartheid in South Africa provides educational researchers with the opportunity to explore many issues in education one of which being knowledge and its epistemology. Since colonization Africa has been mainly a consumer of Western knowledge and hardly a producer of new knowledge. Further, Western scholars have often taken indigenous knowledge and then sold it to its motherland dressed in Western garb. Because of colonization and subsequent apartheid rule the progress of indigenous ways of knowing was marginalized and only Western ways of knowing were formally promoted. Indigenous ways of knowing need to be debated not only by scholars in the main but also by the science learners in African schools. In this context I am using the geographical meaning of the term African.

1.3. Critical questions

Many research studies were carried out on how multicultural education can help the indigenous learner understand Western science and on other ways of bridging the gap between indigenous cultures and the culture of Western science in order to improve the performance of indigenous learners. My research focuses on the beliefs of learners regarding both science and indigenous knowledge.

I will present my three critical questions and use them to clarify the focus of my research.

Critical question one:

> *What are the cultural beliefs, grounded in family, community, school and peers of isiZulu – speaking township learners that are brought into the science classroom?*

This question is mainly descriptive and exploratory. I want to find out what indigenous and Western beliefs, if any, the science learners hold.

Critical question two

How do learners perceive science and indigenous knowledge in practice?

Since learning is about making meaning within a cultural milieu I will explore how learners understand classroom science and indigenous knowledge within this cultural milieu.

Critical question three

How does the township learner negotiate relationships between classroom science and indigenous knowledge and how much do they care about inconsistencies and contradictions?

Science learners are exposed to different subcultures, the subculture of school science and the subculture of their community (Aikenhead: 1996). Indigenous knowledge systems (IKS) are a sub-culture of the community culture and within IKS there may be other subcultures, such as the sub-culture of mysticism and the sub-culture of traditional medicine. The complexity can be heightened if these sub-cultures are not distinct from each other but are different in certain respects. The reductionistic, materialistic and mechanistic attributes of Western science culture places it at odds with the spiritualistic, mystical and holistic culture of IKS. This question addresses how the learner negotiates any perceived relationships between Western Science and IKS.

In Chapter 2 I will present a relatively brief review of literature on multicultural education. Chapter 3 will follow this where I will discuss my research methodology. My analysis of data and research findings will be presented in Chapter 4. My concluding remarks and recommendations will be presented in Chapter 5.

Chapter Two

Literature Review

2.1. Introduction

In Chapter one I outlined the issues surrounding culture, science culture, classroom science and indigenous science that I am exploring in this study. In this chapter I will examine the contribution of other researchers in science education in the debates surrounding culture, science culture, classroom science and indigenous science.

The foci of this literature review are discourses relevant to my critical questions. The discourses and debates that I am about to espouse pertain collectively to all three critical questions, but notwithstanding this I have categorized them according to each critical question.

Critical question one:

> *What are the cultural beliefs, grounded in family, community, school and peers of isiZulu – speaking township learners that are brought into the science classroom?*

This critical question compelled me to examine the discourses and debates around the concepts of culture and worldview and their relevance to science education and review literature on the beliefs of African learners.

Critical question two

> *How do learners perceive science and indigenous knowledge in practice?*

Since, from a theoretical perspective of social constructivism as a learning theory, learning is about making meaning within a cultural milieu and about how learners understand classroom science and indigenous knowledge within the cultural milieu defined jointly by their participation in school and community.

Critical question three

> *How does the township learner negotiate relationships between classroom science and indigenous knowledge and how much do they care about inconsistencies and contradictions?*

"Whenever a learner enters the world of school science it soon becomes evident that science too is another culture with which she has to interact, bringing with her the other baggage of culture she already carries" (Jegede and Aikenhead: 1999b). This led me to survey the literature surrounding issues of culture border crossings, collateral learning and scientism. It led me to explore the extent to which science itself was a 'single' culture, or many. A distinction was necessary here between science as practiced by professional scientists (in industry, environment, health, agriculture and academia) and science as presented by text–books, curriculum policies and teachers.

This question led me to examine the works of researchers that discussed social constructivism, personal constructivism, critical constructivism and the plurality of science.

2.2. Culture and Science

In this study I am interested in the cultural beliefs, that learners bring into the science classroom, grounded in family, community, school and peers of African townships. These are surely complex, for these learners often have access to television, 'pop culture' and modernity in ways that learners in remote rural villages do not. I begin with an examination of concepts of culture, science and worldview by other researchers in education across the globe.

2.2.1. Culture Studies

Culture studies is a theoretical perspective in which "the concept of culture is actually the theoretical underpinning and interpretive framework that we use for understanding much of what happens in science education" (Krugly-Smolska: 1999:3).

I am using culture as a theoretical perspective in a cross-cultural context, where it comprises more than one variable and the various aspects of culture might be understood as separate variables. I accept immediately that this has the advantages and disadvantages of a reductionist approach.

In 1981 Maddock proposed an anthropological viewpoint for science education when he explained that:

> *... science and science education are cultural enterprises which form part of the wider cultural matrix of society and that educational considerations concerning science must be made in the light of this wider perspective (Maddock:1981:10).*

An attempt to clarify the term *culture* will now to be given in order to conceptualise cultural issues within a community, the learning of science and the science in the curriculum. Many definitions of culture have guided research in science education, for example Banks (1988), Bullivant (1981) and Phelan, Davidson and Cao (1991). The following list of attributes of culture can be composed from these sources:

> *Communication (socio-linguistic), social structures (authority, participant interactions), skills (psycho-motor and cognitive), customs, norms, attitudes, values, beliefs, expectations, cognition, material artefacts, conventional actions, technological know-how, and worldview.*

In this study I take as my starting point culture defined by the anthropologist Geertz (*1973:5)* who characterized cultural enterprises suspended in a 'web of significance people themselves have spun':

> *I take culture to be those webs, and the analysis of it is not an experimental science in search of law but an interpretive one in search of meaning.*

From discourses in cultural anthropology, it is often claimed that *to learn science is to acquire the culture of science* (Maddock: 1981, Wolcott: 1991). This is questionable. Can one not learn science without acquiring the culture of science? I would like to change the statement from cultural anthropology to: to learn science is to *understand* the culture of

science; to be able to apply it more or less faithfully, and to be able to critique it. This is at once a requirement that is more demanding than acquiring the culture of science.

It follows from Geertz's definition that cultures can be defined at various levels of generality, depending on the extent of the webs that are involved. Thus we might think of an African culture, a township culture, a peer group culture, a school culture; we might think of a science culture, an engineering culture, an ecology culture, a science classroom culture. Thus we define sub-cultures and micro-cultures, partly with a view to their relationships vertically, but also aware of their interactions horizontally: the webs of culture are complex.

This study is an interpretive way of exploring the learning of science among a specific group of learners within which there may exist several micro-cultures. All the learners in this group may belong to the same racial group but they may not necessarily be within the same family, community or peer culture. A single-race group of learners in a township setting may yet be a multicultural group of learners.

South Africans are enmeshed in a splendid rainbow of people whose cultures are reflections of a heterogeneous mixture of Western, African, Indian and other ethnic-based cultures, and a range of other cultures as well. All South African classrooms reflect this multicultural nature of South African society to a greater or smaller degree. Every classroom is a multicultural zone. I recall a superintendent of education who called me a *Zulu of Indian origin*, a statement that certainly had a point. She might have added that I am a woman, a teacher, a mother, a scientist. The point that I am making here is firstly that culture is not a static concept and secondly the concepts of culture and race, certainly within the Geertz formulation, are not synonymous.

It is similarly an oversimplification to consider 'science' as a single culture. In the natural sciences, the culture of Chemists is typically different from the cultures of Ecologists or Geologists; in the applied sciences, cultures of engineering, medicine and agriculture are highly varied; in the social sciences, differences proliferate and are often highly contested (Kyle and McCutcheon: 1984). The effect is that definitions of 'science' as a culture tend to become very broad, such as with Ogawa's definition of science as *a rational*

perceiving of reality (Ogawa: 1995:588). While such a broad definition of science concedes the plurality of science, it also blurs distinctions between 'science' and 'non-science'. For example law, history, religion, even art could claim to satisfy Ogawa's definition of 'science', and raise profound questions about meanings of 'rationality' and 'reality'. This raises issues about the more or less homogeneous, positivist, empiricist view of science that is typically presented in schools around the world, and the reasons behind that particular choice.

These thoughts are a reflection of Brian Murfin's (1992:11) words:

> *Because of the United States' diverse ethnic mix we have a wonderful chance to bring about a synthesis of the different cultural approaches to science and to teach it to our children. If this could be done it would free many minds from the shackles of our male-dominated, white, European mode of doing science. Who knows what discoveries might be made if we unleashed the mind power of the whole human race instead of depending on the views of a small but powerful minority, the white male?*

2.2.2. What is Western science?

I understand Western science as just *one way of understanding* the world, and I must hasten to add a very important and *useful* way of looking at the world. According to Cobern *"educators have long since viewed science as either a culture in its own right or as transcending culture"* (1994a: 2). In this study I speak of Western science as a subculture of Western culture, since the West is the historic home of modern Western science. By this definition I am not precluding the fact that scientists from non-Western cultures, such as Dr. Rameshchandra Bose, a famous physisist, have influenced Western science or that Western science has acquired knowledge from other indigenous cultures. I am concurring here with Ogawa who states that Western science as it is presented in schools and to the general public today *"pertains to a Cartesian materialistic world in which humans are seen in reductionistic and mechanistic terms"* (1995: 589). Furthermore Ogawa describes Western science as the *"culture of scientific community"* (1999:3) and he provides an interesting definition of science-as-culture:

> ... *(science refers to) systems of shared ideas, to the conceptual designs, the shared systems of meaning, that underlie the ways in which a people named scientist work (*Ogawa, 1999:*3).*

Assumptions about knowledge and reality, values and purpose, people and society that underpin modern science are grounded in Western Secularism (Cobern: 1994). A science education that reflects this secular nature of Western science is bound to marginalize and devalue knowledge systems that exhibit deeply spiritual and supernatural views of the world. This is a complex issue: one of the major achievements of science has been to show, especially in medicine and phenomena such as evolution of species, lightning, earthquakes and eclipses, that magical explanations can be replaced by scientific ones. At the same time, it is an act of faith to claim that all experience and all phenomena will eventually yield to scientific explanation, or that such explanations are the 'best'. For example, Maddock (1983) found, in studies between 1972 and 1980, that science education in Papua New Guinea had a significant alienating effect that separated students from their traditional culture and, to that extent, their community. He questions whether this outcome is 'the best'.

While Ogawa's definition of science as "*a rational perceiving of reality"* (Ogawa: 1995:588) creates spaces for science education in third world cultures, where alternative constructions of science and science education (Cobern: 1994) might be appropriate, many science educators argue for a science education that is acultural and value-free, resting on the empiricist claim for science as 'tested, reliable knowledge'. Aikenhead and Huntley place science teachers in this category. In a study investigating science teacher's views on the cultural aspects of Western science they concluded that

> *The cultural status of science seems to have little currency for teachers.*
> (Aikenhead and Huntley: 1999).

Matthews (1992) argues in favour of this. He concedes that the nature of science is complex, but argues that, at school level, the focus should be on its essence, as knowledge generated from experience and tested by experiment through hypothetico-deductive strategies. This is the view of science into which most science teachers have

been acculturated, and whose propagation they see as their responsibility. It is discussed further below. This position can readily be contested, especially if it is presented as unproblematic. From my own experiences as a science student and subsequently as a science educator it is of particular concern when it marginalizes other ways of knowing by imposing materialistic, reductionistic, mechanistic and exploitive approaches, especially for learners and cultures who hold contrary positions. Some researchers in science education have stated that Western science education can cause a learner to abandon or delegitimize her indigenous way of knowing (Jegede: 1995, MacIvor: 1995, Hodson: 1993, Cobern: 1996b). Lest I be misunderstood, let me hasten to add that although this last sentiment may be singing the tune of anti-science sentiments, this study is not promoting anti-science positions. There is a lot to celebrate about Western science, as noted by many researchers and policy documents in science education, but my concern relates to the detrimental (if any) effects of the celebration of a 'singular' science in African classrooms on African ways of knowing and students' learning.

Hillard and Asa offer the following compelling argument for the plurality of science:

> *The primary goal of a pluralistic curriculum process is to present a truthful and meaningful rendition of the whole human experience. This is not a matter of ethnic quota in the curriculum for "balance", it is purely and simply a question of validity. Ultimately, if the curriculum is centred in truth, it will be pluralistic, for the simple fact is that human culture is the product of the struggles of all humanity, not the possession of a single racial or ethnic group.* (Hillard and Asa: 1992.)

From my own partly Indian background I have long pondered the question of the absence of other sciences, for example Vedic mathematics and Ayurvedic science, in my schooling career. As an adolescent I used to ponder whether learners in India were learning the same mathematics and science that I was learning. Lo and behold, a few years later, this was exactly what I learnt was being taught in most parts of the globe. Then, as part of my university studies, I realised that Western science itself contained a

number of different approaches, ranging from positivist through interpretivist to socially critical.

In the empiricist, positivist view of science commonly presented in science classrooms, science is a singularity. Science is shown in the natural, material world with no connection to social and spiritual worlds. What happens when an African township learner encounters this classroom science? Researchers in science education have held several views on this question.

Early research focussed on the learning of Western science, and saw traditional culture as a barrier to learning (Wilson: 1981). This research explored several cultural factors that inhibit effective learning of science; factors such as indigenous worldviews, language, customs and human relationships. The most common concern among researchers of this earlier period was how to eliminate or circumvent such negative factors in science classrooms. Later studies prompted Cobern to remark that "*traditional culture poses no threat to logic and thus on these grounds need not be viewed as an impediment to the learning of modern science*" (Cobern: 1994:11).

This concern for impediments to learning carries with it notions of cultural deficit, including a non-rational mind or rationality gap (Cobern: 1994a). The anthropologist Levy-Bruhl (1926) was one of the early researchers who suggested that there was a divide between Western thinking and all forms of traditional thinking in his work *How Natives Think* (cited in Cobern: 1994a). Proponents of cultural deficit theories may have found support in such writings. Their underlying claim is that some cultures promote rational thinking while other cultures do not, and their assumption is that Western-style rational thinking is more advanced than alternatives. Western researchers have long believed that the eradication of traditional ways of thinking would be to the advancement of societies throughout the globe (Basalla: 1967, Poole: 1968) and that Western science would help bring about a world culture (Dedijer: 1962). Western culture, with the assistance of Western science education would thus become the dominant world culture in an envisaged global civilization.

Western science is not the only way of understanding the world.

2.3. Worldview

The concept of worldview is a central theme to this study, to all three questions to a lesser or greater extent. To this end I therefore provide a survey of the literature on the concept of worldview.

According to Cobern a worldview is:

> *The set of fundamental non-rational presuppositions on which conceptions of reality are grounded ... antecedent to specific views that a person holds about natural phenomena whether one calls these views common-sense theories, alternative frameworks, misconceptions or valid science* (1996a: *585).*

Kearney defines a worldview as

> *A culturally organized macro-thought; those dynamically inter-related basic assumptions of a people that determine much of their behavior and decision-making, as well as organizing much of their body of symbolic creations and ethno-philosophy in general* (1984:1).

Proper, Wideen and Ivany define worldview as follows

> *A person's set of beliefs held consciously or unconsciously about the basic nature of reality and how one comes to know about it* (1988:547).

The concept of single, consistent worldview assumes the importance of integrity (as against fragmentation and confusion) in a healthy personality or a healthy community. It centres on a set of beliefs that have epistemological and ontological ramifications, and strongly influence behaviour. However, the notion of worldview is surely subject to the same complexities as the notion of culture. Does a person hold one worldview or many, to be used in context? Does a person hold a 'super-worldview' to which various 'micro-worldviews' are subordinated, and through which a person's behaviours are more or less predictable? The answers to these questions are far from clear, and not given close attention by the proponents of worldview theories. At the same time, worldview theories resonate with cultural theories, in that worldview can be defined for an individual as well

as a community. Individuals can have worldviews that are consistent or not with those of a community in which they participate, implying different levels of identification with that community. In this sense, we can talk about a traditional worldview, a scientistic worldview, and relate them to individual worldviews.

Kearney sought to analyse the concept of worldview, and proposed a logico-structural model based on seven categories: non-self (society, nature and supernatural forces), self, classification, relationship, causality, time and space. These seven categories are shown in Table 2.1.

Table 2.1 shows Kearney's seven categories that compose a worldview, and uses them to compare scientistic and alternative worldviews (Cobern: 1991). The descriptors for the scientistic worldview are a result of research that examined the cultural form in which Western science is embedded, and is used here as an example (Capra: 1982). The 'alternative' worldviews are derived from various traditional worldviews, including African worldviews. Discussion of scientism follows Table 2.1.

Table 2.1 Worldview Categories

Worldview Categories	Scientistic Descriptors	Alternative Descriptors
The Other or Non-Self	Materialistic Reductionistic Exploitive	Holistic social / humanistic aesthetic religious
Classification	natural only	natural social supernatural
Causality	universal mechanistic structure / functional	context bound mystical teleological
Relationship	strict objectivism non-personal	subjective personal
Self	dispassionate independent logical	passionate dependent intuitive
Time and Space	abstract formalism	participatory-medium tangible

The belief in mechanistic laws of cause and effect (by which effects can be predicted, at least probabilistically) is very strong in Western culture, but several other cultures see

cause and effect in more complex ways: the same causes can have different effects; effects may be mistaken for causes; the mere fact of being posterior in time does not make an event an effect rather than a cause. (Murfin: 1992). Ogunniyi (cited in Murfin: 1992:3) presents an example of how African and Western science would investigate the phenomenon of malaria. A Western scientist would look for the cause of the disease, e.g. the plasmodium and the vector the Anopheles mosquito. An African scientist might be happy to accept that the malaria was caused by a mosquito bite, but may ask why that person was bitten by that mosquito: the African is looking beyond mechanistic cause-effect, and is not satisfied with the scientist's claim that the mosquito found that person by chance.

Consensus on the definition of the term scientism is illusive, but it most often means a belief in science as tested, reliable knowledge – knowledge that enables accurate predictions – and a belief that eventually all experience will be able to be explained in these ways. According to Cobern (1994b)

> *Though recognizing the tentative nature of all scientific knowledge, scientism imbues scientific knowledge with a Laplacian certainty denied all other disciplines, thus giving science an a priori status in the intellectual world.*

Ziman (1980) provides the following comment on scientism

> *It (*scientism) *reinforces, without question or comment, the widespread sentiment that science should be the only authority for belief and the only criterion for action ... The trouble with scientism is that it takes as given an attitude "for" science without deeper analysis.*

Habermas (1974) defines scientism as

> *science's belief in itself.*

These definitions imply a conviction that Western science is not merely one form of knowledge, but rather knowledge should be identified with science. Scientism then is an ideology that identifies valid knowledge only with Western science. Then by implication

all knowledge that does not display the scientistic worldview is regarded as invalid knowledge. So Ogunnyi's question of why the mosquito bit that particular person, and any suspicion that the mosquito was 'sent' is discounted because science has no answer to it beyond chance.

The scientistic worldview is grounded in the three imperatives of modern Western society (Cobern: 1994a):

> *The imperative of Naturalism – all phenomena can ultimately and adequately be understood in naturalistic terms*
>
> *The Scientistic imperative – anything that can be studied, should be studied*
>
> *The Technocratic imperative – any device that can be made, should be made*

As noted earlier, while other views of science exist (in theory and in practice), this scientistic view is the one typically presented in science textbooks and classrooms. My suspicion is that this choice is ultimately political and indoctrinatory, aimed to garner public support for Western science and impose an ideology. My central argument is that alternative conceptions of science should be part of the curriculum, explored critically; that consonances and dissonances between science and traditional beliefs will invite discussion and enable more effective and more appropriate science education.

2.4. Border Crossing

The process of moving from one cultural setting to another (for example from home to school or from peer group during break to a science classroom) is conceived as cultural border crossing (Aikenhead: 1996). Giroux (1992) proposed the concept of cultural border crossing when he contrasted modernist and postmodernist views on education. On the one hand, modernism defines borders and locates people within those borders along with the social and political power afforded to each location. On the other hand, postmodernism encourages people to have multiple identities by living in a world of border crossings, and living with multiple narratives that define reality (Giroux: 1992:54). Again conceptual difficulties arise: the very notion of 'border crossing' implies

boundaries and compartments that are sharply defined, so that at any moment, an individual 'sits' in one compartment or another. In practice however, the different subcultures might be quite intermingled, interacting with each other.

2.4.1. Enculturation and Assimilation

Aikenhead and Jegede (1999b) have suggested that "when pupils learn science within a multicultural environment ... they need to move between their everyday life-world and the world of school science". This back and forth migration of learners between their life-world and the world of Western science is "border crossing" (Aikenhead and Jegede: 1999a). A cognitive explanation of the process of border crossing is provided in collateral learning (Aikenhead and Jegede: 1999b).

The theory of collateral learning postulates a spectrum of categories of cognitive experiences that explain cultural border crossings. These categories namely parallel, simultaneous, dependent and secured collateral learning, are not distinct categories but points along a spectrum depicting degrees of interaction and/or resolution between the worldviews (Aikenhead and Jegede: 1999b).

Parallel collateral learning, which is also referred to as the compartmentalization technique, is at one end of this spectrum and it occurs when the conflicting schemata do not interact at all. The learner will access one schema or the other depending on the context or need. This *"cognitive apartheid"* (Cobern: 1996) shows the segregation of school science from the learner's life-world within the mind of the learner. This perhaps may also be an indicator that learners believe that there are many sciences. Learners may believe that the solution to some of the problems they encounter is in their indigenous world and other solutions are in Western science. In other words cognitive apartheid may be an indicator of alternate constructions of knowledge in the mind of the learner. In this study I will explore this theory further.

At the opposite extreme of this spectrum of collateral learning is secured collateral learning. Here the conflicting schemata interact and the conflict is resolved in the mind of

the learner (Aikenhead and Jegede: 1999b). The learner holds on to both schemata or allows the one schema to reinforce the other.

There are points of varying degrees of interaction between the two extremes of parallel and secured collateral learning. Simultaneous collateral learning occurs when two world views of a particular phenomenon occur at the same time for example in a classroom activity that provides bridges between two belief systems.

From the perspective of cultural anthropology, teaching science is culture transmission (Spindler: 1987) and learning science is culture acquisition (Wolcott: 1991). If the subculture of science generally harmonizes with a learner's everyday culture, then science education will tend to support the learner's view of the world and the result is *"enculturation"* (Hawkins & Pea: 1987). However according to Costa (1995) and Ogawa (1995) the sub-culture of science is generally at odds with a learner's everyday world. In this case, when the learner's life-world culture is at odds with the culture of science, science education will tend to disrupt the learner's view of the world by forcing that learner to abandon her indigenous or everyday way of knowing and reconstruct in its place a scientific way of knowing. The result is *assimilation* (Jegede: 1995).

2.4.2. Fatima's Rules

Many learners resist assimilation into the subculture of school science (Driver: 1989, Hills: 1989). Attempts at assimilation can *alienate learners from their indigenous life-world culture* (Baker and Taylor: 1995, Maddock: 1981) or alternatively assimilation can *alienate learners from science* (Aikenhead and Jegede: 1999b). Some learners get around this by playing school games that allow them to pass school science without meaningful learning taking place.

Larson (1995) discovered that such games can have explicit rules, which he called Fatima's rules, after an articulate high school chemistry learner.Aikenhead and Jegede (1999b: 24) state that one such rule advises learners to avoid reading textbooks but to *"memorise the bold faced words and phrases"* in order to cope for school learning purposes. Other coping mechanisms in Fatima's rules are *"silence, accommodation,*

ingratiation, evasiveness and manipulation" (Atwater: 1996: 823). Fatima's rules and assimilation are considered undesirable avenues for learning science because they are avenues of learning that do not *"nurture"* learning (Cobern and Aikenhead: 1996).

2.4.3. Four Patterns of Border Crossing

The ability to participate in other sub-cultures varies among the peoples of the world, the differences they perceive and their commitment to the transition.

Anthropologists Phelan et al (1991) identified four patterns to cultural border crossings:

- *Congruent worlds support smooth transitions,*
- *different worlds require transitions to be managed,*
- *diverse worlds can lead to hazardous transitions,*
- *highly discordant worlds can cause students to resist transitions and make transitions impossible.*

Costa (1995) confirmed Phelan et al's anthropological finding in terms of schools in her study of 43 high school science learners and she furthermore proposed a categorization scheme that described learners in terms of their ease of navigating the cultural border between their worlds of family and friends into the culture of school science:

1. *"Potential Scientists"* where the cultural border crossing is smooth because the cultures of family and science are congruent. The borders are invisible to the learners.
2. *"Other Smart Kids"* where the cultural border crossing is manageable because the cultures of family and science are different. The learners do not express a sense of science being a foreign sub-culture.
3. *"I don't Know"* students where the cultural border crossing is hazardous because the cultures of family and science are diverse. These learners

learn to cope and survive, possibly by playing school games like Fatima's rules.

4. *"Outsiders"* for whom border crossing into the sub-culture of science is virtually impossible because these learners tend to be alienated from school itself.

5. *"Inside Outsiders"* find border crossing into the sub-culture of school science to be almost impossible even though the learners "possessed an intense curiosity about the natural world".

2.4.4. Alternatives to assimilation

Cobern and Aikenhead (1996) have stated that conventional science education has produced three avenues for learning science, namely: enculturation, assimilation and Fatima's rules. *"Autonomous acculturation"* and *"anthropological learning"* are two further avenues of learning that emerge when learning is viewed in a cross-cultural or multi-cultural perspective. Autonomous acculturation is a process whereby a learner borrows or adapts attractive content or aspects of another culture and incorporates that content into one's indigenous culture, a process that nurtures learning. Anthropological learning occurs when learners construct meaning out of the foreign subculture but do not assimilate or acculturate the foreign meaning (Aikenhead: 1996).

I question the theory that incongruence between the learner's life-world culture and the culture of school science results in learning that is not meaningful. I do this on two grounds: First it denies as 'meaningful' the understanding of a theory or system of thought that the learner chooses not to believe, such as the evolution of species by natural selection. Second, it denies as meaningful the learner's migration into an abstract world well beyond everyday experience, such as the inner world of atoms, quantum theory and electron orbitals. Such adventures may be hazardous, but they can also be productive, exciting and pleasurable. The same can be said for speculative thought in any domain.

2.5. Multiscience Perspective

Ogawa suggests a broad definition of science. He defines science as

> *rational perceiving of reality* (1995: *588)*

In this definition the term rationality does not mean only Western rationality, but encompasses the kinds of rationality that exist in each culture and implies behaviour in accordance to rules. Hence Ogawa distinguishes three types of science and in effect discards the notion of the singularity of science. The three types of science he identifies are indigenous science, personal science and Western modern science. (Ogawa: 1995.). As noted earlier, Ogawa's definition is problematic, in that it fails to provide criteria for distinguishing between 'science', 'non-science' and 'pseudo-science'. Indeed necessary and sufficient conditions for being 'scientific' are extremely difficult to define: scientists formulate hypotheses and test them through logic and experiment, but so do non-scientists; science values objectivity and rationality, but the act of creating a theory is subjective and inspirational; scientific theories are often tested by prediction, but often they are not (example: in the interpretive sciences of ecology).

There are alternatives to seeking tight definitions that are perhaps more fruitful in science education. They all involve opening up the definition of science, and accepting that any definition is problematic. One strategy is to raise issues about values in science and its applications (for conflicting values are central in notions of borders and border crossings). Another is to explore with learners the meanings and justifications of competing knowledge claims.

At the World Conference on Science held at Budapest, Hungary in June 1999, countries such as India, China, Thailand and Iran called for an international code of ethics for science, which would include guidelines on the regulation of knowledge monopolies. Countries whose indigenous knowledge systems were often at odds with Western science expressed their concern at the conference over the exploitation of those who created and preserved various forms of traditional knowledge. Authors such as Cobern have

advocated bringing different ways of knowing into dialogue, exploring critically their claims:

> *The failure of science education to develop an environment where different traditional culture and the sub-culture of modern science can meet in dialogue on an equal footing, will lead to the advance of one at the expense of the other* (Cobern: 1996:11).

For methodological pluralists such as Paul Feyerabend, *"IK (Indigenous Knowledge) is science because it functions"* (cited in Emeagwali: 2003: 2). For those who believe in the concept of a single science, IK may be considered as scientific in the light of some common features that it may have with Western science. I concur with researchers who believe that there are other ways of knowing based on congruent or incongruent worldviews (Emeagwali: 2003, Murfin: 1992).

Chapter Three

Methodology

3.1. Introduction

The Scottish Philosopher John Macmurray (1957: 12) wrote: " ...most of our knowledge arises as an aspect of activities that have practical not theoretical objectives". All societies, from the very fact that they have survived, must have developed knowledge, be it oral or written that addressed their practical objectives. The knowledge of some societies has been marginalized in school curricula due to historical events such as colonisation, slavery and apartheid as I discussed in my introduction. This has happened especially in the South African school curriculum.

Macmurray (1957: 84) went on to argue that "I do" rather than "I think" is the appropriate starting point for epistemology. Hence knowledge of learners' beliefs about science and indigenous knowledge is essential for science education especially in contexts where science and the dominant culture are incongruent. These ideas urged me to explore the personal beliefs of learners about school science and indigenous knowledge. I wanted to know what these beliefs are and also how learners negotiate relationships between these worlds of similar, different, divergent, harmonious and / or discordant beliefs.

I therefore needed to conduct a quantitative survey among a large group of learners in order to determine ***what*** the beliefs among the general population of learners are. At the same time I wanted to find out ***how*** individual learners negotiate relationships between the indigenous world and the Western world and this needed qualitative responses from learners. I needed to access these discourses from a large number of learners. To answer these questions I needed both quantitative and qualitative data. Hence I decided to use a purposively designed questionnaire that will include both forced – response questions and open – ended questions.

3.2. Clarification of terms

The inyanga, isangoma and umthagathi are traditional healers in the Zulu community. In further discussions I will use the term 'herbalist' for the inyanga and term 'diviner' for the isangoma. Izinyanga and Izangoma are plural for inyanga and isangoma respectively.

3.3. The sample

I conducted my study among township learners partly because many studies on scientific worldview have been conducted with participants in rural areas (MacIvor:1995, Maddock:1983, Murfin:1992, Cobern:1996a). I also had other reasons. I wanted to explore beliefs among a group of learners who are exposed to semi – urban cultures and to explore whether traditional beliefs and practices are still prevalent among non – rural learners.

Hence I selected three schools from one township in Kwazulu Natal. The schools were similar in the sense that most of the learners in all three schools lived in the same township and were isiZulu – speaking. The schools differed in the general performance of learners in Physical Science. School A generally produced above average Physical Science results while school B produced average and school C produced below average results.

I selected the learners from the grade 11 Physical Science classes at all three schools since I believed that these learners will have had considerable exposure to science culture and since this study required learners to respond to questions about their indigenous beliefs as well as beliefs about science.

All the learners at all three schools were very eager to answer the questionnaires so my initial intention of taking random samples of learners from the schools was dropped. The fact that the questionnaire included questions about indigenous culture excited the learners and therefore I believed that they *wanted* to say something important and therefore their voices should be heard. It is not often that people want to give their time and energy so freely and I would have lost a good opportunity if I ignored the eagerness of the learners.

A total of 262 learners answered the questionnaire. The questionnaire was long, with many open-ended questions, from which a wide range of ideas emerged. For this report, I resolved to restrict the analysis to one school (school A with 194 learners), and selected questions. Further analyses will be reported separately.

3.4. Instrumentation

I began the design of the questionnaire by discussions with the grade 11 Physical Science educators from each of schools A and B in my sample in order to ascertain what they considered to be *relevant* ideas about culture, especially in urban townships. They pointed out that there were practicing izinyanga (plural for inyanga) and isangoma in the township, and many people from the township visited the traditional healers in the area. This encouraged me to include ideas about the traditional healers in my study. There are an estimated 200 000 indigenous healers in South Africa and up to 60% of South Africans consult these healers instead of or in addition to using Western biomedical services (Eco-logical technology: 2003). Thus traditional and Western healers are likely to be familiar to most of the learners in my sample. Furthermore the inyanga and the isangoma can provide two contrasting instances in the sense that the inyanga is traditionally regarded as an herbalist who often prescribes herbal remedies. The isangoma's scope is wider, in that she is believed to be a diviner who is spiritually empowered and who has responded to a supernatural calling to practice as an isangoma. She is believed to function more on the supernatural / spiritual / mystical level. (Eco – logical technology: 2003, Traditional Healers in Zululand: 2003.). Hence I used three different contexts to observe the variation in learner responses: inyanga, isangoma and Western doctor.

I saw a focus on healers as important for other reasons: health and illness are obvious domains for theories about cause-effect, in any culture. Further, they are sufficiently personal and deeply experienced that they encourage reflection on values as well as cause-effect relationships. Thus they provide a rich opportunity for students to talk about science and traditional beliefs. I designed the first draft of my questionnaire in discussions with my supervisor. It included a number of sections. The first section was

essentially biographical. Within this section, I wanted to explore not only the circumstances of the learners' lives, but the extent to which they engaged in different subcultures, such as the music they listened to, the TV they watched, activities they participated in after school, whom they talked to about personal problems. I also wanted to see how long they had lived in urban areas. The second section concerned their interest and achievements is studying science, and whom they talked to about science beyond school. The next section focussed on health and illness, and students' views about healers available to them. The last section asked the learners to respond to different scenarios about rain-making. This section echoed ideas about science that were central to the section on health, but concerned phenomena which, from the Western perspective, are impersonal and can be explained entirely through material cause-effect. The results of this last section are not reported here.

Throughout the questionnaire, I chose to use the concept of 'working scientifically' rather than 'who is a scientist' or 'what is science'. The idea of 'working scientifically' is more open and less problematic than the idea of 'being a scientist'. For example, it is not contentious that the Western doctor works scientifically – through her use of scientific knowledge, science-based technologies and the generation and testing of hypotheses (as part of diagnosis), but it might be argued that she is not a 'scientist' to the extent that she in not concerned with the generation of new theories of health and illness. This focus on working scientifically also enabled me to avoid implying dichotomies of science / not-science, with their attendant assumptions of border crossing.

Throughout the questionnaire I opted for a mix of open and closed questions. I favoured closed questions where I felt a prompt was necessary to make the intention of the question clear – for example, for the question "From where do you think the isangoma got his/her knowledge?" I offered ancestors, snakes, books, teachers and God, with requests to indicate Always/ Mostly/ Sometimes/ Never. For questions where I felt prompts were not necessary for clarity, I left responses open – for example, "Do you think the isangoma works scientifically? (yes/no) Give reasons for your answer." There are strengths and weaknesses in this strategy. On the one hand, it allows students to give freely ideas they think are important, or which occur to them at the time. On the other

hand, while not 'forcing' particular responses, neither does it prompt students with ideas they may have considered important if they had thought of them. My preference was for the open responses, depending on the large number of respondents to provide the breadth of ideas. The open – ended questions served two purposes: firstly they provided quantitative information on the number of learners expressing a particular idea / view / belief; secondly they provided learners with free opportunities to express their ideas / views / beliefs about indigenous knowledge, classroom science and learners' negotiation of relationships between these systems of knowledge.

After the first draft of the questionnaire was completed I again discussed it with my supervisor who in turn discussed it with one of his colleagues. We made a number of changes, especially about which questions required prompts, and to improve even-handedness in questions about the inyanga, isangoma and doctor. We also took care with inclusiveness and respect in the questions: who do you live with; who do you talk to about problems and who do you go to when you are sick. We did this by allowing learners to tick more than one option.

I then piloted the questionnaire with 28 grade 11 Physical Science learners at a school in the same township from which the school in this study was selected. After the learners answered the questionnaire, 11 learners volunteered to be part of a panel discussion group the following day. I met with these eager learners in the classroom, with learners who were not members of the panel as audience. The notes in my diary after this discussion prompted significant changes to the questionnaire, and also captured the sense in which traditional knowledge was "shrouded in intrigue and mystery". In the light of the trial and panel discussions during which learners had provided relevant options, some of the questions were changed from open to closed format. This also served to clarify the questions. Initially I was also unclear about the perceptions of learners about communication with ancestors. The clarification came during the panel discussion where it emerged that the indigenous healer literally makes contact with the ancestor and therefore in my analyses later I studied the data from this perspective. The idea about snakes being a source of knowledge was also provided by this pilot study and panel discussion. It was also clear that the learners were not willing to talk about the

umthagathi (witchdoctor) and some of them frankly advised me to remove this aspect from the questionnaire. I took their advice and adjusted the questionnaire accordingly.

I then prepared the third draft of my questionnaire, and discussed it with supervisor and one of my colleagues.

3.5. Method of data analysis

I used the SPSS Data Editor (computer software package for data analysis) to analyse the data. The responses to all 35 questions from the 194 questionnaires were entered into the SPSS Data Editor for analysis. Some of the questions had sub-questions which resulted in at least 1 520 bits of data being entered into the editor. The data was coded using both numeric and string variables. I used a total of 80 variables that facilitated the entry of all valid responses.

Questions 28, 32 and 35 were open-ended questions. The responses to these questions included a large number of ideas and they therefore required to be categorised before coding. During data entry I coded the learner responses into 24 categories but during data analysis I grouped these 24 categories into 5 broad categories of ideas as is shown in Chapter 4. Learners' responses often fell into more than one category and therefore for each of these three open – ended questions I created three variables to accommodate this.

While looking for frequencies of responses I created about 90 additional numeric variables. I used several crosstabulations of responses in order to form subsets of data for further analyses and also to observe the responses of the same groups of learners in different contexts. A three variable factor analysis using varimax rotation was also used to categorise learners according to their beliefs.

Chapter Four

Data Analysis

4.1. Introduction

During this study I used a combination of both qualitative and quantitative research methodologies. I used a questionnaire to elicit responses from learners that would provide me with both quantitative and qualitative data. This was coupled with interviews with science educators and groups of students.

4.2. Discussion with the science educator

My appointment with the educator, Mr. Mkhize, was for 10:00. As I drove to the school there was a group of teenage boys sitting on a street corner. They looked up at me as I drove past, and looked surprised. Two of them waved excitedly and laughingly shouted "good morning ma'am". I felt welcome in the township. *Why were these boys not in school?* Maybe they had completed grade 12 or maybe they were not teenagers?

The school was in session. As I walked past the classrooms, the classroom game was being enacted. Some classes were quiet and others were noisy. Many learners looked out the window as I walked past. They smiled. I met the principal on the corridor and he readily walked me to Mr. Mkhize, as they were expecting me. Both the principal and the educator were excited that the school was included in this project.

My discussion with Mr Mkhize was very fruitful. I put forward my hypothesis that the learners at the school were too modern to believe in traditional ideas because they were far removed from the rural areas where it is believed that traditional ways are more evident and also perhaps because they were doing well in Physical Science and hence would have discarded traditional ways for Western ways of doing things. Mr Mkhize did not concur with me at all. I learned from him that there were izinyanga and izangoma who had lucrative practices in the township. He also frequently observed long queues at the rooms of one of the izinyanga in the township. I also learned that many school children visited the traditional healers but that they most probably will not acknowledge

it. The educator was also not keen to talk about the witchdoctor (umthagathi) whose function was markedly different from that of the herbalist (inyanga) and the diviner (isangoma). In general a lot of mystery, fear and reluctance was expressed about the witchdoctor and eventually I removed this aspect of traditional life from my questionnaire.

We also discussed the 'science' involved in the making of traditional Zulu beer and the offering of this to the ancestors. He argued that ancestors are an important part of culture even in the township. We also talked about rainmaking and rainmakers.

4.3. Implementation of the questionnaire

A total of 194 grade 11 Physical Science learners answered the questionnaires. All the learners were from a well - managed school in an African township in Durban, Kwazulu Natal, South Africa. The teacher allowed me to use the multi-purpose room. The learners' overwhelming response to my call for a group to answer the questionnaire was exciting and encouraging for me.

Their eagerness made me more apprehensive about the questionnaire. Would they find it too long, or irrelevant? (It took about one hour to complete the questionnaire.) My fears were unfounded: the learners were very willing to engage with the questions about themselves, their families, their culture and their school science. About five learners, who were unaware of the session, arrived late, immediately after hearing about it.

They seemed afraid that I would refuse to include them in the project but were visibly overjoyed when I invited them to join the group.

We were off to an exciting start. 194 learners were seated at desks, in a room that could comfortably house about 130 learners. The room was hot, but the learners did not seem to mind. They wrote eagerly. These learners want to "talk" about their culture and science. This was evident to me as I walked among the rows of desks. Further, analysis of the data

showed that almost all learners answered every question.

I implemented the questionnaire myself, because I wanted the learners to respond spontaneously to the questions as they encountered them. I did not want the learners to engage in discussions with anyone (whether learners or teachers) regarding the questions. In this way I was capturing each learner's thoughts, beliefs and ideas as they existed at the time of implementation of the questionnaire.

4.4. Biographical information

95% of the learners responded to the question on gender and I found that 54% of the 194 learners were female and 41% were male. At this township school more girls are enrolled for grade 11 Physical Science than boys.

The average age of the learners who participated in the study was 17 years. Learners were asked about their mode of transport to school and also how long it takes to arrive at school. This was done to ascertain whether the learners live in the township or not. It was found that 67% of the learners do walk to school and that the average duration of travel was 25 minutes. From this information I was able to ascertain that most of the learners in this study are residents of the township. It was also found that 85% of these learners lived in the township for more than two years though 40% of those who completed this question indicated that their previous place of residence had been outside the township in this study.

Almost all learners (98%) reported having access to electricity and 83% of them have in-door water supplies. This is so even though 47% live in informal settlements, suggesting that families or communities have innovative ideas in gaining access to electricity and in-door water supplies.

It was found that 24% live with neither parent, and that 15% live with neither parent nor grandparent. This question was asked in order to establish the stability, to some extent, of

the home environment. Only 34% of the learners live with both parents and 42% of learners live with their mothers and without their fathers. Most of the learners come from homes where at least one of the parent figures is missing.

4.5. Critical question one

> *What are the cultural beliefs, grounded in family, community, school and peers of isiZulu - speaking township learners that are brought into the science classroom?*

4.5.1. Learner Beliefs

In order to get an understanding of the personal beliefs of the learners I examined the perceptions of learners with regard to the acquisition of knowledge that relates specifically to their African-indigenous-societal life-world. I elicited responses of learners in five possible sources of knowledge. Three of these sources, ancestors, snakes and God, I relate to indigenous worldviews. Sources such as books and teachers I relate to Western worldviews.

Table 4.1 gives a quantitative analysis of responses of learners with respect to sources of knowledge in the context of the inyanga.

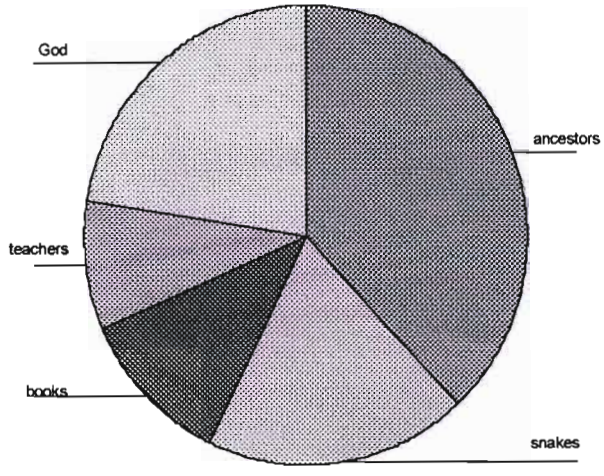
Table 4.1: Sources of knowledge of inyanga

Source of knowledge of Inyanga

	No		Yes	
	Count	%	Count	%
Ancestors	20	10.3	174	89.7
Snakes	107	55.2	87	44.8
Books	141	72.7	53	27.3
teachers	154	79.4	40	20.6
God	91	46.9	103	53.1

beliefs of learners

The following pie chart is an illustration of the high prevalence of beliefs in ancestors, snakes and God as sources of knowledge.



Sources of Knowledge of Inyanga: Learner Beliefs

Table 4.1 indicates that 90% (174 learners) believe that the inyanga communicates with ancestors in order to obtain knowledge. 45% (87 learners) believe that knowledge can be obtained by communicating with snakes. In my pre-questionnaire interview with a panel of learners, the panel had also commented that the inyanga goes down to the river where he communicates with snakes. More than half of the learners who completed the

questionnaire, 53%, believed that the inyanga obtains knowledge from spiritual communication with God. 27% and 20% of the learners believed that the sources of knowledge for the inyanga were books and teachers respectively.

These results show that while most learners believe ancestors are a source of knowledge for the inyanga, most learners do not believe snakes or books and teachers are sources of knowledge in this case.

A factor analysis presented in Table 4.10 shows that there is a high positive correlation between those who believe in ancestors being a source of knowledge and those who believe in snakes in the context of the inyanga. We can see from the crosstabulation in Table 4.2 that almost all the learners (97%) who believe snakes are sources of knowledge for the inyanga also believe that ancestors are sources of knowledge in this case. Hence it can be seen that if a learner believes in snakes there is a strong chance that she also believes in ancestors as sources, but the opposite is not necessarily true as is evident from Table 4.2 where 90% of learners expressed a belief in ancestors while only 42% of them also believe snakes are sources of knowledge for the inyanga. Hence there are many learners who believe in ancestors but not in snakes in this context.

Table 4.2

Inyanga: knowledge from ancestors * Inyanga: knowledge from snakes * Inyanga: knowledge from God Crosstabulation

Count

Inyanga: knowledge from God			Inyanga: knowledge from snakes		Total
			NO	YES	
NO	Inyanga: knowledge from ancestors	NO	10	2	12
		YES	40	39	79
	Total		50	41	91
YES	Inyanga: knowledge from ancestors	NO	4	4	8
		YES	53	42	95
	Total		57	46	103

Already we see that among a single group of indigenous people in an urban township, the individual beliefs are widely spread. However subgroups exist. For example there could be a subgroup that subscribe to the supernatural beliefs (ancestors) but not the mystical beliefs (snakes) and the spiritual beliefs (God) and another where the group members subscribe to the supernatural (ancestors) and spiritual (God) and not to the mystical (snakes) and so on. Already we see that learners' belief systems or worldviews as this data suggests are complex.

From the data it can be seen that a classroom whose inhabitants come from one so-called racial group, is a multicultural zone. Learners have different beliefs about how the inyanga comes to know things, how knowledge is acquired, be it diseases, medicines, causes of diseases, chemicals or roots. This, including the large number of learners who believe in the roles of ancestors, snakes and God, has implications for meaningful and relevant science teaching and learning.

The learners' perceptions of sources of knowledge for the medical doctor are shown in Table 4.3.

Table 4.3. Sources of knowledge of Medical Doctor

Worldviews

	.00		1.00		Total	
	Count	%	Count	%	Count	%
ancestors	145	74.7%	49	25.3%	194	100.0%
snakes	168	86.6%	26	13.4%	194	100.0%
books	21	10.8%	173	89.2%	194	100.0%
teachers	39	20.1%	155	79.9%	194	100.0%
god	84	43.3%	110	56.7%	194	100.0%

Learner's perceptions: Sources of knowledge
Medical Doctor

Note: in table 4.3 the ".00" reads as "No" and the "1.00" reads as "Yes".

Table 4.3 indicates that while 89% and 79% of learners believe that books and teachers are major sources of knowledge for the medical doctor, 25% and 13% believe in ancestors and snakes respectively and 57% in God. The majority of learners have

expressed Western ways of acquiring knowledge for the medical doctor but at least 57% also believe that she is inspired in perhaps the same ways as the inyanga is. This role of God might be explained as: the medical doctors' knowledge about healing comes from God and not solely from practical means like books and teachers. The majority of learners seem to insist that sources of knowledge must include the spiritual (God) as in the case of the western doctor and / or the supernatural (ancestors) as in the case of the inyanga and sangoma. Learners perhaps have a broader interest in the nature of science that includes ideas about creativity, intuition, "direct knowledge" and revelation. Learners perceive knowledge as being acquired in ways that are beyond the material and tangible and that includes God and ancestors primarily. It is interesting to note that this perception of learners is evident in both the western and indigenous contexts of this study. (Note that the question asked learners specifically about 'sources of knowledge', not, for example, about the talents and 'gifts' of the individual healer.)

Table 4.4 Sources of knowledge of isangoma

Indigenous Worldviews

	.00		1.00	
	Count	%	Count	%
Sangoma: knowledge from ancestors	20	10.3%	174	89.7%
Sangoma: knowledge from snakes	78	40.2%	116	59.8%
Sangoma: knowledge from books	152	78.4%	42	21.6%
Sangoma: knowledge from teachers	157	80.9%	37	19.1%
Sangoma: knowledge from God	104	53.6%	90	46.4%

Learner Perceptions: Sources of Knowledge
Sangoma

Note: in table 4.4 the ".00" reads as "No" and the "1.00" reads as "Yes".

In the case of the isangoma the percentage of learners who believe he / she acquires knowledge from ancestors is also 90%, the same as for the inyanga. Crosstabulations indicate that 85% of these learners were the same ones who said that the inyanga acquires knowledge from ancestors.

On the question on teachers being sources of knowledge, only 20% of learners expressed this belief, almost the same as for the inyanga, but much less than the medical doctor. Thus the learners see the inyanga's and isangoma's knowledge as arising much more by revelation from ancestors, snakes and God than from teachers. This interpretation is supported by later questions in the questionnaire: learners at no stage talked about isangoma schools or inyanga schools. This suggests that teachers, like books are seen as a Western way of acquiring knowledge.

On comparison of God's role in knowledge acquisition, the questionnaires show that more learners believe God plays a role in knowledge acquisition for the medical doctor, (56,7 %), than for the inyanga, (53,1 %), or the isangoma, which is the least at 46,4 %. It is evident that spirituality plays a significant role in the worldview of the learners in this study.

From this data and other responses (see later), there appear to be three ways in which God might be important as a source of knowledge. The first is by direct revelation. The second is an association between 'good', healing and God, which argues for a place for God in healing. The third is an explanation for creativity, imagination, intuition and inspiration. Western science and all other sciences depend on creativity, intuition and inspiration. This is as true for both the medical doctor, and other healers making diagnoses as for the biologist inventing new theories about genes. In order to explore the belief in God further I did a factor analysis for the three questions concerning God as a source of knowledge in each of the three contexts. The analysis is presented in Table 4.8 and will be discussed later. While supernatural and spiritual attributes of a worldview may appear to be irrational from a Western perspective, they may not be irrational from within an indigenous perspective. The important point is that most learners believe that spirituality is associated with good science. This need not make it a necessary factor. Many learners saw no role for God in the doctor's acquisition of knowledge. Thus there is room in science for non – believers in God. Current science teaching usually avoids the religious attribute of worldview (Cobern: 1991), but the implication of my study is to bring together indigenous and Western beliefs in some kind of critical inquiry about the nature of science.

4.5.2. Worldviews and sources of knowledge

In an attempt to understand the beliefs of learners from a perspective of indigenous and Western worldviews I recoded the five sources of knowledge into the two categories, namely indigenous worldview and Western worldview, for all three questions on knowledge acquisition of the inyanga and the isangoma and the medical doctor and then I crosstabulated these two categories for each context. The two categories indigenous (ISK) and Western (WSK) are explained as follows:

- **Indigenous Worldview** that will be indicated by the learners who believe that the health care provider obtains his knowledge about medicines and treatments from any one or all of ancestors, snakes and God

- **Western worldview** that will be indicated by the learners expressing beliefs about books and teachers as sources of knowledge. I must hasten to reaffirm here that I am not implying that knowledge is obtained only from books and teachers in the realm of western science, but that they are two of the sources of knowledge as opposed to the oral, supernatural or mystical sources of knowledge as is a characteristic of some indigenous knowledge systems.

From the crosstabulations of the indigenous and western worldviews in each context emerged two further categories. The third I will refer to as heterogeneous sources of knowledge (HSK), a mix of indigenous and western; the fourth is for a small group of learners whose answers did not fit clearly into any of the first three categories.

- **Heterogenous worldview** which will be indicated by learners expressing beliefs about ancestors, God, snakes, books and teachers as sources of knowledge.

The learners in the Heterogeneous category are attempting to interpret their life – world experiences in terms of learning in both the school classroom and their community. These learners are simultaneously holding on to two distinctly different positions, in some way.

The following table is a summary of the results:

Table 4.5 Worldview Categories

Worldview	Context: Inyanga	Context: iSangoma	Context: Medical Doctor
Indigenous	57,7%	63,9%	6,2%
Heterogeneous	37,1%	30,9%	63,4%
Western	2,5%	1,5%	30%
None of the above	2,5%	3,6%	0,5%

4.5.3. Shifting theories

In this study the isangoma and the inyanga were chosen as contexts because they represent practitioners of indigenous ways of knowing and solving problems. The medical doctor on the other hand was assumed to represent a practitioner of Western ways of knowing and solving problems. This study reveals, as has been alluded to earlier, that these grade 11 Physical Science learners do not perceive this dichotomous distinction into purely indigenous and western ways of knowing within any one context.

Table 4.5 shows that only a very minute percentage of learners (2,5%) have abandoned all indigenous beliefs about acquiring knowledge in the context of the inyanga. These particular learners believe that the inyanga, like the medical doctor, obtains knowledge only in typically Western ways, by reading books and schooling. Alternatively, only 30% of the learners believe that the medical doctor is totally foreign to indigenous ways of knowing.

I crosstabulated the data about beliefs across contexts in order to ascertain how many learners expressed a particular belief in at least one context. Table 4.6 is a summary of the results:

Table 4.6 All Contexts: Beliefs

Belief about sources of knowledge	Percentage
ancestors	95%
snakes	68%
God	75%
books	92%
teachers	83%

In all 99,5%, the overwhelming majority, express indigenous ways of knowing as in at least one context. School science has not succeeded in assimilating learners into a scientistic way of thinking, and has not diminished their beliefs.

The data in Table 4.5 indicate that worldview, understood as one attribute of a subculture, is not static even for a single learner. Recall Proper et al's definition of worldview:

> *A person's set of beliefs held consciously or unconsciously about the basic nature of reality and how one comes to know about it* (Proper et al: 1988:547).

If I ignore, just for a moment the data in columns 2 and 3 of Table 4.5 then column 4 reads as:

> *Only 6% believe that knowledge is acquired in purely indigenous ways knowledge acquisition. 63% believe that knowledge is acquired in the simultaneous use of both indigenous and western ways of knowledge. 30% believe that knowledge is acquired in purely Western ways.*

However the whole of Table 4.5 suggests that learners are more fluid in the choices they make depending on context: for example many learners who think that the medical doctor does not acquire knowledge from ancestors think that the inyanga and sangoma do.

Learners solve problems by accessing knowledge from their world of subcultures whether different, divergent, similar or discordant. They make choices but not the same choices (in spite of similarities in their backgrounds and interests). When a learner changes her choices as the context changes one possible reason is that she is confused or ambivalent / ironic; she recognises a hard question and is not prepared to take one side or the other. A second possibility is that she has made 'errors' when completing the questionnaire, perhaps from misunderstanding or from not thinking seriously. A third explanation is that she genuinely accesses different beliefs to meet different challenges. I will show in following paragraphs why I favour this last position.

Questionnaires are prone to error either because respondents work quickly, more concerned to finish than to think carefully or because they genuinely misunderstand questions. This, no doubt, is true in this study, but probably only to a small degree for the following reasons:

- The entire 194 learners volunteered to participate, and wanted to participate.
- They were in no hurry to complete the questionnaires. Learners usually took about an hour. If they had wished simply to 'get the job done' they could have completed much more quickly than that.
- All 194 learners were packed into a single hall and almost all were working busily, silently throughout, suggesting that they were taking the questionnaires seriously.
- The open - ended questions were completed by most learners, often in detail. This suggests that they wanted to say something and gave considerable thought to their answers.
- Their answers to open – ended questions were logically related to the questions, and well expressed, indicating good proficiency in English and accurate understanding of the questions.
- The sample used is large.

- The number of learners who expressed changes in their beliefs as the context changed was large (80%).

The analysis presented in Table 4.5 was obtained taking each context separately. In order to explore the idea of learners expressing different beliefs in different contexts I firstly crosstabulated the responses to the three questions and secondly did a factor analysis by principal component analysis. The crosstabulations were used to test whether the individual learners in any one cell in Table 4.5 were the same learners in another cell.

Table 4.7.

Multiple Worlds: Changing contexts

Sangoma: ISK 1.00

	Inyanga : WSK											
	.00							1.00				
	Sangoma: WSK							Sangoma: WSK				
	.00				1.00			.00			1.00	
	Medical doctor: ISK				Medical doctor: ISK			Medical doctor: ISK			Medical doctor: ISK	
	.00		1.00		.00	1.00		.00	1.00		.00	1.00
	Medical doctor: WSK		Medical doctor: WSK		Medical doctor: WSK	Medical doctor: WSK		Medical doctor: WSK	Medical doctor: WSK		Medical doctor: WSK	Medical doctor: WSK
	.00	1.00	.00	1.00	1.00	.00	1.00	1.00	.00	1.00	1.00	1.00
	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK
	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count
.00		1		1	1					1	1	1
1.00		31	7	50	6	1	11	7	2	24	7	32

What are the sources of knowledge?
Learner perceptions

Table 4.8.

Multiple Worlds: Changing contexts

Sangoma: ISK .00

	Inyanga : WSK											
	.00							1.00				
	Sangoma: WSK							Sangoma: WSK				
	.00				1.00			.00			1.00	
	Medical doctor: ISK				Medical doctor: ISK			Medical doctor: ISK			Medical doctor: ISK	
	.00		1.00		.00		1.00	.00		1.00	.00	1.00
	Medical doctor: WSK		Medical doctor: WSK		Medical doctor: WSK		Medical doctor: WSK	Medical doctor: WSK		Medical doctor: WSK	Medical doctor: WSK	Medical doctor: WSK
	.00	1.00	.00	1.00	1.00	.00	1.00	1.00	.00	1.00	1.00	1.00
	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK	Inyanga : ISK
	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count	Count
.00				2				1	1			
1.00	1	1	1		2		1					

What are the sources of knowledge?
Learner perceptions

Tables 4.7 and 4.8 are complex and therefore I will provide a few points for clarity: an overlap of ISK and WSK categories is the HSK category; all learners in Table 4.7 share indigenous beliefs about sources of knowledge in the context of the isangoma and those in Table 4.8 do not share indigenous beliefs in the same context, as is indicated at the top left - hand -side of each table. I will use the 50 learners in the last row, column 5 of Table 4.7 to illustrate the reading of these two tables. These 50 learners have expressed: indigenous beliefs and not western beliefs about the inyanga; both indigenous and western beliefs about the medical doctor (HSK); indigenous beliefs and not western beliefs about the isangoma. This information is presented in the second row of Table 4.9. Similarly I traced the changing beliefs of all learners on an individual basis as the context changed and presented the data in Table 4.9. I have simplified the logic in Tables 4.7 and 4.8, omitting cells in which the numbers were very small (39 learners in all) and presented the information in Table 4.9.

Table 4.9

Multiple Beliefs

Number of learners	Inyanga	Medical Doctor	Sangoma
31	ISK	WSK	ISK
50	ISK	HSK	ISK
24	HSK	HSK	ISK
7	HSK	WSK	HSK
11	ISK	HSK	WSK
32	HSK	HSK	HSK

The following conclusions emerge from the crosstabulations in Tables 4.7 and 4.8 and the summary thereof in Table 4.9:

- Tables 4.7 and 4.8 indicate that 193 learners, an overwhelming 99,5% of learners, have expressed a belief in indigenous ways of knowing in at least one context. Only one learner (0,5%) expressed no belief in ancestors, God or snakes as sources of knowledge for the inyanga, medical doctor or isangoma.

- 21% consistently expressed beliefs that were aligned to only one of the three worldviews that emerged earlier, namely indigenous, heterogeneous and western. Among these learners 4% consistently expressed a belief only in indigenous ways of knowing, while 17% consistently expressed a belief in heterogeneous ways of knowing and 0,5% consistently expressed a belief only in western ways of knowing.

- The remaining 80% of learners indicated apparently changing belief systems as the context changed. For example a learner could express only western beliefs in

one context, only indigenous beliefs in a second context and heterogeneous beliefs in a third context.

- The belief systems of learners are complex and they express their beliefs in complex ways.
- The beliefs that learners express are related to the context / challenge that the learner is exposed to.

The point that I am making here is that learners are defying dichotomous classifications into Western or indigenous belief systems. They are even defying consistent classification into the three categories: Western, indigenous and heterogeneous.

Table 4.10 Factor Analysis: Sources of Knowledge

Rotated Component Matrix[a]

	Component		
	1	2	3
Sangoma: knowledge from God	.706	.284	-.084
Inyanga: knowledge from God	.581	.266	.123
Inyanga: knowledge from books	.565	-.198	-.273
Sangoma: knowledge from books	.531	-.149	-.169
Medical Doctor: Knowledge from God	.503	.376	.232
Inyanga: knowledge from teachers	.499	-.147	.197
Sangoma: knowledge from teachers	.452	-.132	.102
Sangoma: knowledge from snakes	-.063	.665	.085
Sangoma: Knowledge from ancestors	.161	.624	
Inyanga: knowledge from snakes	-.150	.613	.075
Inyanga: knowledge from ancestors	-.076	.562	-.167
Medical Doctor: Knowledge from ancestors	.255	.117	-.729
Medical Doctor: Knowledge from teachers	.171	.339	.638
Medical Doctor: Knowledge from snakes		.258	-.584
Medical Doctor: Knowledge from books	.253	.296	.566

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

A factor analysis of the questions on sources of knowledge provided an alternative technique for classifying learners according to their beliefs in the contexts of inyanga, isangoma and doctor. The results are in Table 4.10, for a three-factor solution, using varimax rotation. The table shows the loadings of each factor (columns 2 – 4) for each of the questions in column 1. Factor 1 loads high on the isangoma and inyanga obtaining

knowledge from God and books and the medical doctor obtaining knowledge from God; Factor 2 loads high on the isangoma and inyanga obtaining knowledge from snakes and ancestors; Factor 3 loads high - positive on medical doctors obtaining knowledge from teachers and books, high – negative on their obtaining their knowledge from snakes and ancestors. The consistent logic of the factors and loadings in table 4.10 suggests not only that the learners can be classified reasonably well into three groups, but that their responses to the questionnaire were indeed thoughtful.

The three factors relate well to the three categories developed earlier from the frequencies and cross-tabulations:

- Heterogeneous beliefs: this is represented by factor 1 (Table 4.10) where the following items correlated high: knowledge from God for inyanga, isangoma and doctor, knowledge from books for the inyanga and isangoma and knowledge from teachers for the inyanga and isangoma.

- Indigenous beliefs: this is represented by factor 2, based especially in the roles of ancestors and snakes as sources of knowledge for both the inyanga and isangoma, but not for the medical doctor.

- Western beliefs: this is represented by factor 3 where western knowledge comes from books and teachers and not from snakes and ancestors. Learners are talking about acquiring knowledge in practical and concrete ways as is understood in Western culture.

The factor analysis suggests a further criterion that learners used, raised in the interviews with learners and from the frequencies and cross-tabulations: whether the knowledge acquired is potentially for 'good' or 'harm'. The inyanga and the doctor, working in their restricted domains of medicines, counselling and treatments, were concerned almost entirely with healing; the isangoma on the other hand worked more closely with spirits and spells, with potential for good or harm to particular individuals. Thus isangoma can load high on knowledge from God (for some learners) or they can load high (for other

learners) on knowledge from snakes and ancestors. These two views about izangoma arise more clearly in the factor analysis than from the crosstabulations.

Two implications from the heterogeneous category of beliefs emerged from the factor analysis:

- ✓ Learners have grouped the spiritual and written sources of indigenous knowledge along with spiritual sources of Western knowledge. When God is a source of knowledge then that knowledge is worthwhile. The inyanga, medical doctor and often the sangoma are all seen as inspired / gifted people in this same light. By implication indigenous knowledge is worthwhile knowledge, as is Western knowledge. This idea was put succinctly by learner 193:

  193: because Inyanga always mixes herbs, which is also done by scientists

- ✓ Learners have separated spiritual (God) and written (books, teachers) sources of knowledge from the mystical (snakes) and supernatural (ancestors). The important point here is that they observe a difference that implies that indigenous and western ways of knowing are both part of their discourse. This is not necessarily in a negative light as is shown by learners 84 and 131 who make the following statements to support why they believe that the inyanga works scientifically offering supernatural and mystical explanations:

  84: the inyanga can form a lightening to strike that particular person, which is science

  131: He is given instructions by the ancestors then he follows them so that his people get good herbs.

The majority of learners displayed shifts in the beliefs according to context. Putting the classification of beliefs in Table 4.9 (which suggests multiple context-related beliefs)

together with the factor analysis of Table 4.10 (which suggests considerable consistency in beliefs) indicates that learners are quite comfortable in believing for example that the herbalist acquires knowledge from ancestors but medical doctors do not. To these learners the knowledge of the herbalist is linked to the supernatural but that of the medical doctor is not. Shifts in beliefs do not imply *change* in beliefs but rather that in one context indigenous beliefs surface and Western beliefs are suppressed while in another context the opposite might occur. Learners are making conscious choices between incongruent theories of knowledge; they don't appear to be literally crossing hazardous borders between their life world and the world of science.

This approach seems to fit with the principles of *Ubuntu* - fundamental philosophy of African thought. Ubuntu embodies the concept that humans are connected with one another and all creation: "I am a person through other persons" (where everything, animate or inanimate, material or spiritual, is to greater or lesser extent a person); "I participate and therefore I am". Thus the 'self' is collective, the community is an organism, in both instances defined especially through interdependent relationships and participation. It follows that there are many 'selfs', defined by different relationships, and these are to be harmonised rather than resolved. Ubuntu suggests that there is room for various subcultures, languages and points of view (Living Values: 2003; Shutte: 1993). The results on the questionnaire are consistent with U*buntu* in that value is attached to conflicting theories of knowledge, and learners seek to 'harmonise' these various positions and select from them according to context without particular concern for competition between them, or 'border crossings'.

In summary, the data suggest that learners often express a multiple or pluralistic belief system about sources of knowledge and they exercise choice without having to discard or abandon any particular theory of knowledge. In the next section I will explore their beliefs about how science is practiced, and in the section after that the relationship/s between learners' beliefs about classroom science and indigenous knowledge.

4.6. Critical question two

How do learners perceive science and indigenous knowledge in practice?

4.6.1. Introduction

In this study I chose the inyanga, isangoma and medical doctor to test whether students saw the Western doctor as a person who works scientifically (sharing in the culture of the scientific community) and the inyanga and isangoma as persons who do not work scientifically (and hence share in a culture that is not scientific).

The analysis below centres on questions 28, 32 and 35, in relation to my second critical question. The learner was required to explain why she believed that the health care practitioner in question was working or not working scientifically. The three questions were the same, but the context changed from inyanga in question 28 to medical doctor in question 32 to isangoma in question 35. Firstly I did a quantitative analysis of learners' responses, followed by a qualitative analysis.

The learners answered these three questions according to their perceptions of what working scientifically meant and they wrote down what they thought of at that point in time. It is these perceptions of learners that I am identifying in this section. All responses were coded, into categories that arose from the data. I identified five broad categories, namely nature, ancestors, empiricism and 'science works'. The category 'empiricism' was further categorized into six sub-categories.

There are strengths and weaknesses of open-ended questions as discussed in Chapter 3. On the one hand the guiding assumption is that the reason(s) they offered were ones they saw as most important, from their knowledge and perspective. Accordingly the definition of working scientifically that emerges is entirely their own. However my assumption may not be entirely valid. The initial responses of learners need not match their best ideas – they may simply not have

thought deeply or widely enough about why or why not the practitioner in question works scientifically.

On the other hand a very large number of learners talking about a particular category does provide valuable information again since no categories were given. A large number of learners writing about the same ideas provide evidence of the prevalence of that idea.

I purposefully changed the context from indigenous in question 28 to Western in question 32 back to indigenous in question 35 so as to encourage learners to think widely about the meaning of working scientifically.

From the pilot study and interviews with the educators and panel of learners I found that many learners visited the inyanga and isangoma for medicines and other 'treatments' to cure health problems. There seemed to be a greater belief in the medicines and treatments of the herbalist than of the isangoma. Hence I anticipated that learners would think the inyanga works scientifically to some extent, the medical doctor more and the isangoma less.

4.6.2. Science in a multi-science perspective

Learners wrote freely about why they believed the health care provider worked scientifically. In this section I am particularly interested in *what* they were writing about. For the 194 learners as a whole the frequencies with which different characteristics arose provide a measure of learners' conception of working scientifically.

Hence I combined the frequency of responses for the inyanga, isangoma and medical doctor. The data is presented in Table 4.11.

Table 4.11: Learner perceptions: Science in practice

Context	Nature	Empiricism	Science Works	Ancestors	Mysticism
All contexts	53	159	143	60	18
medical doctor	9	148	91	2	0
inyanga	41	122	102	22	21
isangoma	21	86	80	50	9

NOTE: the numbers in Table 4.11 represent number of learners.

I placed learner discourse about herbs, leaves, trees, roots and animals under the category ***nature.*** During the pilot and interviews I learned that the inyanga prepared his medicines using plants and animals that he kept available at his rooms. Hence I expected the nature category to some extent in the context of the inyanga. Overall 27% of learners wrote about nature to support their belief that the health care provider worked scientifically or not. 17% of these learners wrote about nature in the context of the doctor, 77% in that of the inyanga and 39% in that of the isangoma.

Learners wrote about many other characteristics of working scientifically in their perception. Some of these characteristics include: experimentation, testing, research, calculating, measuring, mixing, chemicals, instruments, laboratories, creativity and decision-making. I assigned these characteristics to the third category in the table: ***empiricism***. This was an expected category since school science – that is positivistic and empirical – is the learners' best guide to what working scientifically means. An overwhelming majority, 82% of learners, wrote about empiricism to support their

responses. 77% of learners wrote about empiricism in the context of the medical doctor, 63% in that of the inyanga and 44% in that of the isangoma.

The third category in the table is ***science works***. Many learners responded to the questions by writing whether the medicines and treatments worked or not or they just mentioned the medicines of the practitioner. Learners who expressed beliefs that the medicines of the health care practitioner worked or were useful concluded that the practitioner worked scientifically. Hence those practitioners whose medicines and treatments did not work were not considered as working scientifically. Some learners also wrote about practitioners' lying and guessing (implying that the treatments do not work) about 'cures' for their patients to support their belief that the practitioner does not work scientifically. Overall 74% of learners wrote about these characteristics of working scientifically which I placed in the category ***science works.***

The fourth category in the table is ***ancestors***. 31% of learners wrote about ancestors to support their belief that the person in question is working scientifically or not. In some learner's perception, being in communication with ancestors does not automatically preclude a person from being classified as working scientifically or not and they wrote about this. Although 90% of learners expressed a belief in ancestors in the context of knowledge acquisition, only 31% wrote about ancestors when responding to these questions on science practice. The others were silent about the role of ancestors in the practice of the health care provider. Of the learners who spoke about ancestors, 40 learners cited ancestors as an explanation of why the isangoma does not work scientifically. However, 50% of these 40 learners cited ancestors as an explanation of why the inyanga does work scientifically. This suggests that learners believe ancestors have different roles for the isangoma and the inyanga, helping each to do his work: the inyanga prepares potions and other medicines; the isangoma works more on the psychological, social and spiritual level. Whether or not the healer works scientifically, it is acceptable to the learners that the healer communicates with the supernatural.

The fifth category in Table 4.11 is **mysticism**. All learner responses relating to the supernatural, except allusions to ancestors, were put in this category. Overall only 9% of responses fell in this category.

It can be seen from Table 9 that most learners wrote about 'empiricism' and 'science works' suggesting that the learners associate working scientifically with 'empiricism' and 'science works'.

In the following section I will present each of the categories with quotes from the questionnaires. The quotes that I have chosen are illustrative of the categories; they are not intended to be exhaustive. Furthermore in this section I am presenting the combined data through all three contexts since I want to explore the learners' perception of science in practice. Therefore I will illustrate each category with a mix of quotes from all three categories: inyanga, isangoma and medical doctor.

4.6.2.1. Working scientifically and nature

In this category are learner responses that emphasised the practitioners' knowledge of nature and working closely with nature.

In the context of the inyanga I found that 68% of those who wrote about nature argued that the inyanga works scientifically, while 43% did so in that of the isangoma and 100% in that of the medical doctor. All the learners who proposed nature in the context of the medical doctor did so to support why they believed he works acientifically. The following quotations from all three contexts illustrates the learner responses in the nature category:

- *45: He* (**inyanga**) *uses natural herbs, he collects a certain amount and mix it with another certain different amount of herbs.*
- *6: because he* (**inyanga**) *mix his herbs just like the scientist does with the chemicals.*
- *160:because he / she* (**inyanga**) *mix herbs in order to help people who are*

ill. He / she is like a person who did pharmacy.

- *6: because they* **(sangoma)** *usually mix the herb.*
- *95: because science is about nature.*
- *95: because when they* **(sangoma)** *do muthi they use trees from nature and we know that science is experienced by everything we do.*
- *95: because each and every medicine or facilities that are used by* ***medical doctor*** *are the combination of nature.*
- *28:because the* ***medical doctor*** *don't give patients herbs as they are from the ground, the herbs are changed into sweetened medicine.*

What emerges is that there is good science when working with nature or trying to understand / manipulate nature (when making medicines, umuthi, potions etc). Good science means knowing the herbs and the quantities in which to mix them.

4.6.2.2. Empiricism

An overwhelming majority, 159 learners (82%), wrote about attributes relating to empiricism to support their responses. Learners wrote freely about: experimentation, testing, research, calculating, measuring, mixing, chemistry, instruments, laboratories, creativity and decision-making. I assigned these attributes to the category **empiricism**. Many learners argued that the practitioner in question worked scientifically while citing the attributes stated above as reasons.

82% of the 194 learners engaged in arguments about empiricism when they explained why the health care practitioner, in at least one of the contexts, works or does not work scientifically. This data suggests that almost all learners automatically related pragmatic, observational, concrete and practical ways to working scientifically in all three contexts.

Of the learners who talked about empiricism in their responses I found that in the context of the inyanga 69% of the learners talked about the inyanga working in an empirical way while in the context of the isangoma and medical doctor it was 57% and 97% respectively.

Table 4.12 presents the sub-categories of learner responses included under empiricism.

Table 4.12 Learner perceptions: Empiricism

SUB-CATEGORIES	NUMBER OF LEARNERS
Measuring	69
chemistry	43
experiments, labs, school science	97
testing, research	8
creativity, thinking, using mind	35
technology, instruments, appliances	15

It can be seen that learners place a great emphasis on experimentation, measuring, chemistry and creativity in their view of science in practice. It is also evident from Table 4.11 that this view permeates all three contexts.

These sub-categories tend to overlap a lot. Since learner responses often fell into more than one sub-category I will not separate the quotes from the questionnaires into sub-categories in the qualitative presentation that follows.

As in the preceding section I will now provide a mix of quotes from all three contexts to illustrate the category of empiricism. I will first present some quotes where the learners argued that the practitioner worked in empirical ways and was therefore working scientifically. This will be followed by quotes where learners wrote that the practitioner did not work in empirical ways and was therefore not working scientifically.

- *45: He* (inyanga) *uses natural herbs he collects a certain amount and mix it with another certain different amount of herbs.*
- *71: Because he / she* (inyanga) *mix different kinds of medicines so that is physics, he knows how to mix compounds.*
- *150: because the inyanga use some experiments to test* (sic) *is it going to work or not Use the mind to think.*
- *156: because he* (inyanga) *does mix up all the muthis so that the right muthi will come.*
- *65: because the inyanga uses trees and they need to mix potions which I take like compounds.*
- *64: because they (*inyanga*) use mixture of chemicals (umuthi) to help people. Maybe they know if you mix this chemical with another what you will get.*
- *150: because the inyanga use some experiments to test* (sic) *is it going to work or not Use the mind to think.*
- *63: Because sometimes they* (inyanga) *use their minds to make zulu medicines.*
- 119: *because he / she* (inyanga) *has to know which plants are good for humans and how to use them.*

- 102: *because the medicines that they* (sangoma) *use they mix it by using their minds without looking at books and getting information from teachers.*

- *109: because the sangoma always uses his mind.*

- *120: because they* (sangoma) *used their knowledge to mix some chemicals to get the medicine mixture.*

- *169: because they* (sangoma) *sometimes use their minds to imagine and guess things like the weather . They can also make lightening and that's being scientific.*

- *150: The sangoma does the same work as the inyanga they need to do some experiments first and the science is all about experiments to see how things are done or being done.*

- *63: They* (sangoma) *use the imagination of doing zulu medicines*

- *19: Because they* (medical doctor) *in making their medicine they use machines and some chemicals.*

- *65: for him* (the medical doctor) *to know your sickness they use scientific equipment.*

- *120: cause they* (medical doctor) *mixed chemicals from other chemicals and mixed well to get good medicine for the sick person.*

- *97: medical doctor works scientifically because if he / she is measuring some chemicals so that chemicals cannot be danger on patients.*

- *39: medicine is part of chemistry because they* (medical doctors) *use chemicals*

- *150: ... they* (medical doctor) *have to be scientific. Use the experiments if he/she use this what is going to happen.*

- *156: Because the medical doctor did went to school to learn about the different substances that are used to heal people and they test those substances to make sure that we are not harmed when we take them.*

- *179: because he / she* (medical doctor) *uses chemical fluids which are mixed according to scientific rules to maintain balance.*

I will now present a few quotations to illustrate that some learners used the absence of empiricism in the work of the practitioner to argue that the practitioner was not working scientifically. These quotes are not meant to be exhaustive:

- *166: because they* (inyanga) *don't have the equipment like medical doctors and some are illiterate.*

- *53: Sangoma's are using muthi which smells bad. Muthi is not checked at the lab and it may cause the sick person to be more sick than before*

- *32: He went nowhere for what he / she is. He slept and woke up a sangoma*

- *50: because the sangoma don't go to school and they don't need to study science because they are just damaging roots of trees and they got knowledge from the ancestors and God.*

- *65: because they* (isangoma) *just mix potion ... or maybe because they just know that the medicine is done that way.*

The important point that emerges from these illustrations is that the majority of learners view science in practice as incorporating empiricism.

4.6.2.3. Science works

Many learners, 74% (143) wrote about the medicines and treatments of the practitioner. Most of these learners argued that if the medicines and treatments worked then the practitioner was working scientifically. They were relating working scientifically with **science works**. 62% of learners wrote about science works in the context of the inyanga, 54% in that of the isangoma and 50% in that of the medical doctor.

As in preceding sections I will now provide a mix of quotes from all three contexts to illustrate this category. I will first present quotes where the learners argued that the practitioner worked scientifically because her medicines and treatments worked. This will be followed by quotations where the learners argued that the practitioner was not working scientifically because her medicines and treatments did not work.

- *170: because they* (inyanga) *can make a person live.*
- *because they* (inyanga) *tell you things the way you feel in your structure.*
- *44: Because they* (inyanga) *use the same medicines used by doctors. The difference is that doctors use it after its being converted.*
- 151: *because he* (inyanga) *uses the same medicine as a medical doctor except that it wasn't purified.*
- *115: Putting together all types of herbs etc to form one cure to help somebody, is science in a traditional way.*(in context of inyanga)
- 66: *I think the inyanga's have got their unique ways of doing things and I trust them.*
- *2: They* (inyanga) *can do things which no one can do.*
- *2: Because they (*sangoma*) can change the weather from its nature.*
- *21: ... and they (*sangoma*) do not go to another medical doctor and they know more.*

- *24: They* (sangoma) *know other medicines.*
- *115: The medicine was made through the process of science.*(in context of sangoma).
- *51. Their* (medical doctor) *medicine are mixed in a very proper way and they use machine to do some of their mixture are safe.*
- *104: they* (medical doctor) *use lots of medicines*
- *158: Always medicine work.* (in context of medical doctor)
- *115: The medicine* (medical doctor) *they use for everything was made scientifically.*

I will now present a few quotations where the learners argued that the medicines and treatments of the practitioner did not work.

- *79: They* (inyanga) *sometimes use roots for making medicine that is not perfect.*
- *51: Their* (inyangas') *medicine are not mixed safely, you can get disease from them.*
- *81: they* (inyanga) *use unclarified medicine they can be poisonous mostly not tested.*
- *39: most of them* (sangoma) *practice lying to their patients*
- *35: The sangomas just mix whatever they want to mix in a bowl cause sometimes their herbs do not help others.*
- *93: he* (sangoma) *is just guessing*

The learners' view of science in practice that emerges in this section is: science works. Science in practice works.

4.6.2.4. Ancestors

On these three questions 60 learners (31%) spoke about ancestors to support their belief that the particular individual is working scientifically or not. It can be seen in Table 9 that most of the learners (25%) wrote about ancestors in the context of the isangoma, 11% in that of the inyanga and 1% in that of the medical doctor.

Of the learners who spoke about ancestors, 40 learners cited ancestors as an explanation of why the isangoma does not work scientifically. However, 50% of these 40 learners cited ancestors as an explanation of why the inyanga does work scientifically. This suggests that learners believe ancestors have different roles for the isangoma and the inyanga, helping each to do his work: the inyanga prepares potions and other medicines; the isangoma works more on the psychological, social and spiritual levels. Whether or not the healer works scientifically, it is acceptable to the learners that the healer communicates with the supernatural.

I will now present a few quotes to illustrate this category. Firstly I will present a few quotes where learners have written about ancestors to support their belief that the practitioner works scientifically. This will be followed by quotes from those who believe that the practitioner does not work scientifically.

- *70: because their* (inyangas') *ancestors hold them to this thing that they are doing.*
- *103: They* (sangoma) *get help from ancestors and from God himself*
- *139: because they* (sangoma) *believe in ancestors and dreams*

The following quotes are from those learners who believe that the practitioner in question is not working scientifically:

- *30: I believe that inyanga spirit was a god given talent. So I think god is the one who always keep the inyanga working. The "muthi" is something that is shown by ancestors to him at night.*
- *64: Sangoma don't know about science. All the knowledge they've got, they get from ancestors or snakes.*
- *175: because they told by ancestors what to do*
- 151: *because the sangoma uses her mind and pray to the ancestors*
- *168: They* (sangoma) *get knowledge from the ancestors so they don't need science*

In some learner's perception, being in communication with ancestors does not automatically preclude a person from being classified as working scientifically and they wrote about this. Although 90% of learners expressed a belief in ancestors in the context of knowledge acquisition, only 31% wrote about ancestors when responding to these questions on science practice. The important point that emerges is that it is acceptable to the learners that the healer communicates with the supernatural.

4.6.2.5. Mysticism

Only 9% of learners raised mystical ideas in their explanations of whether practices were scientific. 50% of these candidates used these ideas to support their view that the healer practiced good science while the other 50% used the ideas to support the opposite view of science practice.

The quotes presented below illustrate this category:

- *172: because the inyanga see the things that somebody cannot see*

- *71: Because sometimes they* (sangoma) *make or change the weather of that area eg make lightening, rain. They make unbelievable* (sic) *things. that is physics*

- *179: because he / she* (sangoma) *can direct fire to somewhere without being there but by mixing traditional medicines and some organic ingredients.*

Actually physics is a mystery, almost magical to many a person who has never studied science but not in a sense of admitting the mystical and supernatural causes for natural events. It is just a way of expressing their lack of understanding of a non-personal and objective way of knowing. To learner 71 however the "mysteries" of physics are related to mystical as opposed to mechanistic causes of natural events. At least some learners include the mystical in their view of science and this is the perception with which they engage in the science classroom.

4.6.3. Conclusion

Most learners chose to deploy criteria of empiricism and that 'science works' in order to explain what is good science practice. They maintained this position, generally, even as the context changed from indigenous to Western and back to indigenous.

In the science classroom learners are exposed to laboratory work that includes mixing and measuring, proportion, accuracy, testing, safety, creativity, predictability, decision-making, natural elements and compounds. This study shows that most learners perceive these as descriptors of good science practice. Hence in most of the pupils' responses good science practices that conform to mechanistic, functional, objectivist, materialistic, non-personal and logical ways of working, were perceived to a greater or smaller degree in the practices of both the indigenous and Western healers. Irrespective of the context, be it indigenous or Western, learners identified common ground in defining good science practice.

Another interesting finding is that irrespective of whether the context is indigenous or Western, if the application of knowledge results in solutions that benefit one's health and

community then that work is regarded as good science practice. Thus science is seen by the learners as a positive force in the community, not a negative force.

4.7. Critical question three

How does the township learner negotiate relationships between classroom science and indigenous knowledge and how much do they care about inconsistencies and contradictions?

4.7.1. Introduction

In section 4.3 I showed that the learners come into the class with multiple beliefs about how people come to know things. The learners clearly indicated that they hold different epistemological theories about sources of knowledge and they also exhibited the ability to choose a theory to address a particular challenge. Most learners believe that there are supernatural, mystical as well as Western sources of knowledge.

In section 4.4 I showed that most learners believe that good science in practice is empirical and it 'works', irrespective of the context. These beliefs are consistent with views of working scientifically that are presented in school science. Some learners did not admit the supernatural in their definition of good science practice but expressed beliefs about supernatural sources of knowledge.

In this section I will be exploring how learners negotiate relationships between classroom science and indigenous knowledge. Firstly I will look at the beliefs of learners about indigenous knowledge. Secondly I will look at how they negotiate relationships between indigenous knowledge and classroom science.

4.7.2. Indigenous knowledge Systems (IKS)

Learners have expressed both Western and indigenous beliefs about indigenous knowledge. The beliefs that they expressed about sources of knowledge changed with the context. On the question of sources of indigenous knowledge most learners, 99,5% expressed beliefs that knowledge can be acquired from supernatural, mystical and spiritual sources. Less than 30% of learners believe that traditional knowledge can be acquired from tangible sources like books and teachers. Most of these learners believe that good science works in practice and that it reflects descriptors of empiricism in all three contexts namely the inyanga, isangoma and medical doctor. It seems as though learners perceive IKS as embracing mechanistic Western beliefs as well as beliefs about the supernatural and the mystical.

The data suggest also that IKS itself is composed of distinguishable sub-cultures. Both the inyanga and isangoma are traditional healers, but the inyanga practices as a herbalist and the isangoma as a diviner where she practices mainly on psychological, social and mystical levels determining the causes of her patients problems and prescribing cures for the causes of illnesses. She functions mainly on the supernatural / mystical / spiritual level.

The inyanga practices to a large extent on the physical level when he is prescribing potions and medicines but on the supernatural / mystical / spiritual level when he acquires knowledge about diseases and cures.

When discussing where the inyanga acquires knowledge, the learners express indigenous beliefs but when it comes to his practice they compare it to their perceptions of Western science as derived from school science. They have no trouble separating sources of knowledge from application of knowledge. In IKS supernatural beliefs co-exist with mechanistic beliefs.

4.7.3. Negotiations between classroom science and indigenous knowledge

To explore possible relationships between students' beliefs about knowledge sources and their beliefs about who works scientifically, I applied cross-tabulations and factor analyses. For example, I wanted to see whether students who believed that snakes and ancestors were important sources of knowledge for the isangoma also said that the isangoma did not work scientifically. I found no significant patterns: an individual's beliefs about knowledge acquisition give no guide to her beliefs on whether a person works scientifically or not. In other words, students generally saw sources of knowledge as a discussion separate from how knowledge is used.

The fact that there was no correlation between learners' beliefs of sources of knowledge and working scientifically is significant. One may have expected learners who expressed beliefs about supernatural sources of knowledge for a particular healer to correlate highly with the belief that that healer does not work scientifically. This was not evident in the data. What was evident is that on the question of who worked scientifically the learners shifted their focus to beliefs that they held regarding good science practice: their criteria for 'working scientifically' were generally consonant with views of science presented in schools. The learners looked for congruence between the practice of the healer and this science. Whenever they found congruence they concluded that the healer worked scientifically and if they did not find congruence they concluded that the healer did not. On answering this question most of the learners' beliefs about good science practice and science must work surfaced in their explanations. Beliefs about supernatural / mystical / spiritual influences were strong in defining sources of knowledge, but not in practices of working scientifically.

In 99,5% of the sample the belief systems identified God, spirits, snakes and ancestors as important sources of knowledge, and yet allowed the students to make objective and well defended judgements about who worked scientifically. The beliefs of learners are not static. There was little evidence to suggest that

learners see themselves as crossing borders between their indigenous life-worlds and school science, or, to the extent that such crossings are involved, that the students find them hazardous. On the contrary, they seemed to engage quite harmoniously with their multiple beliefs while accessing particular beliefs to address particular challenges.

4.7.4. A pluralist conception of science

58% of the learners expressed beliefs that the herbalist sometimes works in ways that involve good science practices such as accuracy, experimentation, measurement, testing, etc. The fact that the herbalist also communicates with ancestors for assistance with his work did not automatically preclude him from being a practitioner of good science. It follows that these learners hold complex understandings of science that is at times positivist, for example when the inyanga is preparing his potions and at other times it is more holistic, for example when the inyanga perceives inter-relationships between the supernatural and the physical in his diagnoses of illnesses.

When the context was changed to the isangoma, only 37% of the learners believe that she practices good science. 63% of learners believe that she does not practice good science. Again in this context most learners found that she did not practice good science because of lack of rigorous testing and careful measurement and / or that her medicines did not always work. For most of these learners the deciding factor was not her communication with ancestors. Hence learners express a pluralistic perception of science. Learners perceive science as being positivist/ empiricist, interpretivist, subjective at times and objective at others, reductionist at times and holistic at others.

In the context of the medical doctor as well most of the learners expressed a pluralistic conception of science. 57% of the learners who believe that the medical doctor practices good science offered positivistic / objective reasons while

simultaneously holding on to the belief that God is a source of knowledge for him.

The data suggests that in total 82% of learners believe in a pluralistic conception of science. Most of the learners express multiple beliefs about knowledge. It is therefore important the curriculum developers and teachers recognize the need to teach science in a pluralistic paradigm so that human interests as opposed to only Western interests are served.

4.7.5. Conclusion

Through all three critical questions learners are expressing the following ideas about knowledge, its sources and its practices:

- They recognize and participate in different ways of knowing.
- Sometimes there is an overlap between indigenous and Western ways of knowing, sometimes there is not.
- Learners choose from among their beliefs according to context. These choices are largely individual, but not capricious: there are patterns of belief into which learners can be grouped.
- Learners see questions of the sources of knowledge as separate from the practices of working scientifically, generally seeing roles for supernatural sources of knowledge, even when a practitioner is working scientifically
- Learners have a broad view of science, insofar as they wish to include the supernatural (especially as a source of knowledge and creativity), and the holistic, interpretive approaches of the isangoma, doctor and inyanga.

Chapter Five

Synthesis and Recommendations

5.1. Introduction

The focus of this study is on the beliefs of Zulu-speaking learners regarding classroom science and indigenous knowledge. I attempted to explore this issue by addressing my three critical questions. The first question is: *what are the cultural beliefs, grounded in family, community, school and peers of isiZulu - speaking township learners that are brought into the science classroom?* The second question is: *how do learners perceive science and indigenous knowledge in practice?* The third question is: *how does the township learner negotiate relationships between classroom science and indigenous knowledge and how much do they care about inconsistencies and contradictions?*

In this chapter I will present a synthesis of my findings and offer the framework of Ubuntu as a way of interpreting them. A section suggesting some recommendations will follow.

5.2. Synthesis

5.2.1. Indigenous, Western and Heterogeneous Belief Systems

My first critical question was: *What are the cultural beliefs, grounded in family, community, school and peers of isiZulu-speaking township learners that are brought into the science classroom?*

This question focused on the identification of the personal beliefs held by learners who have access to a mixture of cultures: Zulu traditional culture, urban 'modern' culture (including urban technologies, such as television, radio, shopping centers and health services), peer culture and school culture. Underpinning the research was a question of whether these learners' science education, youthfulness and exposure to Western cultures had led them away from traditional beliefs. I exposed learners to three different contexts in which they expressed their personal

beliefs about sources of knowledge about health and illness: the isangoma, inyanga and doctor.

Almost all learners (99.5%) believed that God, spirits, ancestors and or snakes were important sources of knowledge for one or more of the healers (including medical doctors). Overall, three categories of belief systems emerged from this study, namely:

- Indigenous belief system: the learner expresses only attributes associated with indigenous belief systems, when exposed to challenges in a single context, for example, sources of knowledge for the inyanga.
- Heterogeneous belief system: the learner simultaneously expresses attributes associated with indigenous and Western belief systems when discussing sources of knowledge of medical practitioners.
- Western belief system: the learner expresses only attributes associated with Western belief systems when challenged in a single context.

Only 40 learners (21%) consistently expressed beliefs that were aligned to only one of the three belief systems that were identified in this study. This comprised of 4% of learners who expressed only indigenous beliefs in all three contexts, 16% of learners who expressed only heterogeneous beliefs in all three contexts and 0,5% of learners who expressed only Western beliefs in all three contexts.

Research in science education from cultural perspectives typically talks in terms of only two worldviews, which in this study I refer to as belief systems: indigenous and Western (eg. Aikenhead: 1996, Banks: 1988, Cobern: 1994a, Jegede: 1995). These systems are described as more or less conflicting, requiring border crossings that may be so difficult as to result in alienation, or strictly imposed as enculturation (Aikenhead: 1996). This study has shown that the participants - Year 11 Zulu students in an urban township - are neither wholly indigenous nor wholly Western in their belief systems: they carry different

beliefs, deploying them according to context, relating them thoughtfully, and without apparent stress.

5.2.2. Shifting Belief systems and Multiple Belief Systems

Although 99,5% (193) of the learners under this study expressed indigenous beliefs in at least one context, 79% of learners (154) expressed shifts in their belief systems as the context in which they were placed changed. This finding states that an individual learner subscribes to multiple belief systems. Learners are constantly being exposed to different cultures all of which are part of their learning and thinking. Their personal views shift and develop.

5.2.3. Ubuntu

I suggest that the belief system of Ubuntu offers an alternative way of thinking about the data than the usual one of 'border crossings'. One of the problems with the cultural approaches described in Chapter 4 (Wilson: 1981, Kearney 1984, Cobern: 1991, Aikenhead: 1996) is that, even in their respect for the holistic and interdependent and context-based characteristics of traditional belief systems (including African systems), they impose a reductionist Western rationality in seeking to understand. So for example, they compartmentalize cultures and subcultures, and create sharp borders which have to be 'crossed'. Applying classic Western logic, a particular belief is classified distinctly as 'Western' or 'Traditional', 'science' or 'not science', and these different positions are placed into competition with each other, with a view to one or another emerging ascendant. This does not seem to be a significant issue for the students in my study.

An alternative is to begin not from the Western viewpoint, but an African one, such as Ubuntu. Ubuntu is the fundamental philosophy of African thought. It is a unifying worldview that is enshrined in the Zulu maxim

umuntu ngumuntu ngabantu

which translates as "a person is a person through other persons" (Shutte: 1993: 46).

The South African White Paper on Welfare officially recognizes Ubuntu as: " ... Each individual's humanity is ideally expressed through his or her relationship with others and theirs in turn through a recognition of the individual's humanity. Ubuntu means that people are people through other people. It also acknowledges both the rights and the responsibilities of every citizen in promoting individual and societal well-being" (Government Gazette, 2/2/1996, No 16943, p18).

It is desirable according to the philosophy of Ubuntu to harmoniously co-exist with multiple belief systems, to address problems differently in different contexts and to be able to access relevant beliefs to address specific challenges. Accordingly it is possible that the indigenous beliefs do not necessarily interfere negatively with learning of Western science but expand understandings of science to a pluralistic position. As the students in this study have shown, this is far from a capricious or irrational stance: while almost all students incorporated roles for God, spirits, ancestors and snakes as sources of knowledge, factor analysis sorted the students into three distinct groups. Further, the students argued soundly about what it means to work scientifically and who works scientifically, regardless of their beliefs about sources of knowledge.

The theory of *cognitive apartheid* (Cobern: 1996a) is about the segregation of school science from the learners' life-world in the mind of the learner. However the learners in this study have displayed an ability to find harmonious relationships between their life-world and school science as opposed to cognitive apartheid: for example it is acceptable to the learners that the inyanga sometimes works in empirical ways while at other times he communicates with ancestors.

While some researchers have found that the sub-culture of science is generally at odds with a learners' everyday world (Costa: 1995, Ogawa: 1995), this study shows that learners perceive congruence between science in practice and their life-world. Other researchers have stated that science education can cause learners to abandon their indigenous ways of knowing (Jegede: 1995, MacIvor: 1995). However in contrast, this study shows that these competent grade 11 science learners have not done so.

I found that 95,87% (186 learners) simultaneously hold on to an amalgamation of beliefs that fall within both the worlds of indigenous and western beliefs. These worlds of beliefs do not exist as two distinct worlds, with borders demarcating the distinction between them, but exist as an amalgamation of beliefs that are in a state of harmonious co-existence. The learner has access to different theories of knowledge and can choose among them. This is a process different from Aikenhead's border crossing (1996), whereby a learner migrates back and forth between her indigenous world and the world of science, often with a sense of unease.

There are many precedents for such choosing, if a worldview is considered to be like a 'theory of knowledge'. For example, physicists regard light in some situations as waves, in other situations as particles; the two theories are considered as complimentary, both necessary for an understanding of light. Physicists have come to know which phenomena are better explained by the wave theory, which by the particle theory, and at the same time they have learned to be comfortable with the duality, even celebrate it.

The culture of an individual is not static, but rather it is in a state of flux as is suggested in Geertz's definition of culture (1973). The development of the culture of an individual does not take place in a linear way, where existing beliefs are discarded for new ones and therefore are forever lost. Instead, when individuals are exposed to other belief systems, then the individual adds these beliefs to her existing systems of beliefs to form an amalgamation of beliefs or theories. The grade 11 Physical Science learners in this study are not wholly indigenous or western but rather are ones within whom differing degrees of indigenous and western beliefs surface as demanded by the context or challenge that faces them. This has important implications for teaching and learning in a multicultural environment and to curriculum development as I will discuss in the next section.

5.3. Recommendations

I have conducted this study from a pluralistic perspective of science since the multicultural nature of South African society is ideal ground for exploring the complexities of knowledge. The South African education system should also prepare a climate for the generation of new knowledge instead of simply producing a society that are primarily consumers of predominantly Western ways of knowing.

Learning is more meaningful and relevant if the words of the Scottish philosopher Macmurray (1957:12) are considered:

> *"I do" rather than "I think" is the appropriate starting point for epistemology.*

Science education should incorporate the life-world of learners in critical discourses so that the society that it serves is enriched in terms of knowledge production and economy. As I said earlier Africa has a wealth of science knowledge that learners are being exposed to out of school but knowledge that is kept out of science classroom discourses.

- Curriculum Design

In my opinion the science curriculum in South African schools, especially in grades 10, 11 and 12, is based on a scientistic view of Western science. I am suggesting the following two recommendations for the design of the science curriculum.

1. Pluralistic perspective of science

Science curriculum currently implemented in schools expresses quite unequivocally the superiority of Western scientific ways of knowing. Science curriculum is currently designed from a perception that science is a singularity and that this singularity is identified with Western science.

The curriculum can be designed in a way that expresses the plurality of science, that is that Western science is but one way of knowing, amongst several other knowledge systems. The curriculum design could express the idea that Western science is a sub – culture of science where science itself is a plurality. This design should provide

opportunities for studying alternate ways of making meaning of the natural world. In this design indigenous science is perceived as a sub – culture of science and both Western and indigenous science are in frequent dialogue in the same science classroom.

2. Multiple Science Perspective

Here the science curriculum is designed from a perspective that indigenous and Western science are two streams of knowledge that warrant separate curricula. This will result in learners having a choice of science curriculum between indigenous and Western science.

- Science Education Research

Research in multicultural education should address the following issues:

1. What is the content of indigenous science?
2. How should indigenous science curriculum be designed?
3. What are the strategies of teaching indigenous science?
4. Should indigenous science be taught as part of the traditional Western science curriculum or should indigenous science be taught in its own right as a science?

- Teacher Education

Teacher education should design teaching and learning strategies that challenge learners to make optimal use of their multiple beliefs in understanding their natural world.

BIBLIOGRAPHY

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

Aikenhead, G. and Huntley, B. (1997): Science and Culture nexus: A research report. Saskatoon, SK, Canada: University of Saskatchewan.

Aikenhead, G. (1997): *Recognising and responding to complexity: Cultural border crossing into science*. A paper presented at the international conference on Science Education: Globalisation of Science Education: Seoul, Korea, May 26-30, 101-106.

Aikenhead, G. and Huntley, B (1999): *Barriers to Accommodating Culture in Science Classrooms:* A paper presented to the 9th Symposium of the International Organisation for Science and Technology Education, Durban, South Africa, June 1999.

Aikenhead, G. and Jegede, O.J. (1999a): *Cross-cultural science education: A cognitive explanation of a cultural phenomenon.* Journal of research in Science Teaching. 36(3).

Aikenhead, G. and Jegede, O.J. (1999b): *Transcending Cultural Borders: Implications for Science Teaching.* In Proceedings, National Association for Research in Science Teaching, NARST. Boston. USA 1999. Available from

Atwater, M.M. (1996): *Social constructivism: Infusion into the multicultural science education research agenda.* Journal of Research in Science Teaching, 33, 821-837.

Baker, D and Taylor, P.C.S.:!995: *The effect of culture on the learning of science in non-western countries.* The results of sn integrated research interview. International Journal of Science Education, 17, 695-704.

Banks, D.A. (June 2001): *Reflections of Interpretivist teaching with positivist students*: University of South Australia. Available from david.banks@unisa.edu.au.

Banks, J.A. (1988): Multiethnic education. 2nd edition, MA: Allyn & Bacon.

Basalla, G. (1967): The spread of western science. Science. 156, 611-622.

Bullivant, B.M. (1981): Race, ethnicity and curriculum. Melbourne, Australia, Macmillan.

Capra, F. (1982): *The Turning Point: Science, Society And The Rising Culture.* New York, NY. Simon and Schuster.

Cobern, W.W. (1991): *World View Theory and Science Education Research.* National Association for Research in Science Teaching, NARST. Monograph No. 3. Cincinnati, OH.

Cobern, W.W. (1994a): Alternative Constructions of Science and Science Education: A plenary presentation for the second annual Southern Africa Association for Mathematics and Science Education Research, University of Durban-Westville, South Africa, 27-30 January 1994.

Cobern, W.W. (1994b): *Point: Belief, understanding, and the teaching of evolution.* Journal of Research in Science Teaching. 31(5), 583-590.

Cobern, W.W. (1996a): Worldview theory and conceptual change in science education. *Science Education, 80(5),* 579 – 610.

Cobern, W.W. (1996b): *Traditional Culture and Science Education in Africa: Merely Language Games?* A paper presented at the meeting for Traditional Culture, Science and Technology, and Development: Toward a New Literacy for Science and Technology. Tokyo Institute of Technology. Meguro-ku, Tokyo, Japan, 28 September 1996.

Cobern, W.W. and Aikenhead, G.S. (1996): *Cultural Aspects of Learning Science.* SLCSP Working Paper #121.

Costa, V. B. (1995): *When science is "another world": Relationships between worlds of family, friends, school, and science.* Science Education, 79(3), 313-333.

Driver, R. (1989): *Students' conceptions and the learning of science.* International Journal of Science Education, 11, 481-490.

Eco-logical Technology, Horticultural Division, Indigenous medicinal plants, (2003): Available from www.spindrift.co.za/horticulture.htm.

Emeagwali, G. 2003: *African Indigenous Knowledge Systems* (AIK); Implications for the curriculum". An essay in honor of Adu Boahen, Ghana in Africa, Africa World Press, New Jersey.

Geertz, C. (1973): *The interpretation of culture.* New York, NY: Basic Books.

Giroux, H (1992): *Border Crossings*: Cultural workers and the politics of education. New York: Routledge.

Habermas, J. (1974): *Knowledge and human interests*: (2nd edition), translated by J.J. Shapiro, London: Heinemann. (German original: Erkenntinis und Interesse. (1968), Suhrkamp Verlag).

Hawkins, J. and Pea, R. D. (1987): Tools for bridging the cultures of everyday and scientific thinking. Journal of Research in Science Teaching, 24(4),291-307..

Hillard III, Asa, G. (1992): *Why we must Pluralize the Curriculum,* Educational Leadership, 49(4): 12 – 14.

Hills, G. L. C. (1989): Students' "untutored" beliefs about natural phenomena: primitive science or commonsense? Science Education, 73(2), 155-186.

Hodson, D. (1993): *In search of a rationale for multicultural science education.* Science Education, 77: 685-711.

Jegede, O. (1995): *Collateral Learning and the eco-cultural paradigm in science and mathematics education in Africa.* Studies in Science Education, 25: 97-137.

Kearney, M. (1984): *World view.* Novato, CA: Chandler & Sharp Publishers.

Krugly-Smolska, E.: (1999): *Research on Multiculturalism Applied to Students' Learning School Science: Some Theoretical Issues.* In Proceedings, National Association for Research in Science Teaching, NARST. Boston. USA 1999. Available from

Kyle, D.W.and McCutcheon, G.: (1984): *Collaborative research: Development and issues.* Journal of Curriculum Studies. 16(2), 173-179.

Larson, J.O.: (1995, April): *Fatima's rules and other elements of an unintended chemistry curriculum.*Paper presented at the American Educational Research Association annual meeting, San Francisco.

Living Values, (2003): Newsletter. Living Values Educational Program. Available from

MacIvor, M. (1995): *Redefining science education for aboriginal students.* In M. Battiste & J. Barman (Eds.), First Nations education in Canada: The circle unfolds. Vancouver, Canada: University of British Columbia Press, 73-98.

Macmurray, J. 1957: *Persons in relation.* London: Faber and Faber.

Maddock, M.N. (1981): Science education: *An anthropological viewpoint.* Studies in Science Education, 8, 1-26.

Maddock, M.N. (1983): *Research into Attitudes and the science curriculum in Papua New Guinea:* Journal of Science and Mathematics Education in S E Asia. VI(1), 23-35.

Matthews, M.R. (1992): *Old wine in new bottles: a problem with constructivist epistemology.* A paper presented at the annual meeting of the National Association for research in science teaching, Cambridge, MA.

Murfin, B (1992): *African Science in School Curriculum.* A paper presented at the NSTA National Convention, Boston, Massachusetts: African Science, African and African-American Scientists and the School Science Curriculum: March 26-29, 1992.

Ogawa, M (1995): *Science education in a multiscience perspective.* Science Education, 79, 581 – 593.

Poole, H.E. (1968): *The effect of urbanization upon scientific concept attainment among Hausa children of Northern Nigeria.* British Journal of Educational Psychology. 38. 57-63.

Phelan, P. , Davidson, A and Cao, H. (1991): Students' multiple worlds: Negotiating the boundaries of family, peer and school cultures. Anthropology and Education Quartely: 22, 224-250.

Proper, H., Wideen, M.F. and Ivany, G. (1988): Worldview projected by science teachers. A study of classroom dialogue. Science Education, 72, 547-560.

Shutte, A, (1993): *Philosophy for Africa*, Rondebosch, South Africa: UCT Press.

Spindler, G. (1987): Education and cultural process: Anthropological approaches (2nd Ed.). Prospect Height, IL: Waveland Press.

Thelen, L.J. (1983): Values and valuing in science, Science Education, 67, 185-192.

Traditional Healers in Zululand, 2003: Available from www.smom.za.org.

Wilson, B. (1981): *Cultural contexts of science and mathematics education: A bibliographic guide. Leeds, UK: Centre for studies in Science education, University of Leeds.*

Wolcott, H. F. (1991): Propriospect and the acquisition of culture. Anthropology & Education Quarterly, 22(3), 251-273.

Ziman, J. (1980): *Teaching and learning about science and society.* Cambridge, UK: Cambridge University Press.

Appendix

LEARNER QUESTIONNAIRE

SECTION A: GENERAL INFORMATION:

INSTRUCTION :

1. Place a tick in the appropriate box -
   example : Do you like sport? YES ☐ NO ☐

2. A blank space is provided, where you are required to write in an answer –
   Example: _____

SECTION A: GENERAL INFORMATION:

1. Gender: Female ☐ Male ☐

2. Age: _____years

3. How do you come to school?

   FOOT ☐

   TAXI ☐

   BUS ☐

   PRIVATE CAR ☐

   OTHER (kindly specify) _____

4. How long does it take you to come to school? _____

5. How many years have you been living in the area where you are now?
   _____ years

5 Where did you live before coming to your present home? _____

6. Do you have electricity at home? YES ☐ NO ☐

7. Do you get water from taps inside your home? YES ☐ NO ☐

8. Do you live in an informal settlement? YES ☐ NO ☐

9. Who do you live with? ***(you may tick more than one box)***

With your mother ☐

With your mother and father ☐

With your grandparents ☐

Alone ☐

With relatives ☐

With your friend ☐

Other (kindly specify) _____

10. Do you **enjoy** school science? YES ☐ NO ☐

11. Give a reason for your answer in question 10.

_____

_____

_____

12. What mark did you get in your last science test?

My mark was _____ marks out of a total of _____

SECTION B:

13. What is your **first language**? _____

14. What is the first language of your mother? _____

15. What is the first language of your father? _____

16. What religion do you practice?

An African religion (eg Shembe) ☐

An Eastern Religion (eg Hindu) ☐

A Christian Religion ☐

Islam ☐

No Religion ☐

Other (kindly specify) _____

17. When you have a problem, who do usually you go to first? *(you may tick more than one box)*

Your grandmother ☐

Your grandfather ☐

Your mother ☐

Your father ☐

Your friend ☐

Your brother ☐

Your sister ☐

Your school teacher ☐

Nobody ☐

Other (kindly specify) _____

18. What do you do after school? After school, you

Go home immediately after school ☐

Hang out with your friends and go home before dark ☐

Hang out with your friends and go home after dark ☐

Go for extra lessons ☐

Other (kindly specify) _____

19. What kind of music do you like the most?

POP ☐

RAP ☐

KWAITO ☐

AFRICAN TRADITIONAL ☐

WESTERN CLASSICAL ☐

OTHER (be specific) _____

20. How often do you watch TV?

Every day ☐

Sometimes ☐

Often ☐

Hardly ever ☐

21. Which TV programme do you like the most?

SPORT ☐

SOAPIES ☐

NEWS ☐

EDUCATIONAL ☐

FILMS ☐

MUSIC ☐

COMEDY ☐

22. Do you talk about science outside school? YES ☐ NO ☐

23. Who do you talk to about science? *(you may tick more than one box)*

FRIENDS ☐

PARENTS ☐

RELATIVES ☐

GRANDPARENTS ☐

BROTHERS ☐

SISTERS ☐

OTHER (kindly specify) _____

SECTION C:

24. When you are sick, do you usually go to the

Inyanga ☐

Medical doctor ☐

Sangoma ☐

Other (kindly specify) _____

25. When other members of your family fall sick, do they usually go to the

Inyanga ☐

Medical doctor ☐

Sangoma ☐

Other (kindly specify) _____

26. From where do you think the **Inyanga** got his/her knowledge about medicines?
(The blocks are numbered.
Example *If you think that the inyanga gets his/her knowledge:*
mostly from ancestors – tick block a2 and
sometimes from books – tick block b3
You may tick more than one block)

OPTIONS	ALWAYS	MOSTLY	SOMETIMES	NEVER
Ancestors	*a1*	a2	a3	a4
Snakes	s1	s2	s3	s4
Books	b1	b2	b3	b4
Teachers	t1	t2	t3	t4
God	g1	g2	g3	g4

27. Do you think the Inyanga works scientifically? YES ☐ NO ☐

28. Give reasons for your answer in question 27.

29. From where do you think the **medical doctor** got his/her knowledge about medicines?

(The blocks are numbered.

Example *If you think that the inyanga gets his/her knowledge:*
mostly from ancestors – tick block a2 and
sometimes from books – tick block b3
You may tick more than one block)

OPTIONS	ALWAYS	MOSTLY	SOMETIMES	NEVER
Ancestors	*a1*	a2	a3	a4
Snakes	s1	s2	s3	s4
Books	b1	b2	b3	b4
Teachers	t1	t2	t3	t4
God	g1	g2	g3	g4

31. Do you think the medical doctor works scientifically? YES ☐ NO ☐

32. Give reasons for your answer in question 31.

_____

_____

_____

33. From where do you think the **Sangoma** got his/her knowledge about medicines?

(The blocks are numbered.

Example *If you think that the inyanga gets his/her knowledge:*
mostly from ancestors – tick block a2 and
sometimes from books – tick block b3
You may tick more than one block)

OPTIONS	ALWAYS	MOSTLY	SOMETIMES	NEVER
Ancestors	*a1*	a2	a3	a4
Snakes	s1	s2	s3	s4
Books	b1	b2	b3	b4
Teachers	t1	t2	t3	t4
God	g1	g2	g3	g4

34. Do you think the Sangoma works scientifically? YES ☐ NO ☐

35. Give reasons for your answer in question 34.

_____

_____

_____

36. Are there some illnesses that you think the inyanga can cure best?

YES ☐ NO ☐

37. Give examples of some illnesses that you think the inyanga can cure best.

_____

_____

_____

38. Would it be good to discuss the inyanga's medicines and treatments as part of school science?

YES ☐ NO ☐

39. Give a reason for your answer in question 38.

_____

_____

_____

SECTION D:

Mr Abel Afouda, told the story of the rainmaker below:

The rainmaker made a huge wood fire underneath a big jar filled with a liquid to which he added a blue dye. When the liquid began to boil, the rainmaker began to sing, as he took a pinch of salt plus some herbs and green leaves and put the lot into the fire, sending a thick smoke up into the sky. The rainmaker repeated these steps several times and then he stopped. He said that his enemies had found out what he intended to do, and were blocking his success.
Nomsa, Tulani, Zinhle and Phumla were watching the rainmaker. When the rainmaker stopped, they started talking. (Adapted from Hountondji, 1997)

40. Nomsa agreed with the rainmaker, that his failure was due to his enemies.
    Tulani felt that if the fire was larger and more smoke went up into the air, the rain would have come.
    Zinhle felt that it is impossible for rain to be made in this way – a person cannot change the weather.

    Why do you think the rainmaker did not succeed in making rain?

    _____

    _____

    _____

41. Nomsa said that she had seen the rainmaker make rain, a month ago.

    Tulani felt that there was sufficient green leaves and the correct herbs on that day. He believed Nomsa.

    Zinhle just shook her head and said that it would have rained anyway, even without the rainmaker.

    Phumla felt that there were no enemies on that day – that is why he was successful. She believed Nomsa.

    Do you believe Nomsa? Give reasons for your answer.

    _____

    _____

    _____

    _____

42. Tulani thought that they should do a school project to find out what role the herbs play in making rain.

Zinhle was fed-up. She said that there is no use for this kind of study in the science classroom.

Phumla was excited. She said that it would be better to find out how other rainmakers make rain.

Do you agree with Tulani, Zinhle or Phumla. Give reasons for your answer

_____

_____

_____

_____

43. Zinhle said that ***western scientists*** cannot make rain. Do you agree with her?

YES ☐ NO ☐

44. Give a reason for your answer in question 43.

_____

_____

_____

Thank you for your co-operation

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