INTEGRATION OF MODERN SCIENCE AND INDIGENOUS KNOWLEDGE SYSTEMS: TOWARDS A COEXISTENCE OF THE TWO SYSTEMS OF KNOWING IN THE SOUTH AFRICAN CURRICULUM

by

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DECLARATION

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I declare that INTEGRATION OF MODERN SCIENCE AND INDIGENOUS KNOWLEDGE SYSTEMS: TOWARDS A COEXISTENCE OF THE TWO SYSTEMS OF KNOWING IN THE SOUTH AFRICAN CURRICULUM is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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SIGNATURE DATE

(Ms)

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DEDICATION

This dissertation is dedicated to my late parents: my mother, Mandu Tong (formerly Nomadolo), and my father, Mokgothu Tong, who taught me from childhood that there was absolutely nothing wrong with my being a Batswana/AmaXhosa descendant and taught me to respect all people and their cultures and transcend tribalism, racism and many other -isms that have been used to cause suffering to mankind. It was a real privilege to have been your child and to have been raised by you. May your teachings continue to inspire me and may your souls rest in peace.

ABSTRACT

The integration of modern science and indigenous knowledge systems in the science education curriculum for South African schools represents social justice for the majority of South Africans as they determine the knowledge necessary for themselves and for future generations in the new South Africa.

An exploratory research reveals tension and a dichotomous relationship between modern science and IKS, caused by false hierarchies that are influenced by factors such as colonialism, capitalism and modernisation to the exclusion of the core values held by indigenous people in their relationship with nature.

The thesis demonstrates that the integration requires an epistemology that puts humanity first and a framework that accommodates both ways of knowing. This should allow for the best in the two systems of knowing to serve humanity in a dialogical manner.

KEY WORDS: Indigenous knowledge systems, modern science, education, holistic education, scientific paradigm, scientisization, mathematization, structural violence, science policy, cognitive justice.

ACRONYMS

ANC	African National Congress
IK	Indigenous knowledge
IKS	Indigenous knowledge systems
RDP	Reconstruction and Development Programme
NCS	National Curriculum Statement
SAQA	South African Qualifications Authority
SARChI-DE	South African Chair in Development Education
WCED	World Commission on Environment and Development

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CHAPTER 1: INTRODUCTION

"But if men of the future are to break the chains of the present they will have to understand the forces that forged them"
- Barrington Moore

1.1 Personal reflections and dilemmas growing up in Apartheid South Africa

I was introduced to the world of modern science through subjects in the discipline of science—Chemistry, Physics, Botany and Zoology, Biochemistry, Metallurgy, Ecology, Climatology, Agricultural Science, Geophysics and many more—all describing nature and natural phenomena. The disciplines and subjects as ways of looking at nature were different from my understanding of nature, where knowledge was not compartmentalised into rigid disciplines. In my world all phenomena were related to each other; the rigid divisions did not exist.

My study was influenced by my interest in the different knowledge systems that I was exposed to, first indigenous knowledge while growing up and later modern science as part of my studies. It is this experience and appreciation of both knowledge systems that inclined me to embark on a project on the integration of modern science and indigenous knowledge systems. The following is my story.

I was born in Apartheid[1] South Africa and lived in many parts of what was then the largest province of South Africa, the Cape Province. I was educated under the infamous Bantu Education[2] policy, which was a policy designed to give African children an inferior version of the education provided to Whites, Indians and Coloureds in South Africa. Nothing made sense to me under this system of governance; the poverty of blacks, the discrimination against blacks by whites in every conceivable situation, the hatred of whites on blacks even though blacks were slaving as maids and servants to make white lives easy and comfortable. My earliest impression of whites in South Africa was one of perpetual anger and violence

[1] **Apartheid** was a system of legalised discrimination based on the colour of one's skin that was adopted by the South African Nationalist Party in South Africa before 1994.
[2] **Bantu Education Act 47 of 1953:** The apartheid regime established a Black Education Department which enforced a curriculum suited to the "nature and requirements of the black people" as the regime deemed it appropriate. The aim of this law was to prevent black Africans from receiving an education that would allow them to work in positions that they were not allowed to hold under the Apartheid laws. (List of apartheid laws, n.d.).

towards blacks in their voices and actions. The constant intimidation, humiliation and denunciation of blacks by whites as a means of entrenching the superiority of whites and the inferiority of blacks was a reality that I grew up under.

My recollections are of the separate amenities for blacks, including schools, where the amenities for blacks were always inferior to those provided for whites; the random assaults of blacks by whites—even young white children on older members of our communities (which was taboo in our culture); old people struggling to express themselves in Afrikaans or English in order to communicate with the white people. Life then was a nightmare. I grew up extremely confused, angry, unhappy and distressed. Apartheid and Bantu Education have influenced the choices and attitudes of every South African. While some people have been able to escape the onslaught of apartheid on their minds and souls, most have become victims of apartheid.

My parents were teachers under the Bantu Education system in South Africa in the sixties and would be summarily transferred from one remote area within the Cape Province to another. I spent my childhood tagging along and living amongst many different cultures, under diverse conditions. We lived mostly in areas bordering Namibia, the then South-West Africa, and Botswana. This area, the Kgalagadi region, normally referred to as the Kalahari by the white people of South Africa, is a semi-desert with sand dunes, hot days and cold nights and many desert animals including scorpions and the blue-headed lizards that used to amaze us with their head dance as we sang to them. These were rural areas where there was a confluence of cultures, with the Namas, who were called !Xamma, the Khoisan, Batswana, Coloureds and other small groups from within South Africa all living together peacefully as one people.

As I grew older, my parents finally settled in the farming community of Taung, which was situated further inland and far from the Kgalagadi region. The new village bordered on the then Transvaal province. The inhabitants of this village, which was my mother's birthplace next to the Vaalharts irrigation scheme[3] on the Vaal River,

[3] A large irrigation scheme developed to facilitate large-scale farming for the Afrikaner members of the South African community.

had regained their ability to sustain themselves with reduced resources after the violent annexation of large tracts of land belonging to the Batlhaping and Barolong. They had used the land as pastoral land and for subsistence farming for many years. This land became the Vaalharts irrigation scheme, where only white farmers could farm and own land. The Vaalharts scheme pushed the black people into very small areas, where despite this violence, they still managed to thrive in their reduced circumstances. Many blacks had no option but to work on the white-owned farms for low wages because of the numerous laws, most notably the taxation laws, made by the apartheid government to force Africans to work for them.

The black people of South Africa were subjected to taxation laws that forced them to leave their homes in order to earn the money they needed to pay the various taxes imposed on them. The need to have money, unheard of in pre-colonial Africa, changed the manner in which communities functioned. The hut tax, the dog tax and the head tax will be discussed briefly.

According to this website, http://www.sahistory.org.za/events-leading-bambatha-rebelliono The **hut tax** was one of the first laws imposed on Africans that wrested them from their land and families in order for them to earn money and thereby become cheap labohttp://www.sahistory.org.za/events-leading-bambatha-rebellionur for the colonialist. This law demanded that each family pay the colonialists in money, labour, grain or stock. As the result of their reduced capacity as farmers, Africans were forced to sell their labour, especially in the colonial economy. Families whose wealth was in cattle ranching had to send members to work for the colonialists in order to raise cash with which to pay the tax.

From time immemorial Africans have owned dogs and used them for sheep herding, hunting and security. The **dog tax,** a tax paid for owning dogs, forced Africans to pay the colonialist rulers a tax for owning their dogs. Large numbers of African men had to abandon their lifestyles in order to earn money by becoming cheap labour supporting the colonial economy. Hunting was an age-old activity practised by Africans to get meat for their families. This activity is now only accessible to rich people who own guns, perpetuating the privilege of the mostly white members of the

population through regulations and laws that make hunting accessible only to a particular class of society—one that can afford hunting rifles and money for permits.

Ghandi, in an article in *Time* magazine entitled: “SOUTH AFRICA: Black Tax” shows how the additional tax, called the **head tax** was also used to further disenfranchise blacks in South Africa.

> Every South African black man over the age of 18 must pay a "head tax" of £1 ($2.80) per year. Since even a black industrial worker's average yearly wage is only $369, more than 150,000 blacks are jailed every year for failure to pay. Last week South Africa's House of Assembly passed a bill that will nearly double the head tax on blacks this year. South Africa's white men do not start paying taxes until they are 21, and half pay no taxes at all if they earn less than $420 a year. (Times 1958).

Gandhi called this taxation system the proletarianisation process. In his book *Satyagraha in South Africa*, he described it this way:

> In order to increase the Negro's wants or to teach him the value of labour, a hut tax has been imposed on him. If these imposts were not levied, this race of agriculturists living on their farms would not enter mines hundreds of feet deep in order to extract gold or diamonds, and if their labour were not available for the mines, gold as well as diamonds would remain in the bowels of the earth. Like, the Europeans would find it difficult to get any servants, if no such tax was imposed. (South African History on line (n.d))

These imposed tax laws forced male black Africans to leave their land, livestock and families in search of work from white farmers and industries so as to be able to pay these taxes in order to avoid jail, where without any labour protection these Africans were fully exploited. This removal of young men – husbands and sons - from their homesteads left a vacuum in traditional society and led to the neglect of livestock, land and families.

Later, when more modernisation projects were introduced by white South Africans under the Bantu Investment Corporation Act 34 of 1959,[4] the small farmers were forced into mechanised farming with promises of big yields and reduced labour costs, but most were reduced to bankruptcy instead. The mechanisation of black farms, with equipment supplied by white-owned businesses in South Africa, forced the poor farmers into poverty while the white-owned businesses bringing mechanisation to them made aggressive profits from such endeavours. Many of these farmers were pushed into bankruptcy and some in my village even committed suicide because of the large amounts of money for which they had become indebted to the owners of the big machines that were doing the work they used to do manually.

In apartheid South Africa, modernisation (acquisition of the Western lifestyle in terms of clothing, housing, food, furniture, appliances and cars) for what it was worth, was driven by the white minorities. This resulted in huge economic leveraging of their collective economic and cultural situation. They had the skills that were needed—they could repair the modern equipment now used by blacks and build modern houses, although they were mainly shouting orders to the unskilled black labourers during such building activities. They could drill boreholes to provide water for families who wanted boreholes, mostly paid for by their livestock. They also had licences to own shops selling clothes, food and furniture in both white and black areas. Just as in many parts of Africa, people who could not afford to buy remained needy, poor and vulnerable.

The villages had been units where there was self-reliance and interdependence amongst villagers before the changes brought about by the tax system and modernisation described above. Elders in these villages who used to be knowledge holders were no longer cradles of wisdom; knowledge itself was only attainable through schools and teachers and extension officers employed by government. The knowledge brought to villages through immunisation campaigns and campaigns aimed at the eradication of certain types of vegetation was the only type of knowledge deemed credible, reducing whole villages that had been self-reliant to

4 The **Bantu Investment Corporation Act 34 of 1959** helped underpin the apartheid system of racial segregation in South Africa. In combination with the Bantu Homelands Development Act of 1965, it allowed the South African government to capitalise on entrepreneurs operating in the Bantustans. It created a Development Corporation in each of the Bantustans.

people without any knowledge. In all my travels as a young girl, I had met many Africans with a vast knowledge of nature, plants, animals, health, nutrition and the environment. Their knowledge had been valued by the villagers and they had spent most of their days exchanging bits of knowledge as it came their way. The new knowledge simply displaced the knowledge that villagers had grown up with, without any attempt to allow villagers to understand it or integrate it into existing systems of knowledge in the village.

Village life, characterised by hard work, was also a life where villagers had their own joys and codes of conduct. There were many ceremonies in my village and neighbouring villages: the birth of a child, the days that follow the birth of a child, the times when villagers could come and view the child and almost every stage of development of children were marked with ceremonies of a different kind, but each was accompanied by joy, the giving of gifts,[5] feasting, dancing, singing and laughter. Marriages, graduation from traditional schools as well as many celebrations were enjoyed by all; all were welcome without any special invitation. Almost everything was a celebration in all the villages I had lived in, except of course, death. Death was followed by strict codes of conduct and respectful mourning by all villagers, whether they knew the deceased person or not. Some activities stopped altogether; the dress code changed, there was genuine respect for the dead and children stayed away.

Later, when I entered university to study science, I realised that the chemistry and physics that I was studying did not have immediate application in the village in which I grew up. Some of the concepts that I learnt in chemistry, for example "*factors affecting rates of reaction"* from a chemistry lesson were clearly applicable but too obvious to be the new knowledge known as "science", but the language, concepts and the mathematics used to explain them made such topics seem difficult to understand and explain. The use of English as well as the nomenclature in what was often referred to as "scientific language" made this subject rather difficult to grasp or even to share with non-science students. The science education at university had almost nothing to do with the vast knowledge I had collected in the course of my travels. In areas where there was convergence, the science, now expressed

[5] Gifts would be fruit, vegetables, domestic animals, woven baskets, clothes or utensils made by the villagers themselves.

mathematically, was part of everyday knowledge in my community; only this knowledge was expressed as qualitative science and in indigenous languages with no mathematics except relative terminology.

I could not explain the processes, beliefs and practices that I grew up observing in the Kalahari or in Taung near the Vaalharts scheme. They did not have a scientific equivalence. Science was a new world! It worked though; I could see the results of this new world around me, more pronounced in modernity. Life in this world was easier; we had automation, and conveniences like electricity, cars, flights, TV and many electrical gadgets – all ascribed to science. But the world that I had grown up in also worked, and it was far removed from this form of modernity and its traits.

The people in my village were not modern scientists; some of them could not read or write, but they knew things—many things. They had raised families, some were midwives or physiotherapists (which we called basididi), while others were farmers. They could mend the broken bones of their livestock without X-rays or plaster of Paris; just using natural substances that were free and available to all, they could treat their livestock of many diseases. They could differentiate between plants that looked very similar to the untrained eye, by looking closely at the leaves or seeds, by touching, smelling or doing something as small as scraping off a sample from a seed or plant. They could interpret the behaviour of animals and train them. They could read omens about future events just by looking at animals, insects or the moon. This was intriguing. They knew many things but none of the things they knew were in the science curriculum. Sometimes I would hear them say things like: *"Makgoa ga a itse go alafa bolwetsi joo. Ba itlhaganelela go sega motho ba mo koafatsa"* (The white men do not know how to treat such and such a disease; they always hurry to do surgery, weakening someone for life and making people prone to more diseases).This distrust of the other was to a large extent due to the lack of dialogue between the western medical practitioners and the indigenous medicine men.

Later through schooling I was told that this knowledge was unscientific; there was no truth in this knowledge, there were no laws or theories that could be used to explain why certain things could happen. As the scientific paradigm became the dominant knowledge paradigm advocated in the schools, by the media and government, I saw

the holders of indigenous knowledge becoming less visible in society, becoming poorer and slowly moving towards the fringes of society. Everyone was now learning the new knowledge, the need for their knowledge was diminished as people moved away from everyday activities like growing and processing food to buying ready-made food, which was already processed, thereby losing the skills and knowledge required to source, grow and process their own food. The local midwives were no longer familiar figures in villages as everyone went to hospitals and clinics. This new knowledge had one prominent characteristic: one had to pay a lot of money for it!

Crime levels began to be noticeable as everyone tried to do or sell whatever they could to get money. In increasing numbers, people started to look for work to get money; men left their families to look for work in the cities, the lifestyle in the villages gradually changed; the songs and the ceremonies stopped, the mud houses gave way to cement houses (as a sign of prosperity), the differences among villagers became more noticeable as everyone marched to the beat of modernisation, with the poor some distance behind the rich, or rather those with money. Oppressive structures made it impossible for people to live their own lives without money, and that meant working for someone who had money. This deprived villagers time to pay attention to their preferred way of life, like rearing their own livestock or growing their own food. Some modernisation projects, such as diversion of rivers, also disrupted rural life since people along rivers depended on the river for their livelihood. All these acts reduced villagers to jobseekers.

In most cases language was used to coerce people into modernisation through the use of words that implied that the modern way was the best or only way. The use of words like “official” and “modern” to denote non-traditional where these words implied “better”, “efficient”, “preferred” or even “civilised” made people gradually edge into modernity. With each modernisation project, however, part of village life was lost. I pondered and concluded that, if left alone, these people would most probably thrive on their own in their own circumstances. Maybe they did not need science as much as we all thought they did? In fact most of them were critical of the modern way of life, of modern food and medicine and of almost everything that was not natural. The modern way of life was not embraced by all, even in these villages.

As I grew older I began to look at the constitutive rules that made policies, laws and practices and noticed how they were designed to further marginalise people, and how they increased dependency by failing to create space for self-reliance and how everyone seemed to accept everything that they were told. I began to notice how young children had become remote from the experiences of nature that I so enjoyed in the Kalahari; they did not even know the names of beetles or plants in their own gardens. To them, every insect had to be killed with a pesticide, whatever its name. Every plant, if not attractive enough to be picked, had to be destroyed. I realised as I became aware of the environmental challenges that if these children are the future adults who will control the world when we are older, we are all going to reap the fruits of failing to teach our children the knowledge of and respect for nature. This lack of knowledge on nature that we enjoyed as we were growing could lead to the world becoming uninhabitable.

After the democratic elections in South Africa, in the period following the challenges caused by apartheid, I hoped to see an education system that is different from apartheid education and that will empower everyone and bring equity to South African black people in all spheres of life. Africans should now be able to determine the kind of education they need versus the one imposed by colonialism, apartheid and Bantu Education. The envisaged transformation that is expected in this new democracy has to recognize the plural availability of knowledges and not only the universal validity of science (Visnanathan 2009) so as to give the formerly subjugated a voice in the running of their own affairs.

This research explores the two forms of knowledge as my contribution to what I consider a democratic process in knowledge production and methodologies under a democratic government. This is expected of an education system in a multicultural society. I would like to indicate that I know that it is not possible to return people to the kind of life I described above because of both the new political and socioeconomic realities and globalisation. That is not the intention of this study. Change happens in societies and will continue to happen; however, change that comes from outside the communities concerned without any negotiation with the communities always leaves them desperate, poor, disoriented and fragmented. The dichotomous relationship between modern science and indigenous knowledge

systems is filled with baffling notions, and fraught with contradictions and sometimes plain deceit as a way of continuing the subjugation of indigenous knowledge. This study aims at a knowledge system that embraces both knowledge systems, recognises plurality, and allows humanity to draw the best from both knowledge systems.

1.2 Modern science and indigenous knowledge systems in policy

Scientific knowledge, as the most dominant of the knowledge systems, occupies a prominent position in all modern societies; this is the knowledge that is perceived to be credible and superior in almost all areas of human existence (Volmink 1998). Scientific research in the areas of food production, medicine and technology is generally trusted by the public and by decision makers. It informs public policies, laws, conventions and treaties between nations and between individuals as well as in the decisions taken by governments. The on-going scientific research and publications have ensured that the results of scientific research are within the reach of anyone; scientist and non-scientist alike, and they occupy a prominent position as credible universal knowledge.

On the other hand, its local counterpart, “indigenous knowledge”, which has been described as primitive and pre-modern, while being used by 70% of mostly indigenous people, is knowledge that was not recognised, developed, promoted, protected and properly documented until recently, following initiatives on the part of the South African Department of Science and Technology. The people in indigenous communities who possess indigenous knowledge include herbalists, people with veterinary knowledge and pastoralists. These people have knowledge of the habitat and life cycles of plants and animals and various other aspects of other resources (Hoppers 2002).

Indigenous societies have always generated the knowledge that they need (Hays 2013) for their survival and not for the purposes of some romantic idealism (Volmink 1998). The organisation of education in indigenous society is therefore needs-based and addressed the immediate needs of communities.

Despite the seemingly low status of indigenous knowledge, this knowledge is used in the west, notably by pharmaceutical companies as the basis for most allopathic medicines. Shiva estimates that the current value of the world market for medicinal plants cultivated in response to leads from indigenous and local communities is estimated to be $443 billion. This is the result of "biopiracy" and "intellectual piracy", which are terms used to describe the practice by Western commercial interests of claiming products and innovations derived from and currently used by indigenous knowledge traditions as their "intellectual property rights" and "patents" (Shiva 1993).

This practice emerged and is continuing as a result of the devaluation and hence the invisibility of indigenous systems of knowledge as real knowledge and the lack of protection of these systems (Shiva 1993). This double theft robs indigenous people, who are knowledge holders, of their creativity and innovation since once this knowledge has been stolen and is patented the owners of this knowledge are robbed of economic options in their everyday struggle for survival. Knowledge stolen from the holder (indigenous person) ceases to be the holder's knowledge after patenting (Mshana 2002).

South Africa exported 26 500 tons of medicinal plants and aromatics to Europe in 1996, which placed it second only to China (Gurib-Fakim 2009). Although indigenous knowledge is not fully exploited and appreciated in the curriculum, its usefulness and economic value in medicine, as demonstrated in this example, show how useful knowledge is being exploited by countries other than South Africa. In this attempt to integrate modern science and IKS, the socioeconomic and political factors that led to its subjugation and removal from mainstream curricula will be explored in order to inform the process of integration.

1.3 Background to South African education policies prior to 1994

The education of South Africans is inextricably linked to the politics of this country. Education in apartheid South Africa has often been blamed for the perpetuation of the social classes that have come to characterise the South African political and socioeconomic landscape. The knowledge production processes, allocation of

resources, both human and material, under the apartheid government ensured that blacks, the largest population group in the country, received the smallest allocation while the white minority received the best facilities, human resources and material resources. Blacks on the other hand received knowledge that made them jobseekers. This created a chasm in terms of qualifications, expertise and opportunities between the majority blacks and their white counterparts, while other racial groupings, namely coloureds and Indians, occupied the middle area (Kallaway 2002).

The oppression of the majority of the citizens of this country by the minority and the provision of their education in the form of Bantu Education, in the formulation of which they had no say, demonstrates a challenge that the new government needed to take into consideration in its provision of education in post-apartheid South Africa (Kallaway 2002). The merging of different education departments that had been separated on the basis of skin colour was naturally accompanied by stereotyping and biases resulting from the knowledge that had sustained apartheid in South Africa for many years. It was through the knowledge that people had access to and the knowledge that people did not have access to that their attitudes were shaped. These attitudes were expected to be corrected through the education of South African citizens in what came to be called "the New South Africa". Knowledge that would bring healing and understanding was therefore necessary for this transformation. It is necessary to touch on the history of South Africa in the periods of colonialism and apartheid in this study, as these periods are the basis for understanding the need for the integration of indigenous knowledge systems and modern science in the science curriculum.

The colonisation of South Africa began with what Simson described as barbaric land grabs (Simson 1980) from the time the colonisers landed at the Cape in 1652. The violent land grabs, and later the Natives Land Act of 1913,[6] displaced the indigenous people and brought about a major change in the land tenure system (Van Wyk 2003; Mathews 1986). Land for the indigenous Africans had for generations been a common – where the land belonged to no one in particular but at the same time belonged to all. The land act changed this system of land use and turned the land into

[6] The Natives Land Act of 1913 was the first piece of segregation legislation where land belonging to the commons in South Africa was taken into the private ownership of the white minority after the first barbaric land grabs

the private property of white people, who used it mostly for commercial farming, using the displaced blacks to till the land. Sol Plaatjie, an African leaders who experienced this violence on Africans – once expressed how the African became a "pariah" in his own country almost overnight and had to survive by selling his labour to the new landowners for a pittance (Van Wyk 2003).

The brutal white minority, whose concept of democracy resembled what some authors have described as fascism (Simson 1980), introduced apartheid as a policy of governance in South Africa. The South African government under apartheid had based its entire constitution, legislative system and practically every other phase of life on differential treatment of different sections of its population (Tobias 1961:1), the only country in the world to invest so much in maintaining this differential treatment of residents of its own country. The separation between Blacks, Whites, Coloureds and Indians was so ingrained in the psyches of South Africans that the majority of white people in the country, convinced of their superiority, treated the other race groups with the disdain intended by the apartheid policies, practising the policy of apartheid themselves, which resulted in large-scale exploitation and abuse of the indigenous people, who were relegated to inferior positions at all levels of society (Van Wyk 2003; Mathews 1986; Magubane 2007). These distorted views of power and democracy where the minority ruled the majority with brutality are still ingrained in the psyches of those who were favoured and those who were oppressed by the apartheid state and have to be changed.

Many South Africans, including South African born professor Phillip Tobias, an internationally renowned paleoanthropologist who had collaborated with anthropologist Raymond Dart[7] in his field felt it was the duty of science to expose the truths about race. In one of his lectures, he indicated in his introductory comments to this lecture,

> in a society in which the question of race has come to loom as largely as it does in South Africa, there is, I

[7] **Raymond Arthur Dart** (4 February 1893 – 22 November 1988) was an Australian anatomist and anthropologist, best known for his involvement in the 1924 discovery of the first fossil ever found of *Australopithecus africanus*, an extinct hominid closely related to humans, at Taung in the North of South Africa in the province Northwest (Raymond_Dart. n.d.)

> believe, a positive duty on a scientist who has made a special study of race to make known the facts and the most highly confirmed hypotheses about race, whenever a suitable opportunity presents itself. I should be failing, therefore, in my academic duty, if I were to hold my peace and say nothing about race, simply because the scientific truth about race runs counter to some or all of the assumptions underlying or influencing the race policies of this country. In no field is the need of guidance from qualified scientists more imperative than in this very subject of race" (Tobias 1972 i).

He had sought to inform the South Africans that the colour of someone's skin is genetically of no scientific importance whatsoever and it can therefore not be used to inform apartheid policies (Tobias 1972). According to him, all human beings belonged to the human race. This scientific knowledge however never made it to the science education for South African learners or the public and race continued to inform policies and attitudes.

The policies of the new government, including its education policies, are aimed at empowering South Africans with new knowledge, attitudes and methodologies that will usher in a period of healing, transformation and democracy. This is the object of the White Paper on Education and Training of 1995, which is a document that sets the direction for education "transformation". Appropriate knowledge and attitudes informed by apartheid need to change in order to build a new South Africa where values of democracy, human rights and citizenship for its own citizens are espoused. The psychological scars of the perpetrators and the victims of dehumanisation through the law remain with all South Africans who survived apartheid. Education therefore needs to prepare learners, who are the leaders of tomorrow, to be sensitive to decisions that perpetuate the dehumanisation of fellow human beings while at the same time also dehumanising the perpetrator of such acts (Freire 1989; Magubane 2007). It is against this background that the South African government sought to use education as one of the means to transform South African society.

The education provided for the majority of the black people under the Bantu Education Act of 1953[8] was centrally decided by the apartheid regime, without any input from black people. The aim of this education was to prepare the blacks for labour in areas specifically designated by the white minority under a barrage of laws which included the Job Reservation Act of 1926 and many other oppressive pieces of legislation (Kallaway 2002; Behr 1988). The knowledge transmitted as education had been stripped of any useful content that would make blacks in South Africa self-reliant. Dr Hendrik Verwoerd, the South African Minister of Native Affairs who later became Prime Minister from 1958 to 1966, speaking about his government's education policies in 1950, left no doubt as to the purpose of Bantu Education when he said:

> There is no place for the Bantu in the European community above the level of certain forms of labour ... What is the use of teaching the Bantu child mathematics when it cannot use it in practice? That is quite absurd. Education must train people in accordance with their opportunities in life, according to the sphere in which they live (Lapping 1987:109).

This resulted in a country where the white minority had the best possible education under apartheid rule while the majority of South African blacks, were given inferior education as a way of ensuring excess cheap labour for the privileged minority. This entrenched the position of whites as the people with superior knowledge and skills and the rest as the people who could only learn from whites, be directed by whites and controlled by white people. The Africans for generations were destined to become cheap labour, having no other opportunities and as perpetual learners while whites were perpetual teachers.

1.3.1 The new South Africa post 1994

After the demise of the apartheid government, the new democratically elected government came to power in 1994, and the biggest liberation movement in the country, the African National Conference (ANC), came to power. The new

[7]The Bantu Education Act of 1953 was an act of parliament in apartheid South Africa that made it illegal for people of different colour to share educational facilities.

government made it its priority to address the myriad of problems that the new democratically elected government had inherited from the apartheid regime. Under its Reconstruction and Development Programme or RDP (1994), a framework that was to drive development was adopted. The RDP provided a framework from which major policy changes were to be derived in order to create what came to be known as "the New South Africa". The government had located education, among others, in its Reconstruction and Development Programme, where the new education system was envisaged as an integrated system of education and training that was non-discriminatory and was to address the development of knowledge and skills, thus enabling its recipients to produce high-quality goods and services and to develop their cultures, society and the economy and deal with the past.

The adoption of the Constitution of the Republic of South Africa, 1996, provided a basis for curriculum transformation and development in South Africa. Among the many aims of the Constitution, the following two are relevant to the research being undertaken. The first is to:

- heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights; the second aim is,
- to improve the quality of life of all citizens and free the potential of each person (DoE, 2003).

The new constitution therefore opened up avenues for the formerly subjugated to enter into discussions and express their understanding of words like "knowledge", "education" and "science education"; words which had previously been defined for them.

The White Paper on Education and Training of 1995 located education and training within the national Reconstruction and Development Programme, where new priorities and values for the education and training system were outlined. The Reconstruction and Development Programme expressed its wish for an education system where:

> Education must be directed to the full development of the individual and community, and to strengthening respect for human rights and fundamental freedoms. It must promote understanding, tolerance, and friendship among all South Africans and must advance the principles contained in the Bills of Rights (RDP 1994).

The RDP policy took note of the domination of the minority government at the expense of the majority where it states:

> Apartheid patterns of minority domination and privilege are not confined to the state and parastatals. Every aspect of South African life is deeply marked by minority domination and privilege. A vast range of institutions in the private domain (in civil society) benefitted from apartheid, and also actively fostered and sustained it (RDP 1994).

The new government was determined to use education as a vehicle for change. The vision for the new education system was a bold departure from the old type of education. The White Paper recognised the role played by education in the reproduction of social class distinctions that were associated with the ethnic structure of economic opportunity and power (White Paper 1995). It outlined various ways in which education, including science education, was to be used to heal South Africans. The Education Department as a vehicle through which knowledge is transmitted was therefore entrusted with the transmission of the kind of education that can heal South Africans. The kind of knowledge that education transmits to recipients has been associated with the kind of society produced after people have undergone such an education.

As part of reconstruction, reconciliation and redress, many policies were drawn up to facilitate the social integration of a South Africa which had formerly been divided along racial lines. The new Constitution sought to build a new nation from the racially segregated South Africans, a nation in which social justice and many other forms of justice and democracy would be afforded to all South Africans. Among the myriad of policies, the Indigenous Knowledge Systems policy of 2004, which forms the cornerstone of this study, emerged.

1.3.2 Knowledge and education

In an attempt to integrate indigenous knowledge systems and modern science, which is the purpose of my research, it becomes necessary to reach agreement on what knowledge and education are understood to be from the perspectives of both modern science and indigenous people. The broad definitions of knowledge and education will be revisited as a way of locating the integration of modern science and indigenous knowledge systems within an understanding that is acceptable to both knowledge systems.

Many questions have been raised by scholars and ordinary people regarding the role of western education in African societies (Nyerere 2004). What knowledge ends up in the curriculum as education? What is the role of the knowledge that we impart as education in schools? Hoppers and Richards (2011) in their book, *Rethinking Thinking*, have also asked questions on the role of education in the light of a myriad of "intractable problems" that engulf humanity. This study probes how an inclusive science education and education in general can best serve the people of South Africa. Is it possible to offer an education that capacitates people to self-employ and to solve their problems using the knowledge they gained at school and in their communities? Is science education imbued with strategies of citizenship, governance and democracy to attend to issues of democracy and citizenship? How does science education serve humanity? These questions and many others led the need to want to understand what knowledge is in the first place.

On the issues of curriculum content, this study asks: What influences the choice of the knowledge that is eventually transmitted through education? Is scientific knowledge the only type of knowledge that people need? Why is there still so much suffering despite the fact that so much scientific knowledge is offered at schools and universities? Lastly, what knowledge do communities need in order to cope with the demands of everyday living? All these questions cannot be answered through a single research project. In this research the two knowledge systems, modern science and indigenous knowledge systems, will be examined and a model of integration will be explored.

1.3.3 The orientation of my study

My study was carried out at the University of South Africa under the supervision of Professor Catherine Odora Hoppers, of the South African Research Chair in Development Education (SARChI-DE), whose keynote address struck a chord with me when I met her for the first time in 2008. I had never heard such a relevant address from an academic, delivered in a manner that was easy to follow and understand. She skilfully and passionately demonstrated a vision of a possible future in which education serves humanity. As one of the attendees who flocked out of the hall to get her details as she left, I knew then that this could be a starting point on my journey towards an understanding and reconciliation of my past, present and future. I realised I could define my role in my space and chart a way into the future armed with the understanding of necessary concepts.

The SARChI in Development Education is funded by the Department of Science and Technology, administered by the National Research Foundation and hosted by UNISA. The SARChI in Development Education has the following goals:

> To:
>
> - Move beyond post-colonial theorizations to transformative intervention;
> - Commit to transforming the University from an ivory tower to a Civic space;
> - Make transdisciplinarity a core facet of Leadership;
> - Offer robust expositions of the constitutive rules and norms that control current thinking and practice;
> - Represent an epistemology of hope—hope that probes the future and thereby illuminates the possibilities of the present (SARChI in Development Education Poster).

It is this vision of SARChI that has influenced me first of all in undertaking this study and it will be obvious throughout my study that it has largely shaped my thinking in the writing of this topic.

The following concepts are the key drivers of development education at SARChI:

- Education as transformatory pedagogic action.
- Knowledge(s) in the plural.
- Interface between self-determination and co-determination
- Coexistence with the "other."
- Human development as the re-negotiation of human agency.
- The cultural, knowledge and epistemological "Common" as the link between nature, livelihoods, sharing and citizenship.
- Reclamation of citizenship in the knowledge production and ownership arena (SARChI in Development Education Poster).

One of the distinctive features of the SARChI scholarship methodology is what my supervisor calls "immersion". This is a process where students meet one another and meet leaders from various academic fields, knowledge holders from indigenous communities and speakers on a wide variety of topics. This diverse group of people is assembled at various stages in the lives of students and interaction takes place on various topics with people from diverse cultural and academic backgrounds. This is a process where ideas get shaped, changed, abandoned and new ideas reformulated. Ideas on science, education and nature expressed in this study have been shaped by these interactions as well as by the literature.

In conducting this study: "Integration of modern science and indigenous knowledge systems: Toward a coexistence of the two systems of knowing in the South African science education, which will culminate in a suggested model for the integration of indigenous knowledge systems and modern science, it becomes necessary to first of all establish what the broad understanding of knowledge is and then narrowed it down to how the two knowledge systems view knowledge. As this study attempts to integrate the two knowledge systems it is necessary to understand the original ideas about knowledge; this is rather like defining knowledge from first principles. What do indigenous people consider to be knowledge, how do they produce knowledge, what do they use knowledge for? The currently held notions of what knowledge is and what education ought to be are part of the dominant Western discourse whose conceptions and philosophies of knowledge were constructed without the participation of indigenous people.

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The current thinking and accepted norms that control the lives of millions in Africa are part of the dominant discourse which has historically been influenced by colonisation, resulting in the subjugation and oppression of black people. The voiceless Africans have not played a decisive role in the formulation of the constitutive rules or of forces that bind them in every facet of their lives. In finding freedom from this oppressive past, these formulations need to be understood by all and renegotiated in a space where knowledge and education are redefined. It is a place where dialogue should begin for both the oppressor and the formerly oppressed.

1.4 The research problem

Contemporary global politics have relied on policies, constructs and knowledge systems of Western origin, to the exclusion of the people to whom such policies, laws and treaties are regularly applied (Nabudere 2011). The transformation of South Africa from a state under apartheid rule to a democracy came with a constitution that promised among others social justice, environmental justice and cognitive justice, along with rights that included the right to education and the right to participate in the culture of their choice (Constitution of the Republic of South Africa 1996).

The proposed integration of indigenous knowledge is an act aimed at the inclusion of the formerly ostracised, humiliated and marginalised black people into the knowledge production arena in South Africa. This attempt to use both African knowledge and African ingenuity to inform African education, practices and problem solving in Africa was one of the many ways to cement the transformation in South African politics. It also formed part of redress, where excluded people and their culture are brought into the mainstream of politics of the new South Africa. The introduction of indigenous knowledge systems into the politics of South Africa in general and into the curriculum in particular was probably the most effective way of achieving social and cognitive justice, if not the only way (DST 2004).

The Indigenous Knowledge Systems Policy (IKS) of 2004 was spearheaded as a way of formalising the affirmation that indigenous people of Africa have knowledge that is necessary and useful to the indigenous people as well as to other peoples of the world. Black people were being given an opportunity to say what they have always known but have not been able to share with the world owing to colonisation and other structural constraints that their new government have found themselves confined by as a result of colonisation (Hoppers 1998). It is in this light that this study makes an important contribution towards marrying the two knowledge systems, the indigenous knowledge system and modern science, so as to get the best from the two models of knowing. The IKS policy has explicitly outlined to the education system how this policy should be enacted in the education system. The education system has in all its subjects policies included the need to "value indigenous knowledge" across all subjects.

Several researchers who have studied IKS practice at schools and in the science subject in particular have unfortunately shown that the implementation of this policy is proving to be a challenge to teachers from both the epistemological and the pedagogic perspectives (Mosimege 2001; Naidoo 2010; Linneman, Lynch, Kurup, Webb and Bantwini 2003). In cases where teachers have tried to integrate the knowledge systems, they have followed very different approaches, and this is likely to jeopardise or further marginalise indigenous knowledge systems. Furthermore, in a study carried out by Nnadozie (2009) she concluded that "there was in fact no evidence of a proper understanding and integration of indigenous knowledge in their teaching". The study further recommended that the curriculum designers should make the ideas of the policy documents more explicit, by including some instructional strategies in the policy document (Nnadozie 2009).

It does not appear to be easy to reach consensus on how to implement this policy at school level, given the different epistemological and axiological frameworks of the two systems of knowing. The current education system is essentially structured along the lines of century-old systems of teaching and learning (Roeper 1990); these systems succeeded in excluding indigenous knowledge systems from the education of blacks. This research seeks to establish how indigenous knowledge systems and modern science can be integrated into a curriculum that employs best educational

practices and knowledge from both modern science and indigenous knowledge systems. The research attempts to find a model that can guide teachers in the South African education system to integrate both modern science and indigenous knowledge systems into the science curriculum in the South African education system.

Knowledge that people have and knowledge that they do not have determine the kind of society that they create (Harding 2010). Knowledge is invariably transmitted through education, formal or informal. The envisaged transformation of South African society was never going to be easy given that the knowledge held by South Africans and the knowledge in the public domain was knowledge that had been used to dehumanise both the victim and the perpetrator in South Africa. The integration of indigenous knowledge systems into education meant that the integration has to happen in the entire subjects being taught. In this study, the integration is looked at in relation to the science subjects. As a way of advancing the arguments in favour of the integration of IKS and modern science, and drawing from the philosophies and definitions of education and knowledge, the following questions are asked in the light of the challenges facing Africa in general and South Africans in particular:

1. Which knowledge are we using in the South African schooling system, is it modern science or is it indigenous knowledge?
2. What model can be used to integrate modern science and indigenous knowledge systems?

1.6 Aims and objectives

The overall aim of this study is to critically analyse the tension that exists between modern science and IKS in order to provide a model for the integration of the two systems of knowing in the South African science curriculum.

1.7 Objectives of the study

1. To provide an extensive review of the definition of knowledge and education.
2. To give an overview of modern science and the indigenous knowledge systems.
3. To describe the South African science education policies and the IKS policy.

4. To construct a model of indigenous knowledge systems in conjunction with modern science as a way of transforming science education through enlargement.
5. To present an analysis on the literature on modern science and indigenous knowledge systems and provide conclusions for future research.

1.8 Methodology

Research is the systematic process of collecting and logically analysing data for some purpose (McMillan & Schumacher 2006). It has been widely assumed that the goal of research is to find new knowledge of the world (Hammersley 1995). This research aims to find a way of integrating IKS and modern science without compromising the integrity of either knowledge system. A qualitative approach is deemed as an appropriate methodology for this enquiry as will be explained in the following discussions.

Qualitative research is an umbrella concept covering several forms of inquiry that help us to understand and explain the meaning of socio-cultural phenomena without disrupting the natural setting. It is based on the view that there is a contrast between reality and individuals interacting with their socio-cultural worlds. In contrasting qualitative research with quantitative research, quantitative research is seen as research that takes apart a phenomenon in order to examine the component parts (which become variables of study), while qualitative research reveals how all the parts work together (Merriam 1998). The integration of modern science and indigenous knowledge systems seeks to find a way for the two systems of knowing to work together rather than finding out how each works. A qualitative methodology focuses on the qualitative aspects of meaning and is employed in order to explore the meaning, or describe and promote understanding, of human experiences.

Qualitative work, according to Lindsay Prior, was developed by anthropologists while examining life in non-literate societies (Prior 2003). In discussing the knowledge of people who are not necessarily literate, or rather people whose knowledge does not depend on literacy, it is therefore prudent to use a methodology that was designed to accommodate the aspect of non-literacy.

Exploratory design research studies topics that have not previously been studied and attempts to identify new insights and new understandings, to discover new meanings and to explore factors related to the topic (Brink & Wood 1998; Neuman 2006). The purpose of exploratory research is intertwined with the need for a clear and precise statement of the recognised problem. Researchers conduct exploratory research in order to diagnose a situation, and to find alternative new ideas http://custom.cengage.com/static_content/OLC/0324324979/qualresCh06.pdf .

The **exploratory design** for this study is deemed as most appropriate due to the lack of sufficient experience or research on the integration of modern science and indigenous knowledge systems being available. As stated earlier, the studies on integration have mainly been on integration within specific subjects. This study is different as it goes a slightly different route by studying the integration as knowledge and not subjecting indigenous knowledge systems to the compartments as pre-determined by western education and science. The flexibility, consistent with the exploratory design allows the researcher to move away from the rigidity that could be a constraint in finding new avenues for expression and knowledge production. The envisaged model, it is hoped will allow for a new repackaging of information into knowledge in a manner that makes it easily attainable and useful to all.

Secondary data will be collected from literature on modern science and indigenous knowledge which is literature on the two knowledge systems. Data will also be sourced from the policies of the Department of Education. The policies of the Department of Basic Education will not be analysed but simply coded for themes which will then be used to support the envisaged model.

The dominance of modern science over indigenous knowledge is suggestive of unequal power relations between the two knowledge systems. The relationship between the two knowledge systems needs a method that is able to critically examine the nature of this relationship. Indigenous knowledge as the older of the two forms of knowledge, which could arguably be deemed as the source of all knowledges, appears to have been replaced by a relatively younger form of knowledge - modern science- stripping indigenous knowledge systems most of what it stood for. This relationship seems attributable to the use of text, oral or written and maybe even both

as ways of communicating the two forms of knowledge because it is only through forms of communication that knowledge makes it to the public domain.

Critical discourse analysis (CDA) as a method that examines the way power and discourse influence each other in sociocultural and political presuppositions, seems to be the most appropriate analytic method to use in order to analyse data so as to get insights into the nature of the relationship between the two knowledge systems and to shed light on discursive processes that allowed for the dominance of modern science over indigenous knowledge systems. In this study, critical discourse analysis maintains that inequalities and injustices are enacted, reproduced and legitimated by, among other things, notions, text and talk (Fairclough 1992, Van Dijk 1993). Critical discourse analysis as a method is considered relevant as a way of exposing the structural constraints that are invariably contained in modern science texts (Fairclough 1992; Van Dijk 1993). It is these structural constraints that have necessitated the need for this study. The study employs discourse analysis to interpret and support the envisaged transformation buried in the policies of the Department of Education

1.9 Rationale and significance of the study

In all its subject policies the Department of Education has called for the valuing of indigenous knowledge systems. This means that all teachers in all subjects are expected to infuse indigenous knowledge into the teaching of their subjects. The Indigenous Knowledge Systems Policy of 2004 also calls for the integration of indigenous knowledge in all subjects.

Plurality in ways of knowing and doing has been called for by communities of formerly colonised nations as a way of finding what they lost as a result of the brutality of colonisation. Allowing communities to use what they know for their livelihood is a right they should not be denied in any democracy. Africans have long relied solely on the intellectual, technological and financial resources of other countries since colonisation and after independence. In valuing indigenous knowledge as the knowledge transmitted at schools, learners of this generation are able to retrace their culture and knowledge, restore their dignity and recover

whatever knowledge systems existed among Africans. This should go a long way into building self-reliant and confident African communities. The challenge that teachers are facing is that most do not know what indigenous knowledge systems entail, having been exposed to only western constructs of knowledge during their teacher training; they know little about indigenous knowledge systems themselves.

This study is an important contribution to education in general and science education in particular because education, formal or informal, is a vehicle through which the values and knowledge that all societies possess are transmitted to future generations (Nyerere 2004; Durkheim 1979). Education needs to value the individual, the community and the world. It also needs to lead to sustainability of the environment, promote livelihoods and promote human rights, peace and security.

There is limited documentation on the integration of IKS and modern science. The literature that deals with the integration of IKS tends to limit the integration to a subject or to integration within the subject, for example integration in ecology, environmental studies and agriculture. This study will, however, not confine itself to a particular subject as subjects are considered here to be very small representations of disciplines, where the content is arbitrarily selected (Beane 1995) based on the likes and or dislikes of whoever is picking the content; instead the study will deal with the integration of science as a discipline, with indigenous knowledge systems.

Harding contends that the content of science as a subject was subservient to the knowledge needed for the European expansionist voyages into Africa and had little to do with the welfare of Africans. The choice of content was in some cases necessary to the subjugation of the colonised. The particular content developed had little or nothing to do with the welfare of the colonised (Harding, 2009) in this case Africans. This means that for Africans studying science as the only truth about nature, their own knowledge on nature is sacrificed, lost and unbeknown to them eventually exploited. Science curricula in schools therefore do not contain all that there is to know about nature. Some of the knowledge on nature is still with the local inhabitants of such communities. It becomes prudent therefore to get what remains of indigenous knowledge while the holders of such knowledge are still alive.

1.10 Limitations of the study

The following are the limitations of this study:

- There is not enough documentation on IKS.
- The literature that deals with the integration of IKS tends to stick to integration within subjects or disciplines. This assumes that indigenous knowledge can be taught in disciplines as in western science.
- In dealing with indigenous knowledge, the assumption is that what modern science considers knowledge and how this knowledge is produced applies to indigenous knowledge definition of knowledge and its considerations in production of knowledge.
- The integration of any knowledge system and IKS has not been successfully carried out anywhere.
- Science and IKS have never been successfully integrated; therefore the model being developed is not fully supported by literature.

1.11 Clarification of concepts

1.11.1 Modern Science

The body of knowledge that emerged after the ancient methods of knowledge production were radically changed over the years. Modern science uses the scientific method as a means of knowledge production (Greenwood 1959). This knowledge was radically different to knowledge produced before this era. More on this is discussed on the section dealing with modern science in chapter 3.

1.11.2 Indigenous Knowledge systems

Indigenous Knowledge Systems is defined as

> The combination of knowledge systems encompassing technology, social, economic and philosophical learning, or educational, legal and governance systems. It is knowledge relating to the technological, social, institutional, scientific and developmental experiences including those used in the liberation struggles (Odora-Hoppers & Makhale-Mahlangu 1998).

1.11.3 Integration

Integration refers to the combining of two or more things so that they work together effectively (Integration n.d). The word “integration” has also been used to described as a process of attaining close and seamless coordination between several departments, groups, organisations, systems etc. (Businessdictionary n.d.)
In this case, the integration refers to the two knowledge systems.

The proposed integration of indigenous knowledge systems and modern science requires the two knowledge systems to be used in a manner that does not compromise either. They should both be used as “knowledge” and the artificial distinctions should be done away with. Knowledge in both systems of knowing should be used in the curriculum as knowledge that prepares learners for their responsibilities in their communities, their country and the world.

According to Beane, curriculum integration begins with the idea that the sources of curriculum ought to be problems, issues, and concerns posed by life itself. These concerns would be:

1) self- or personal concerns and
2) issues and problems posed by the larger world.

According to Beane, the central focus of curriculum integration is the search for self- and social meaning. This allows for young people to integrate learning experiences into their schemes of meaning so as to broaden and deepen their understanding of themselves and their world and also engage them in seeking, acquiring, and using knowledge in an organic not an artificial way (Beane 1995).

1.11.4 Coexistence

The Free Dictionary http://www.thefreedictionary.com

- To exist together, at the same time, or in the same place;

- To live in peace with another or others despite differences, especially as a matter of policy.

Coexistence in time leads to hybridisation of knowledge, and ultimately to a more integrated representational field. Hybridisation is a process that creates new representations out of dialogues between areas of knowledge over time. Almost all knowledge systems are hybrids (Jovchelovitch 2007).

1.11.5 Cognitive justice

The term "cognitive justice" was coined by an Indian scholar, Visvanathan. It is a concept that arose in response to the destructive impact of hegemonic Western science on developing countries and non-Western cultures. It is based on the recognition of the plurality of knowledge and expresses the right of the different forms of knowledge to coexist. According to him, the different knowledges are related to different livelihoods and lifestyles and should therefore be treated equally (Visvanathan 1997).

1.11.6 Hegemony

The Merriam Webster dictionary defines hegemony as "the social, cultural, ideological, or economic influence exerted by a dominant group" (Merriam Webster Dictionary 2013). In Marxist philosophy, cultural hegemony describes the domination of a culturally diverse society by the ruling class, who manipulate the beliefs, explanations, perceptions, values, and way of life— so that the views of the ruling class become the world view that is imposed and accepted as the cultural norm. The dominant ideology of the ruling class now becomes accepted as the universally valid dominant ideology that justifies the social, political and economic status quo as natural and inevitable (Columbia Encyclopaedia 1994). Science curriculum in the South African education system is characterised by hegemony, with learners from diverse cultural, geographic and environmental settings learning the same concepts and finally being examined using a national examination with a set memorandum.

1.11.7 Holistic education

Holistic education is a philosophy of education based on the premise that each person finds identity, meaning and purpose in life through connections to the community, to the natural world, and to humanitarian values such as compassion and peace. Holistic education aims to call forth from people an intrinsic reverence for life and a passionate love of learning. This is the definition given by Ron Miller, who started the journal *Holistic Education Review* (now entitled *Encounter: Education for Meaning and Social Justice*). The term holistic education is often used to refer to the more democratic and humanistic types of alternative education as opposed to the current homogenous Western education inherited from colonial times. Martin distinguishes holistic education from other forms of education on the basis of its goals, its attention to experiential learning and the significance that it accords to relationships and primary human values within the learning environment (Martin 2002).

The concept of holism refers to the idea that the system as a whole determines how its parts behave. This means that all the properties of a given system in any field of study cannot be determined or explained by the sum of the component parts. A holistic way of thinking tries to encompass and integrate multiple layers of meaning and experience rather than defining human possibilities narrowly. This is in opposition to the fragmented and compartmentalised form of education as expressed in subjects and disciplines, taught in a manner that seems to suggest that there is no relationship between them.

Holistic education attempts to prepare students to meet the challenges of living as members of their communities, who participate in activities and problem solving in their communities, in addition to being academics. Holistic education believes it is important for young people to learn:

- About themselves
- About healthy relationships as well as expected behaviour at school, and to learn pro-social behaviour
- Social development

- Emotional development
- Resilience

In addition, they need to develop the ability to

- See beauty, experience awe and transcendence, and appreciate “truths” in some sense (Holistic-education n.d)

1.11.8 Social transformation

Social transformation refers to large-scale social change as in cultural reforms or transformations (Social_transformation n.d.) The social transformation referred to in this dissertation is multifaceted since it involves the class structure, imposed by both the colonial and the apartheid systems and the knowledge structures that have sustained the abuse of many South Africans.

Colonisation and apartheid have brought upon the Africans a form of social transformation from pre-colonial Africa to the kind of society Africa now has. Social transformation in this context requires a shift in the collective consciousness of a society—local, state, national or global—so that reality is refined by consensus. Scientific discoveries, like religious and royal edicts, have triggered many social transformations throughout history. Social transformations are such that when they sustain over time, attitudes and values that are held in a completely new context (or paradigm) are based upon different assumptions and beliefs (Social Transformation n.d) and even new knowledge. The envisaged social transformation should be realised through knowledge used in the process of policy formulation and education.

1.11.9 Social justice

Social justice is a process, not an outcome, which seeks fair (re)distribution of resources, opportunities and responsibilities; it also challenges the roots of oppression and injustice and empowers all people to exercise self-determination and realise their full potential; finally it builds social solidarity and community capacity for collaborative action (Berkeley socialwelfare n.d).

1.11.10 Commons

Commons refers to the cultural and natural resources accessible to all members of a society, including natural materials such as air, water, and a habitable earth. These resources are held in common, not owned privately. The resources held in common would include everything from natural resources and common land to software.

1.11.11 Marginalisation

Marginalisation generally describes the overt actions or tendencies of human societies whereby those perceived as being without desirability or function are removed or excluded (i.e. “marginalised”) from the prevalent systems of protection and integration, so limiting their opportunities and means of survival. The following definition of social mobilisation is seen as the best definition to captures South African context:

> Marginalization has been defined as a complex process of relegating specific groups of people to the lower or outer edge of society. It effectively pushes these groups of people to the margin of society economically, politically, culturally and socially following the policy of exclusion. It denies a section of the society equal access to productive resources and avenues for the realization of their productive human potential and opportunities for their full capacity utilization. This pushes the community to poverty, misery, low wage and discrimination and livelihood insecurity. Their upward social mobility is being limited. Politically this process of relegation denies people equal access to the formal power structure and participation in the decision making processes leading to their subordination to and dependence on the economically and politically dominant groups of society. As a consequence of the economic, political and cultural deprivation a vast chunk of the population has emerged to be socially ignorant, illiterate, uneducated and dependent. Devoid of the basic necessities of life they are relegated to live on the margins of society. (Sociology Guide n.d).

1.11.12 Subjugation

"Subjugate" is defined as: To bring under control; conquer or to make subservient; enslave. Subjugation is like oppression or conquest: one group takes control over another and forces them to do as they are told. Subjugation is one of many types of injustice in the world. It has to do with one group of people dominating another group by taking away their freedom (Subjugation n.d.).

1.12 Summary of chapters

Chapter 1 is a reflection on my past, my experiences of the events of the changing world around me. I describe the effect that the political changes in South Africa had on the new policies after apartheid as well as the new policies that foster the new system of education. The relationship between modern science and indigenous knowledge systems is briefly discussed.

Chapter 2 discusses the meaning of knowledge and indigenous knowledge systems and its epistemic constructions.

Chapter 3 explores the historical constructs of modern science and science education. Education policies in the South African education system are explored.

Chapter 4 explores alternative forms of science education that have been suggested at various points in the history of science. It also reveals factors that contributed to the marginalisation of indigenous knowledge.

Chapter 5 discusses Afrikology as a theoretical framework for studying the integration of indigenous knowledge systems and modern science. The relevance of Afrikology for deconstruction is discussed. The factors that contributed to the marginalisation of indigenous knowledge systems are also dealt with.

Chapter 6 describes the research design for this project. Data analysis is carried out and findings reported.

Chapter 7 discusses necessary conditions for integration of the two knowledge systems. Alternative forms of education are explored and a model proposed for integration.

Chapter 8 Discusses the integration of modern science and IKS. The model is explained to demonstrate how it brings the two systems of knowing together.

Chapter 9 Presents Conclusions, recommendation

Conclusion

This chapter locates my study in the experiences I have had, growing up in traditional societies that relied on indigenous knowledge systems for their survival, well-being and sustainability. This chapter also highlights the changes in the lives of indigenous communities in their encounter with colonisation and apartheid. It demonstrates the use of political power and brutality shrouded in policies in the subjugation of indigenous knowledge systems and the ultimate coercion of indigenous people into the dominant structure that they eventually became part of. Biopiracy exposes dishonesty in the perceived dichotomy between the two knowledge systems. The next chapter focuses on the epistemological frameworks of indigenous knowledge system and brings into focus the knowledge produced in the indigenous systems of knowledge production.

CHAPTER 2: KNOWLEDGE IN THE INDIGENOUS KNOWLEDGE SYSTEMS

The study seeks to critically analyse the tension that exists between modern science and IKS – the two knowledge systems. In working towards finding means of integrating the two knowledge systems, an extensive overview of what knowledge is needs to be deliberated on in order to facilitate the process of working towards the envisaged integrated knowledge system that will encompass both knowledge systems. The first objective of this study requires an extensive review of the definition of knowledge and education while the second objective requires an overview of indigenous knowledge systems and modern science.

In defining knowledge and education, these concepts are interpreted as they apply to the two knowledge systems so as to facilitate integration. The discussion in this chapter should facilitate the design of a model of integration, which is also one of the objectives of this study. The skewed power relationships inherent in the two knowledge systems call for an understanding of what knowledge is, how knowledge is acquired and structured and where the roots of the dualism and power between modern science and indigenous knowledge systems originated.

2.1 The many faces of knowledge

Knowledge is generally transmitted through some kind of education, formal or informal. In this chapter, a look at how knowledge and education are understood in modern science and indigenous knowledge systems is explored. Overviews of both knowledge systems, their philosophical and epistemological frameworks are also explored. This is an important undertaking as it brings to focus the areas of convergence and divergence as a prelude to the integration of the two knowledge systems. Discussion of how knowledge is currently produced in the public domain in South Africa forms an important basis that needs to be considered as a way of informing the integration of modern science and indigenous knowledge systems in the South African curriculum.

Hoppers and Hountondji see knowledge as a universal heritage and a universal resource that is diverse and varied and is found in all cultures. Knowledge accordingly informs values inherent in societies as well as traditions around the world (Hoppers 2002; Hountondji 2002). This is supported by Harding, who recognises that all societies produce knowledge; this nullifies the tabula rasa idea that had been perpetuated by the West during their colonisation adventures (Harding 1994, 1997). All cultures have therefore produced knowledge that guides their well-being.

The Catholic Encyclopaedia includes religion in its description as follows:

> The consciousness of an object, i.e. of anything, fact or principle belonging to the physical, mental or metaphysical order, which may in any manner be reached by cognitive faculties. An event, a man, a geometric theorem, a mental process, the immortality of the soul, the existence and nature of God, may be so many objects of knowledge (New Advent n.d)

The Catholic definition of knowledge embraces spirituality, something that has increasingly been separated from knowledge in the mainstream discussions on knowledge, as will be shown in the following chapters. While millions of human beings regard knowledge of the spirit world as the lynchpin of their whole orientation in this world, spirituality is increasingly being left out of the education transmitted through formal education and in the lives of the young. In some circles, spirituality is sometimes even frowned upon. Many have blamed the loss of spirituality for the moral degeneration that has engulfed the modern world (Masters 1987; Ellis 2005).

Davenport and Prusak (1998) define knowledge as a fluid mix of framed experience, contextual information, values and expert insight that provides a framework for evaluating and incorporating new experiences and information. This framework regards knowledge constructed by any individual as valid knowledge. This suggests that everyone is essentially a knowledge producer.

Dewey sees knowledge as a perception of those connections of an object which determine its applicability in a given situation (Dewey 2001). In Dewey's definition

knowledge is not static, it continues to change as new relationships are formed with new situations presenting.

Another dimension of knowledge that emerges from Dewey's definition is that knowledge can also be seen as power. Knowledge as power has allowed those with the knowledge or those with the power to decide what knowledge should be in the public domain to dominate others. The domination of nations over other nations has not always been based on brute force but on the knowledge at their disposal; knowledge they do not have as well as, of course, the innovation and creativity they bring to bear in using their knowledge. Knowledge acquisition should ideally create opportunities for innovation and creativity on the one hand, and avert discrimination and oppression on the other.

Dewey defines ideally perfect knowledge as knowledge that presents a network of interconnections where all experiences are valued and seen as contributing to knowledge already accumulated in order to solve problems in new contexts in the future. This knowledge is accordingly acquired through experience, study and what others have ascertained and recorded (Dewey 2001). Formal education should ideally make room for experiences of learners that are not in the curriculum.

It is a common scientific cliché that "knowledge" is "power". The expression is attributed to Sir Francis Bacon. However, Hobbes also wrote "The end of knowledge is power ... the scope of all speculation is the performing of some action or thing to be done." This means that the power of knowledge lies in its consequences. Knowledge itself does not have power, but the consequences of knowledge embrace power (Macpherson 1968). Scientific knowledge, as knowledge that is currently powerful, therefore has power.

2.2 Knowledge and discourse

In his theory of the relationship and interrelationship between power and knowledge, Foucault argues that knowledge and power are inseparable, that forms of power are imbued with knowledge, and that forms of knowledge are permeated by power relations. No body of knowledge, states Foucault, can be formed without a system of

communications, records, accumulation and displacement which is, in itself, a form of power. Conversely, no power can be exercised without the extraction, appropriation, distribution or retention of knowledge. Power and knowledge are two sides of a single process. Discourses are, therefore, about what people are allowed to say or think but also about who can speak, when, where, and with what authority (Foucault 1980).

Ball (1990) concedes that the possibilities for meaning, for definition, are pre-empted through the social and institutional position from which this discourse comes. Meanings thus arise not from language, but from institutional practices, from power relations, from social position. Discourses construct certain possibilities for thought. They order and combine words in particular ways to exclude or displace other combinations (Foucault 1971; Ball 1990; Hoppers 1988). This intention plays itself out in modern society where meanings and definitions are pre determined for the masses. This is pronounced in many education systems; where meanings are pre determined and kept in place through examinations and memoranda.

2.3 Categories of knowledge

According to Gustavsson, there are three forms of knowledge:

- scientific knowledge
- practical knowledge
- ethical knowledge

He argues that these categories of knowledge open the field to the building of a democratic and humanistic value-based education system, located in different activities and action spaces. He further argues that the dominating discourses of human capital reduce knowledge to economics and tend to marginalise the humanistic and democratic dimensions (Gustavsson 2007). Knowledge transmitted through the schooling system should ideally balance the three components on knowledge as defined by Gustavsson.

Knowledge has been used as a commodity, especially in recent years. The technologies protected under intellectual property rights have afforded those with particular knowledge a monopoly on inventions and business (Clabaugh & Rozycki 1999). If useful technological knowledge is tied in intellectual property rights, one wonders if there is still value in the knowledge now transmitted in science curricula in our schools. Knowledge now tied in intellectual property is basically knowledge that is denied learners! Despite this, the acquisition of knowledge at the school level and at university has, become a commercial undertaking on many levels, with schools becoming unaffordable for many parents. The largest budgetary allocations in Africa go to education provisioning according to this website; http://www.tradingeconomics.com/south-africa/public-spending-on-education-total-percent-of-government-expenditure-wb-data.html. What was traditionally a conversation between people exchanging information in African informal settings has becomes commercialised to the point where those who do not have the means to attend schools acquire are likely to remain outside the knowledge circle. Institutions of higher learning are becoming more and more expensive, thereby running the risk of reproducing social hierarchies, because only those with money are able to afford to send their children for higher learning. Unless the production of knowledge is encouraged on all levels, a society that is reminiscent of the medieval societies where knowledge was the preserve of priests in monasteries will eventually be created - the universities will come to resemble the monasteries of ancient times.

2.4 Knowledge as institutional power

Institutional knowledge is directed and controlled by the dominant groups in society (Van Dijk 1993). According to Van Dijk, this institutionalised knowledge gives the dominant groups the power to decide what knowledge makes it to the public space and what knowledge does not. This essentially means the majority of the people who are not part of the dominant group are simply controlled through the knowledge they are allowed to access and the knowledge they are not allowed to have access to. This form of collecting and organising knowledge is therefore a discourse. The example of knowledge about racism in South Africa, and the whole world, is in itself a discourse. The different race groups in South Africa remained separate as a result of the knowledge they held that made them believe in the notion that they belonged to

different “races” as opposed to the human race and were therefore not different. The laws promulgated under this scientifically flawed reasoning made South Africa thrive as an apartheid state owing to the state withholding knowledge from its citizens. The state intervention in allocating people of different social groupings different resources and opportunities cemented the belief in the superiority of white people in the country. Science as a dominant knowledge system agrees that the use of the word “race” to imply black, white and yellow is a misnomer, and yet science fails to explain to everyone that all human beings belong to the human race (Tobias 1961). This knowledge has yet to make it to any curriculum.

Dewey seems to counter the institutionalisation of knowledge with his description of knowledge as presenting a network of interconnections where all experiences are valued and seen as contributing to knowledge that has been accumulated in order to solve problems in new contexts in the future. This knowledge is accordingly acquired through experience, study and what others have ascertained and recorded (Dewey 2001). In Dewey’s definition of knowledge, the power to determine what is and is not knowledge lies within individual personal experiences. In education a learner should be able to establish his or her own relationships instead of recalling previously established concepts as part of learning (Dewey 2001). This seems to contrast with the acceptable practice of knowledge transformation in schools, where learners as Freire asserts are consumers of knowledge produced for them and not producers of knowledge (Freire 1989), making the experience of learning to be less innovative and developmental.

2.5 Knowledge and education

Durkheim sees education as the influence exercised by adult generations on their young in order to stimulate and develop them physically, intellectually and morally, as demanded by both political society as a whole and the particular milieu for which a young person is specifically destined (Durkheim 1979). The kind of knowledge transmitted to learners therefore determines the values they eventually uphold and these are usually reflected in the kind of communities they build. Education as we know it in South Africa, and possibly in other countries where there has been colonisation, has been conceptualised and constructed without the participation of

indigenous people and in the process the colonised people have been removed from their indigenous learning structures while the colonised people were drawn towards the structures of the colonisers (Kelly & Altbach 1984). The values, attitudes as well as what indigenous people considered knowledge has been removed from what influences their young as they become adults. By ignoring the cultural education of learners, education offered to learners will not empower them to build societies that carry their values and attitudes.

Lundgren describes education, society and knowledge in this manner:

> Education can be understood as the genetics of society. It is through education that we produce, from one generation to the next, our values, habits, attitudes and knowledge. It is through education that we create the conditions for cultural and economic growth. This insight is fundamental for educational planning, and thus for governing and monitoring education (Lundgren 2007:35).

The responsibility for developing human beings fully is therefore the responsibility of education systems, where this responsibility extends beyond the transmission of facts and includes all those aspects of humanity that are desirable. Society is a reflection of the knowledge transmitted by its education system.

The pre-1994 South African Nationalist Party maintained its grip on power through various draconian laws and through propaganda which determined the kind of knowledge deemed appropriate for the population (Kallaway 2002; Simson 1980; Tobias 1961). The type and content of knowledge allowed in the public space maintained and promoted the social structures (DoE 1995) as well as the conflict experienced by the majority of South Africans under the brutal regime of the Nationalist Party. This knowledge included racial ideologies which, although scientifically flawed, remained part of the South African political discourse (Tobias 1961). The transformation of educational discourse in Africa therefore requires a philosophical framework that respects diversity, acknowledges lived experience and challenges the hegemony of Western forms of universal knowledge (Higgs 2003). The integration of indigenous knowledge systems and modern science can only take place within such a framework.

If the new democratic government is to usher in new democratic ideals rooted in social transformation, human rights and equality as well as other ideals associated with democracy, knowledge that can promote these ideals is needed. The knowledge and structures that had legitimised oppression and oppressive forms of control over people's lives first need to be understood and deconstructed and new structures, new knowledge and new attitudes ushered in. Modern science as a dominant form of knowledge has played and is still playing a role in framing policies, agreements and practices and is the generally accepted form of knowledge that has been promoted in the public space.

2.6 Knowledge production and the South African situation

When the Nationalist government came to power in 1948, its apartheid policies had major implications for the way in which post-war science in South Africa would develop. In the development of knowledge, heavy emphasis was placed on strategic research within the science councils in order to serve the national security goals of the government of the apartheid nationalist state (Bawa & Mouton 2002; Tobias 1961). In the higher education landscape under apartheid, Ian Bunting, a former Dean at two South African universities, describes the efforts of the apartheid Nationalist government to control universities in South Africa as reducing them to what he calls "instrumentalists", which he describes as institutions which take their core business to be the dissemination and generation of knowledge for a purpose defined or determined by a socio-political agenda, in the case of South Africa the agenda being Afrikaner Nationalist ideology. These universities have consequently been viewed as having a narrow problem-solving, applications-based approach to pedagogy and research and therefore unable to ask critical questions that are able to understand, probe or disrupt official policy or standard practice (Bunting 2002; Jansen 2001).

The white English-medium universities, on the other hand, referred to themselves as the "liberal universities" as they did not always agree with the apartheid government on a variety of aspects but were nevertheless always tied by the laws of the country into submission in many areas of their operation and management (Bunting 2002).

The anti-apartheid stand taken by these universities was what set them apart from the Afrikaans-medium universities but according to some they were never major agents for social and political change in South Africa. Mamdani maintains that their systems of governance and their intellectual agendas made them islands of white social privilege during the years of apartheid oppression, and further maintains that they displayed little sense of social accountability to the broader South African community during this period (Mamdani 1998). These institutions depended on the apartheid government for funding (Bunting 2002).

The historically black universities in the Republic of South Africa (RSA) were under the full control of the Nationalist Party and their administrations were even headed by Nationalist Party supporters. According to Bunting, they simply reproduced what the Afrikaans-medium universities were doing, being products of these universities themselves. They could never produce knowledge that their communities needed.Bunting asserts that these universities produced "useful graduates" who were primarily required by the black school systems and as black civil servants in the racially divided civil service of the Republic of South Africa (Bunting 2002).

Mahmood Mamdani (1999) quoted in Seepe (2008) commented:

> Both the white and black institutions were products of apartheid, though in different ways. The difference was not only in the institutional culture, that the former enjoyed institutional autonomy and the latter were bureaucratically driven. The difference was also in their intellectual horizons. It was the white intelligentsia that took the lead in creating apartheid-enforced identities in the knowledge they produced. Believing that this was an act of intellectual creativity unrelated to the culture of privilege in which they were steeped, they ended defending an ingrained prejudice with a studied conviction. The irony is that the white intelligentsia came to be a greater, more willing, prisoner of apartheid thought than its black counterpart.

Knowledge production in South Africa was therefore flawed, unrepresentative of South Africans, distorted and not liberating. The South Africans now occupying positions of authority and driving transformation are products of this education system, both black and white. In order to correct this, universities in South Africa as

institutions that should challenge the existing paradigms, are called to help deconstruct, expose, and systemically reject the euphemisms of epistemic violence that have entrenched the marginalisation of so many in South Africa and the world over (Hoppers 2012).

Hoppers see tertiary institutions as representing pinnacles of authority in knowledge production, accreditation, legitimating and dissemination. What these institutions choose to include, exclude, or denigrate can make all the difference to the cognitive and operational capacities of the products of this industry in a post-training period. From this perspective, the reconstruction of knowledge, the critical scrutiny of existing paradigms and the epistemological foundations of existing academic practice, together with the identification of the limitations that they impose on creativity, need to precede any specific work on curricula, research or teaching methods because it is there, up-stream at the levels of epistemological foundations, that the orientations that feed the curriculum and details of teaching-learning practices emanate (Hoppers 2001).

It is against this background that knowledge, along with its transmission and methodologies, was conceptualised in South Africa. The voice of the indigenous people had been left out in all the processes that conceptualised and defined education concepts and the way this education should take place. The following section outlines indigenous knowledge systems, in order to pave the way for its integration with modern science.

2.7 Indigenous peoples

Indigenous peoples are found worldwide: for example, Native Americans; First Nations of Canada, Indian nations of South America; the Maori of New Zealand, Africans and the Hawaiian kupunas.[9] The common denominator among indigenous communities is that they have all been subjected to colonisation at some point in their history. It is for this reason that the experiences and thoughts of indigenous peoples who are not necessarily African are shared in my study in order to provide a

[9] Elders of Hawaii

broad understanding of the nature of indigenousness. The colonial experience and the adoption or rather imposition of Western education, modernisation and lifestyles is a common factor among the indigenous peoples of the world. In discussing indigenous people in Africa, Dei points to common elements in African indigenous knowledge systems which he says can be found in variant forms among indigenous people in other parts of the world (Dei 2000).

Varieties of indigenous knowledges are unique to given localities, societies and cultures (Martin 2002). African indigenous communities show many similarities, with minor differences, in the way they look at nature (Jegede 1998). These similarities justify one in speaking of an African world view. According to Jegede, the African indigenous knowledge systems share four fundamental features:

1. The belief in God, the supreme God;
2. A belief in the continuation of life after death;
3. The human being as the centre of the universe;
4. A theory of causality (Jegede 1998).

This African world view, according to him:

> governs the way Africans act, the way they relate to one another and there are socio-cultural antecedents of how Africans learn science and technology (Jegede 1998: 158).

In indigenous communities, the concrete and the spiritual are not separated, they coexist side by side and their activities are informed by this coexistence, complementing and enriching rather than competing and contradicting (Nakashima & Roué 2002; Elaboror-Idemudia 2000).

2.8 Indigenous knowledge systems

Odora Hoppers and Makhale-Mahlangu (1998) in Odora Hoppers (2002) describe indigenous knowledge systems as:

> the combination of knowledge systems encompassing technology, social, economic and philosophical learning,

> or educational, legal and governance systems. It is knowledge relating to the technological, social, institutional, scientific and developmental experiences including those used in the liberation struggles (Odora-Hoppers & Makhale-Mahlangu 1998).

Serote (2001) defines IKS as:

> human experiences, organised and ordered into accumulated knowledge with the objective to utilise it to achieve quality of life and to create a liveable environment for both human and other forms of life (Serote 2001).

Serote's definition encompasses experiences as knowledge— technologies, know-how, skills, practices and beliefs—that enable the community to achieve stable livelihoods in their environment (Serote 2011). Both definitions will be adopted for this study as they are more complementary than contradictory.

Indigenous knowledge systems, sometimes called indigenous science, present themselves as knowledge deeply tied to the earth and everything in it. They present themselves as a holistic form of knowledge that values all human experiences. This knowledge is generally held by indigenous people and transmitted mainly orally.

David Peat, a theoretical physicist, after spending time with the indigenous Native Americans learning about their culture and knowledge, characterised the Native Americans' indigenous knowledge systems as a science, which he described in the following terms:

> a disciplined approach to understanding and knowing, or rather, to the processes of coming to know understanding and knowing. It has supporting metaphysics about nature and reality, deals in systems of relationships, is concerned with the energies and processes within the universe, and provides a coherent scheme and basis for action, on the other hand it is not possible to separate Indigenous science from other areas of life such as ethics, spirituality, metaphysics, social order, ceremony and a variety of other aspects of daily existence. Thus it can never be a "branch" or a "department" of knowledge, but rather remains inseparable from the cohesive whole, from a way of being and of coming-to-knowing (Peat 1994:240).

Cajete describes Native science as:

> a celebration of renewal, where the ultimate aim of the knowledge is not to explain and objectify the universe, but it is rather learning about and understanding responsibilities and relationships and celebrating those that humans establish with the world. The science of the Native Americans is about attention to the subtle, inner natures wherein lie the rich textures and nuances of life rather than seeking to control natural reality (Cajete 2000:79).

Peat observes the holistic nature of indigenous knowledge systems and recognises indigenous knowledge as knowledge in its own right (Peat 1994). Indigenous knowledge, unlike modern science, is not compartmentalised and neither is it reductionist. There is a seamless transition between the material and the spiritual and between all things living and non-living. In indigenous knowledge systems such boundaries are permeable (Cajete 2000; Castellano 2000). The description of indigenous knowledge as "holistic" means that all senses, coupled with openness or intuitive or spiritual insights, form part of the knowledge (Castellano 1998). It must be noted that the aspects of intuition and spiritual insights are not part of modern science.

According to Cajete, who is also a scientist, indigenous science observes the subtleties of nature as part of the knowledge system. According to him, these subtleties are not used to control nature but to help the observer to be in harmony with nature (Cajete 2000). This education, passed on for free in indigenous communities throughout life, is valuable for survival and sustainability. Knowledge in indigenous communities includes not just knowledge in its own right but also ways of using the knowledge. It is not enough to know the properties of a plant, for instance; knowledge of how to prepare the plant for use is equally vital (Nakashima & Roué 2002; Castellano 2000).

2.8.1 Knowledge sources in indigenous societies

The knowledge valued in indigenous societies is derived from multiple sources, including:

1) Traditional teachings, from previous generations, through various vehicles, including story telling;
2) Empirical sources of knowledge gained through careful observation of ecosystems by many people through the generations;
3) Dreams, visions and intuitions revealed to the people and understood by them to be spiritual in origin (Dei, Hall & Rosenberg 2000).

Throughout the millennia indigenous people have had their own unique ways of looking at and relating to the world, the universe, and each other (Asher 2002). Their traditional education processes were carefully constructed around observations of natural processes. They adapted modes of survival and doing, they also learnt to adapt to their physical environment and establish a supply of sustenance from the plant and animal world by using natural materials to make their tools and implements. They developed unique ways of understanding their environment; these largely included demonstrations as well as observation accompanied by thoughtful stories in which the lessons were embedded (Kawagley 1995; Cajete 2000). Indigenous views of the world and approaches to education have, however, been placed in jeopardy by the spread of Western social structures and institutionalised forms of cultural transmission (Barnhardt & Kawagley 2005). While their knowledge is not recognised in formal education, indigenous people still rely on this knowledge for their survival.

According to Hoppers, 70% of African people live in rural areas and use this rural basis of livelihood, existence, contribution to development and subsidisation of the state in areas where communities use their own resourcefulness to overcome their difficulties (Hoppers 2002). Indigenous knowledge about the natural world included knowledge of the fauna and flora in their environment, and their own version of meteorology, physics, chemistry, pharmacology, psychology and the many other skills that are necessary for everyday existence (Dei, Hall, & Rosenberg 2000). The adoption of laws governing indigenous communities is a collective matter for communities (Seymour 2004) with all members of such communities participating in the decision making and knowledge production exercise. Knowledge of the social sciences (politics, the military, economics, sociology, and ethnology) and humanities

(communication, arts and crafts) also formed part of the knowledge basis of indigenous communities. This study will however reflect only on metallurgy, food, health and the environment.

2.8.2 Metallurgy

People in many African countries were knowledgeable about how to find metals, refine them and use them as they were traders in such metals. In South Africa evidence of the rich history of Southern Africa, dating back to about 2000 BC, lay hidden for many years. This evidence of a highly civilised existence hundreds of years before the first Europeans arrived revealed the advanced technologies that existed in what is known as Mapubungwe (Rebirth Africa Life n.d.). The knowledge and skills of Africans and South Africans before colonisation were not included in the sources of knowledge offered to them during and after colonisation. Because these skills were lost through many forms of brutality against the colonised, Africans have been depicted as people who do not have knowledge. The knowledge they once possessed has now been replaced with knowledge that is not always accessible to the majority.

During the colonising of Africans, many of their technological inventions were looted by the colonisers and taken to the countries of the colonisers; these inventions are now gracing museums in Europe and America (Emegweali and Hilliard undated). The Ghana golden mask from the era of the Ashante kingdom, stolen in 1874, demonstrates knowledge of metallurgy, not only knowledge of how to create sculptures but indigenous knowledge of how to mine and refine gold, and indigenous methods of using gold to make artefacts. This loss of knowledge has left the Africans intellectually poorer as they also lost the knowledge, methods and procedures associated with such activities (Opoku 2011).

Artefacts from Benin, made from bronze, also stolen and are now in museums overseas. The well-documented case of the Ethiopian obelisk is also an example that also demonstrate fine workmanship and an understanding of what in today's Western terminology could be classified as geology, technology or just science. This obelisk, taken by Italians as loot, remained on display in Italy in front of a government

department for many years until it was returned to Ethiopia in 2005, after much reneging by the Italian government. The following pictures show the artefacts on metallurgy:

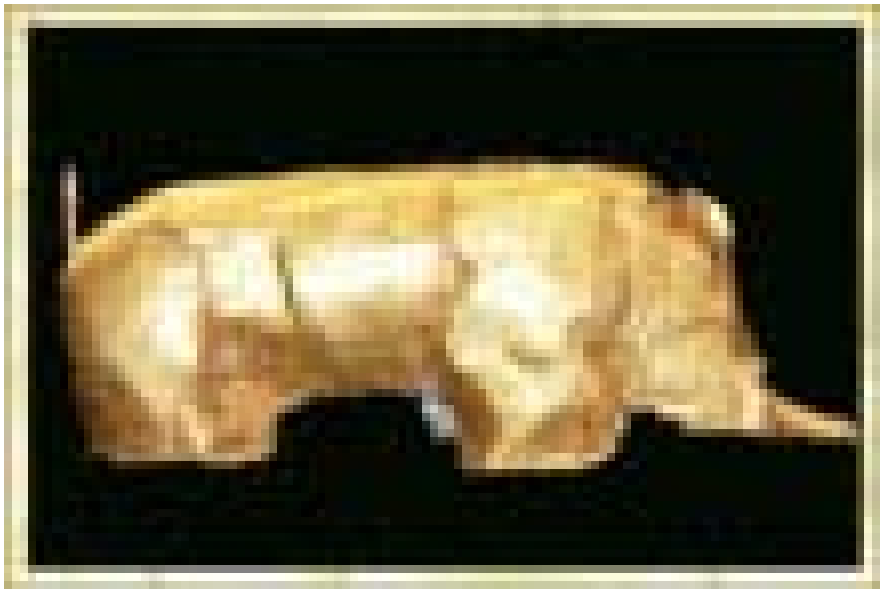

Figure 1 (a) **MAPUBUNGWE Gold Rhino**
http://www.southafrica.net/uploads/legacy/1/313211/sat%2027%20-%20mapungubwe.jpg

Figure 1(b) **YORUBA BRONZE HEAD SCULPTURE**, Ife, Nigeria c. 12th century A.D.
http://ingpeaceproject.com/wp-content/uploads/2012/09/7BronzeHeadSculptureIfeCastOfAKing1.jpg

Figure 1 (c**) IFE KING'S HEAD** in British Museum, dated around 12th century
http://ingpeaceproject.com/wp-content/uploads/2012/09/7-BronzeHeadSculptureIfeCastOfAKing1.jpg

Figure 1 (d) **GHANAIAN GOLD MASK**, 20 cm in height, weighing 1.36 kg of pure gold, seized by the British from Kumasi, Ghana, in 1874 and now in the Wallace Collection, London, United Kingdom
http://www.afrikanet.info/typo3temp/pics/289337cd3d.jpg

Fig 1 (a –d): Examples of metallurgy in pre-colonial Africa

2.8.3 Food

Indigenous communities have always relied on themselves to grow, preserve and store their own food. Their knowledge included knowledge of agriculture, health care, food preparation, education, environmental conservation and a host of other activities (Crossman & Devish 2002). Very few indigenous people today know how to grow their own food, preserve it and trade in food. Traditional methods of growing food have given way to government-funded, industrialised high tech methods of farming that usually require battalions of salaried experts and intellectuals. According to Tudge, these technologies trample on the humble traditional crafts instead of building on them (Tudge 2011). This has left communities poorer, hungrier and dependent on government or international aid for food. In indigenous education this aspect of life was central to the education of every citizen.

2.8.4 Health

Indigenous health knowledge embraces both material and non-material properties of plants, animals and minerals. Sacred associations and empirical frameworks form part of the understanding of health and healing; this includes assumptions about the cosmos, causality and taxonomies that are usually different from the ideas of modern science (Sillitoe, 2007). The traditional health systems follow a holistic approach to treatment which takes into account the mental, social, spiritual and ecological dimensions of well-being. Human illness is not separated from environmental sickness. Recently some Western physicians have also woken up to the idea that the current medical models are not holistic since they neglect external factors in healing (Peat 2008).

African women have always relied on plants to heal various diseases; their vast knowledge of plants ensured that they were able to deal with diseases in their homes and communities. They could diagnose and treat a variety of ailments and problems, such as malaria, headaches, stress, the need to space children, stomach aches, the need to increase lactation, remove the placenta and cleanse the uterus after childbirth (Wane 2000).This knowledge was not institutionalised in hospitals and clinics but was available within communities for free and was easily accessible through

informal and formal education within societies. The indigenous curriculum ensured that this knowledge was passed on through generations.

Emeagwali describes how evidence has been found in Ancient North-East Africa of an understanding of neurosurgery, orthopaedics, gynaecology and pharmacology. Surgical procedures that include male and female circumcision, brain surgery and the excision of tumours as well as the alignment of dislocated bones and the treatment of collarbone fractures have also been documented. Anaesthetics derived from plants identified as having analgesic capabilities have been used in these regions. According to Emeagwali the World Health Organization has recognised the contributions of traditional medicine to psychiatry (Emeagwali 2003).

Most recently, treatments for cancer, obesity, drug addiction, diabetes and other ailments have followed leads from traditional African pharmacologists through plants such as the African willow (South Africa), the hoodia plant (Namibia), iboga (Gabon and Cameroon) and other botanicals. Shaman Pharmaceuticals collaborated with 58 traditional doctors from communities in Guinea, West Africa, between 1994 and 1998 and have since identified plant species found to be useful for the treatment of type 2 diabetes mellitus (Emeagwali 2003). This treatment, if available at a local level, would alleviate the burden of health care for African countries.

2.8.5 The environment

The relationship that indigenous people had with their environment was that of respect for nature (Seymour 2004) because nature provided all their needs, and they depended on the environment for their medicines, food and shelter. Plants were seen as important in native societies and native societies realised a long time ago that a sustainable relationship with plants is the foundation of all human and animal life. Key social and ecological relationships as well as lessons in coexistence drawn from environmental relationships were cultivated by all members of these communities from birth (Cajete 2000). The indigenous ways of caring for the environment have shown that their knowledge of the environment is essential if the future threat of environmental hazards to indigenous communities is to be addressed (Mercer Kelman I, Taranis L and Suchet-Pearson 2006). Many studies attest to this.

2.9 Indigenous education

The education for the African before the coming of the European was an education that prepared him for his responsibilities as an adult in the home, his village and his tribe (Scanlon 1964). This education took the form of a variety of formal observances in addition to the experiences of daily living. It impressed upon the youth his place in the society in which religion, politics, economics and social relationships were invariably interwoven. This education also served to perpetuate the cultural heritage of the ethnic community and to preserve its boundaries, inculcate feelings of group supremacy and communal living and to preparing the young for adult roles and status. It involved youngsters in intellectual, physical and attitudinal training in order to develop them fully into acceptable adults in the society (Scanlon 1964, Baguma and Aheisibwe, 2009). This education had a specific role and was not offered in the formal setting of schools where learners spent their days being taught by teachers.

Special schools for special skills were arranged at specific times during the lives of the young. The most common method of teaching was the method sometimes referred to in the Western world as constructivism, where learners learn by participating and doing. The curriculum was therefore not written but tacitly organized in sequence to fit the expected milestones of different developmental stages that the culture perceives or recognizes (Nsamenang, 2005). Children learnt what fits their abilities as well as their stages of development.

2.9.1 Indigenous education as a preparation for life in communities

The content of education in African society grew naturally out of the physical and social situation and it was shaped by the needs experienced. Values were also taught as part of the education of African children; each member of the family was expected to uphold these values throughout their lives as members of their communities. Those members who did not comply with these expectations from time to time were judged by their own societies and there were repercussions for such behaviour (McCormick 1976).

Education for self-reliance, as advocated by Julius Nyerere, was a type of education that had always been part of African society (Nyerere 1967). In contrasting the education of the African before the coming of the European and the introduction of colonial and post-colonial education, the former appears to have been an education that prepared the recipient for his responsibilities as an adult in his home, his village and his tribe (Scanlon 1964) while the latter was an education that prepared the recipient for modernity (Odora, 1993) and capitalism. Indigenous education took the form of a variety of formal observances as well as the experiences of daily living. These impressed upon the youth his place in a society in which religion, politics, economics and social relationships were invariably interwoven (Scanlon 1964; Baguma & Aheisibwe 2009). This holistic education prepared learners for life in the community as opposed to life outside the community. Since it was not education about facts only, but also about how to be part of society, every aspect of community life was taken care of (Baguma & Aheisibwe 2009).

2.9.2 Indigenous education and its methodologies

Environments for learning in indigenous communities were not artificially arranged to stimulate learning. The everyday environment as it appeared in nature was a stimulus in itself. Indigenous African education incorporates the children's daily routines and the manner of living of their family and community, merging skills and knowledge about all aspects of life into a single curriculum. It does not divide curricular contents into disciplines such as arts, sciences, agriculture, economics or arithmetic. All these skills are used as and when they are needed. This curriculum was designed to address the day-to-day needs of societies in which the children found themselves and to prepare them for their future roles in society as adults, parents and community leaders. The curriculum was therefore needs-based and was intended to give the recipients knowledge and skills that help them make decisions about their lives. The medium of instruction was the mother tongue (Nsamenang 2005).

Mazonde in "Culture and education in the development of Africa" summarises this type of education and its methodologies as follows:

> Understandably in accordance with these objectives the content of African customary education grew out of the physical and, what is more important for our present purpose, social situation. As to methods, both formal and informal processes were utilized for the transmission of knowledge, skills, ideas, attitudes and patterns of behaviour. Thus tribal legends and proverbs were told and retold by the evening fireside, and through them much of the cultural heritage of the tribe was kept alive and passed on to the children. There were riddles to test children's judgement, and myths to explain the origin of the tribe and the genesis of man. Such oral traditions, narrated with care and repetition, additionally constituted the African child's training in what was often a complicated linguistic system without a script. Names of trees, plants, animals and insects, as well as the dangers and uses of each were learnt as boys herded cattle or farmed land with their fathers, and girls helped their mothers in household work. Imitative play, too, formed an important part of informal education. Boys staged mock battles, and made model huts and cattle pens; girls made dolls, played at husband and wife and cooked imaginary meals. The importance of play in customary education in Africa has been underlined by many observers. A major part of the cultural heritage of an African people was transmitted to children and adolescents through these informal activities (Mazonde 2001:3).

It is in the loss of such traditions that the cosmologies of people are forgotten. Matters of life and death are solely in the hands of science and where science fails, people have no recourse. Perhaps this is responsible for people's estrangement from nature, from other people and from themselves.

2.10 Values in indigenous education

The values which influenced the epistemological framework of indigenous societies are discussed in this section.

2.10.1 Spirituality

African spirituality includes notions of harmony, the sanctity of nature, humans as part of nature rather than apart from nature, recognising that human beings are the most vulnerable link in the vast chain of nature. In the world of the indigenous

peoples, God is illuminated in everything in nature and their whole relationship with nature reflects their understanding of the power and mysteries of God in creation. Their deep respect for nature and reverence for the mysteries of nature made them respect nature, allowing only for limited and necessary disturbances, and thereby protecting the delicate ecological balance of nature (Holmes 2007, Cajete 2000). Indigenous people believed that any disturbance of the environment has repercussions for the environment and beyond (Peat 1994). They believed that the earth and nature had to be acknowledged as their mother and they had to live in harmony with and reverence for nature. In indigenous spirituality, God is revealed simultaneously to all peoples of the world. Their collective identities include collective self-reliance and the brotherhood/sisterhood of humans, plants and insects and all creatures. Spirituality in indigenous communities in pre-colonial times was an integral part of everyday life (Dei 2000; Ntuli 2002).

2.10.2 Ubuntu

The word “ubuntu” exists in many languages across Africa and many other indigenous communities elsewhere. Ubuntu is an African ethical or humanist philosophy focusing on people's allegiances to and relations with each other, which simply means recognising any human being as having the right to be as well as the right to dignity (Ubuntu_(philosophy) n.d). Ubuntu is an indigenous African sense of being human. It speaks about compassion, hospitality, generosity and the wholeness of relationships between relatives, communities and all people. African humanness as a value system attests to the importance of relating to, rather than mastering, nature and the environment. African civilisation was not only a matter of technological advancement—it was rooted in social responsibility and environmental sustainability as well (Dei 2000).

In building the culture of Ubuntu, decency of speech and behaviour as well as the spiritual aspects of their communities were impressed upon children from an early age. On reaching adolescence they were taught conformity to expected norms and values, avoidances in line with the expectations of their societies, and prohibitions from what society deemed dangerous or unpleasing to themselves, society and the environment; they were also taught how to curb their natural impulses, especially in

relation to the opposite sex, all in the interest of their communities. Strict codes of morality existed to secure harmony and respect for self and others in these communities (McCormick 1976; Dei 2000). The tribal law and moral codes of African boys and girls were written on minds and hearts and were part of all thinking, feeling and ultimately being (McCormick 1976).

There have been calls for the incorporation of the principle of Ubuntu into the South African school curriculum. This move is seen as having the potential to instil the values required for the transformation of South African society; these values would include tolerance, democracy, communalism, non-sexism and non-racism, as enshrined in the country's constitution and espoused by the Department of Education (DoE, 2003). Many argue that from an early age, schoolchildren should be familiarised with African values such as Ubuntu and communalism so as to ensure that when they enter institutions of higher learning they will be able to engage in discussions of these values in a critical and meaningful way (Letseka & Venter 2012). As children become adults and decision makers, these important values should be able to inform their decisions on behalf of members of their societies. As they participate in civic duties, Ubuntu would provide a framework from which engagements as well as decisions on how to run the country could be drawn.

Conclusion

This chapter has brought into focus various definitions of knowledge and education. The definitions provide a basis from which to design a model for the integration of the two knowledge systems. The chapter also provides an overview of indigenous knowledge systems (IKS). Very little has been said about IKS in academia and indigenous knowledge has been completely excluded from the education of Africans, despite its potential to educate Africans about aspects of their everyday life.

Indigenous knowledge as discussed in this chapter shows the sophistication of this knowledge for example in infusing knowledge on the material and physical aspects of nature as showcased in metallurgy and the intricate knowledge of relationships with the environment and with each other.

The Africans have always had knowledge on nature and technologies they invented, and their knowledge has contributed to the body of knowledge currently used by the world. The lack of acknowledgement of this knowledge has led to the continued subjugation of Africans, their values and their systems of knowing and doing. This exclusion means that the constitutive rules used by the world, and by Africans themselves as a result of relationships in the global environment, are likely to violate the African way of being and doing as they have excluded African knowledge systems.

The need to integrate indigenous knowledge systems into the education systems in Africa and democratic South Africa has become urgent for Africans in educating their children so as to allow for a plurality of knowing and being in a world beset with challenges. This integration of indigenous knowledge systems into the curriculum should ideally not be confined to Africa but shared with the rest of the world in order to offer the world values contained in the African indigenousness and way of being and doing which could help in meeting the challenges facing humanity outside Africa (Brock-Utne, 2008). The technologies and knowledge of Africans, which have in some cases been used without acknowledgement, represent a unique understanding of the laws of nature.

The exclusion of African indigenous systems from the teaching and learning of science in Africa still ties generations of young Africans to the thinking that excluded Africans and their values from the mainstream thinking that has so far facilitated colonisation in Africa and apartheid in South Africa. This chapter demonstrates that what is referred to as IKS is indeed knowledge and the epistemological frameworks of indigenous people, including African indigenous people, are inclusive of both the material and the spiritual aspects of being. The next chapter explains modern science, which is another one of the objectives of this study.

CHAPTER 3: KNOWLEDGE IN MODERN SCIENCE, SCIENCE AND SOCIETY AND SCIENCE EDUCATION

This chapter provides an overview of modern science, an objective of this study. This is deemed as necessary in the integration of the two knowledge systems, modern science and IKS, as it provides an understanding of the frameworks that gave birth to science in the first place. The history of the development of modern science is important as a means of illustrating the ontological and epistemological frameworks of modern science because they have influenced the decisions taken and these decisions have affected the kind of knowledge produced. The relationship between science and society is also important as it shows the impact of this knowledge system on humanity. Science education, as education driven by this knowledge system and the only form of education presented in the schooling curriculum, is examined in relation to the views of recipients of such knowledge as an education that represents knowledge of nature.

3.1 A brief history of modern science

The history of modern science has its roots in the study of nature and philosophy. While the church was the authority on knowledge about nature at the start of the modern scientific period, there was general interest in the understanding of nature by the indigenous people of Europe. The philosophy of ancient Greece made little distinction between what we would now assign to science and the things that we would assign to metaphysics (Mickley 1994). Peat describes an era before the middle ages where Europeans lived in a universe that appeared alive to them. This era was marked by the connectedness of the indigenous people of Europe to nature and to an era in which they discovered the secrets of nature. He describes this era as:

> a world ripe with connections, “sympathies” and correspondences where the alchemist, artist, miner and metalworker were the midwives of nature, assisting her in striving for perfection (Peat 2008:20).

Science comes from the Latin word for knowledge, namely *scientia*. Science is therefore just knowledge. Until the 1840s what we now call science was known as

"natural philosophy". The *Free Dictionary*, 2010, defines modern science, usually referred to simply as science as:

- the systematic observation of natural phenomena for the purpose of discovering laws governing those phenomena.
- the body of knowledge accumulated by such means.

Science is a body of empirical, theoretical and practical knowledge about the natural world, produced by researchers
(Modern_science n.d).

The word science, according to Huff (1993), came from the word scientists, which is a word that was coined by a Cambridge philosopher of science, William Whehel, in the 19th century. For knowledge to be admitted as scientific, it should have passed through what is commonly known as the scientific method.

The scientific method is generally described as a series of the following steps:

- Observations
- Questioning
- Hypothesis
- Testing
- Explanation

This description of the scientific method seems to suggest that those aspects of being and of nature that are not possible to observe, question, hypothesise on, test and explain are left out of the education of students of science. Yet there are phenomena that exist, even though they cannot be explained by science. If this is the case, then surely the way nature is presented to students of science is incomplete? Those aspects of nature that science cannot explain are a reality of nature.

The scientific revolution began in Europe towards the end of the Renaissance and continued through the late 18th century, influencing the intellectual social movement now known as the Enlightenment. During this era, developments in mathematics,

physics, astronomy, biology, medicine and chemistry caused views on society and nature to move away from the original teachings of the church. (Scientific revolution n.d.).

The gradual move away from the control of the church over knowledge gave scientists new freedom in their quest to understand nature. This study will, however, only concern itself with the few scientists whose contributions changed the course of scientific knowledge radically. While many people contributed towards the development of what we call science in different ways, what will be discussed in the following sections is only a sample of those people. This section signifies significant changes in the manner in which nature was viewed by society and how science eventually developed. These people range from Nicolas Copernicus, Galileo Galilei, Francis Bacon and René Descartes to contemporary nuclear scientists. Directed by socioeconomic demands, the evolution of science has gone through many shifts in its development. These socio-economic demands have shaped the direction of scientific development (Harding 1994; Harding 1997; Harding 2009).

3.1.1 Mikolaj Kopernik (1473-1543): From geocentrism to heliocentrism

Mikolaj Kopernik's Polish name was latinised to Nicolaus Copernicus. He is credited with spearheading a different way of thinking, which was contrary to the views on nature of the established knowledge system of the time. To the ancient and mediaeval astronomers the only acceptable theory about the universe was that of geocentrism, namely that the Earth is the centre of the universe, with the sun, moon, planets and stars moving around it. Astronomers could not explain some of their observations on the basis of the geocentrism theory (the earth is the centre of the universe).

Copernicus noticed that it would make sense if the sun rather than the earth was at the centre of motion i.e heliocentrism. This explanation was better able to account for the other observations that were not consistent with geocentrism. Copernicus was not, however, able to advance proof for his theories (Nicolaus Copernicus n.d.).

3.1.2 Galileo Galilei (1564-1642): Mathematization of physics

Galileo Galilei was able to confirm the Copernican theory by providing proof in support of heliocentrism (the sun at the centre of the universe) as the acceptable explanation of the celestial using mathematics. The church, still embracing geocentrism, tried him by the Inquisition, found him “vehemently suspect of heresy” and forced him to recant. He spent the rest of his life under house arrest.

These discoveries obviously dealt the church a blow and this could have given scientists like Bacon the courage to explore nature without paying much regard to the beliefs of the church about nature (Galileo Galilei n.d.). This began an era where mathematics could be relied upon to explain nature.

3.1.3 Francis Bacon (1561–1626): Domination of nature

Francis Bacon was one of the leading figures in natural philosophy and in the field of scientific methodology in the period of transition from the Renaissance to the early modern era. He was a lawyer, Member of Parliament and Queen's Counsel. He wrote on questions of law, the state and religion, as well as on contemporary politics. He also published texts in which he speculated on possible conceptions of society, and he pondered questions of ethics even in his works on natural philosophy.

Francis Bacon, widely regarded as the father of the scientific method, which changed the manner in which men viewed nature. He advocated the use of scientific knowledge for the conquest of nature as he saw the practical value of science with its power to dominate and control nature as a way of restoring the power and dominion of man, and the human race over the universe (Brown 1986). He considered the domination of nature as an alternative to the domination of man over man in the unending wars of the time (Dewey 2001).

3.1.4 Rene Descartes (1595-1650): Dualism

Rene Descartes proposed the dualism of knowledge. In his model a distinction had to be made between living and thinking things and non-living and non-thinking things. He constructed a system of knowledge where only facts mattered. This was during an era where churches were the brokers of knowledge of nature. He discarded perceptions in this construction, as according to him, they were unreliable. He went further to argue that the nature of the mind (that is, a thinking, non-extended thing) is completely different from that of the body (that is, an extended, non-thinking thing), and therefore it is possible for one to exist without the other (Wozniak 1992.).

The most significant consequence of this split was that scientific enquiry focused entirely on the world of matter in order to discover its intrinsic laws, unencumbered by any metaphysical assumptions of a mental nature. These knowledge and belief systems however, are still retained by some communities. In the positivistic philosophy of science words like “life force”, “spirit”, “mind” or “consciousness” in natural affairs no longer had a place, and came to be considered as mere superstition (Sabbadini 2010). Objectifying nature became a characteristic of modern science, this according to Peat, is what has led to a loss of sensitivity and to a lack of meaning as regards our being “in the world” (Peat 2008; Masters 1987).

3.1.5 Sir Isaac Newton (1642-1727): Newtonian mechanics

Newton's views were deeply ingrained in Western culture and were equally embraced during the Industrial Revolution as the triumph of materialism. These views paved the way for the mechanisation era by establishing a clear connection between cause and effect. This mechanistic account required that matter move in accordance with strict mathematical laws. Newton’s views represented a further movement away from religious explanations of the mystical forces that moved humans out of the realm of the divine and into the mechanistic world that scientists could understand and were able to manipulate (Wolff 2009)

In 1687, together with the astronomer Edmond Halley, Newton published his single greatest work, the Philosophiae Naturalist Principia Mathematica (Mathematical Principles of Natural Philosophy) (BBC n.d.).This formed a basis for the understanding of science and eventually informed science education.

Newtonian mechanics, an offshoot of Newton's work, has influenced all aspects of science as a way of understanding nature. Nature was and is still understood to obey Newtonian mechanics and is explained in Newtonian mechanics. Even though Newtonian physics was, formulated before the rise of quantum physics, and Newtonian physics is not able to describe the recent concepts of quantum mechanics which suggests that essentially the physical universe is just a myriad of "tendencies to exist" associated with a vast interconnected energy field (Patterson 2008), Newtonian mechanics is still a preferred way to explain nature. The developments in quantum theory have, however, made many scientists rethink their understanding of some aspects of nature.

3.1.6 Quantum mechanics (Max Planck, Albert Einstein, Niels Bohr and others)

Quantum mechanics is a branch of theoretical physics that replaces Newtonian mechanics and classical electromagnetism at the atomic and subatomic levels. It underlies the mathematical frameworks of many fields of physics, chemistry and other areas of study in the study of matter. Many scientists, from Max Planck to Albert Einstein, worked on these new insights into nature, concerning the quantisation of light. Many years later more physicists are still required to create modern quantum theory (Quantum mechanics n.d.).

Many scientists have linked the findings of quantum physics to ancient eastern beliefs and many other traditional beliefs about the nature of the universe (Sabaddini 2010). This therefore calls for a rethink on the body of knowledge we already have and opens up avenues for considering knowledge we had in the past, now lost during the development of Newtonian mechanics.

3.2 Modern Science: Multiculturism or European culture?

The following segment seeks to understand the contributions of diverse people in the universe to this body of knowledge. It seeks to demonstrate the fact that knowledge now referred to as science and filtered into different disciplines or subjects, is knowledge on nature and innovation that the people of the world had. The following

are a few of the contributions to modern science from around the world, especially Africa:

3.2.1 Mathematics

Newtonian mechanics uses mathematics in its conception on nature. The three laws of motion, sometimes called *Newton's laws of motion*, underlie the explanations of nature using other laws of physics. These laws are basically mathematical equations, used in various forms throughout physics. The development of mathematics therefore played a crucial role in explaining the universe in Newtonian mechanics.

Counting and modern mathematical concepts were developed in Africa, more than 35 000 years ago. Egyptians used mathematical operations like division and multiplication of fractions and geometric formulas to calculate the area and volume of shapes as well as distances and angles; the algebraic equations and mathematically based predictions were used mainly to estimate the size of the floods of the Nile River as well as to re-establish borders after the floods.

The Yoruba people in Nigeria as well as the people in present-day Zaire developed their own numeration system, based on units of 20 (instead of 10) and required an impressive amount of manipulation to identify different numbers - eight thousand years ago (History of science and technology in Africa n.d.). This demonstrates that some mathematics was already in place before the Newtonian era.

3.2.2 Decimals

The ingenious method of expressing every number using a set of only ten symbols (each symbol having a place value and an absolute value) emerged in India. Romans had used unique symbols or unscientific combinations of symbols to represent numbers. The West had adopted Roman mathematics, which it discarded later because it was impractical for bigger calculations. The Indian method of expressing numbers, proved to be the most useful. Albert Einstein is said to have remarked:

> We owe a lot to the Indians, who taught us how to count, without which no worthwhile scientific discovery could have been made (Albert Einstein n.d.).

This contribution now forms part of the scientific way of dealing with decimals.

3.2.3 Astronomy

Several ancient African cultures gave birth to astronomy and some, like the Egyptians, charted the movements of the sun and constellations and the cycles of the moon. They also developed a calendar system containing 365¼ days and made use of clocks made with moving water and sundial-like clocks. The Dogon culture, steeped in ceremony and tradition that was mainly centred on space events, knew of Saturn's rings, Jupiter's moons, and the spiral structure of the Milky Way and the orbit of the Sirius star system long before colonisation. They also knew that this system contained a primary star and a secondary star (now called Sirius B) of immense density which was not visible to the naked eye. They were able to plot orbits in this system accurately from hundreds of years ago to the year 1990 (History of science and technology in Africa n.d.).

3.2.4 Metallurgy and tools

Metallurgy and tool-making across the whole of ancient Africa existed long before colonisation. There is evidence that steam engines, metal chisels, saws, copper and iron tools and weapons, nails, glue, carbon steel and bronze weapons and art had been developed in Africa long before colonisation (History of science and technology in Africa n.d.). These have however been included in the scientific knowledge realm using only science concepts to explain these innovations and inventions.

In Tanzania, Rwanda and Uganda the level of development surpassed the colonial level of development before colonisation. Technologies developed in these areas included ancient Tanzanian furnaces that could reach 1 800° C–2000 °C, 400° C hotter than those of the Romans (History of science and technology in Africa n.d.).

3.2.5 Architecture and engineering

Various societies in Africa created sophisticated built environments that included the raised obelisks and the more than 80 pyramids. The largest of the pyramids covering 13 acres was made of 2.25 million blocks of stone. Great cities in Zimbabwe and Mozambique were built around massive stone complexes that formed the hubs. These cities featured huge castle-like compounds with numerous rooms for tasks like iron-smiting. Timbuktu, a great 13th century city from the Mali empire that was noted for its grand palaces and mosques is an example from that era (History of science and technology n.d.)

3.2.6 Medicine

Many treatments used today, now referred as scientific, were used by several ancient peoples throughout Africa in areas now known as Egypt, Nigeria and South Africa long before the European invasion of Africa. Plants containing salicylic acid for pain (as in aspirin), kaolin for diarrhoea (as in Kaopectate) and extracts that were confirmed in the 20th century to kill gram-positive bacteria have been part of the African medical system since time immemorial. Plants that had cancer-fighting properties and many other uses were known to these people while medical procedures such as vaccination, autopsy, limb traction and broken bone setting, bullet removal, brain surgery, skin grafting, filling of dental cavities, installation of false teeth, Caesarean section, anaesthesia and tissue cauterisation were also used in Africa. Surgeries under aseptic conditions were performed in Africa long before the concept began to emerge in Europe (History of science and technology n.d.)

3.2.7 Navigation

Evidence suggests that ancient Africans sailed to South America and Asia on trade missions hundreds of years before Europeans. Genetic evidence from plants and descriptions and art from societies in South America show that small numbers of West Africans sailed to the east coast of South America, China and back, carrying elephants as cargo. Many ancient societies in Africa living along the sea front and

along the Great Lakes built a variety of boats. The Mali and Songhai built boats of up to 100 feet long and 13 feet wide, capable of carrying cargoes of up to 80 tons (History of science and technology n.d.). Africans living along the lakes and rivers still build boats that they use for a variety of needs.

People of African descent come from ancient, rich and elaborate cultures that created a wealth of technologies in many areas (ASBMBStoday 2013). This has in many ways contributed to the world knowledge on technology.

3.2.8. Ayurveda

Ayurvedic medicine is a system of traditional medicine native to India. A number of medicinal preparations and surgical procedures for the treatment of various ailments were developed by practitioners of this craft. Today, current practices derived from Ayurvedic medicine are regarded as part of complementary and alternative medicine (Ayurveda n.d).

3.2.9 Tawhid

The study of nature from an Islamic standpoint is considered to be linked to the concept of Tawhid (the Oneness of God), as are all other branches of knowledge. In Islam, nature is seen as an integral part of Islam's holistic outlook on God, humanity, and the world (Iqbal 2007; Toshihiko 1964). The following are some of the contributions from Islam:

- Many forms of mathematics
- Astronomy
- Medicine
- Dentistry
- Cartography, which produced an ancient map of the world (Islam and science n.d.)

The Islamic teachings and civilisation developed their own knowledge of natural science and did not accept foreign scientific theories if they were not in

line with their belief system. This led to the exclusion from their curriculum of much of the science derived from the Greeks (Huff 1993; Aikenhead 2007). Islamic science is therefore rooted in Allah and nature as one. This calls for respect of nature and the environment.

3.2.10 Papermaking, printing, gunpowder and other inventions

Most of the recorded technologies are ascribed to the Han dynasty (202 BC–AD 220). The following are some of those technologies that made important contributions to the world:

Most of the recorded technologies are ascribed to the Han dynasty (202 BC–AD 220). The following are some of those technologies that made important contributions to the world:

- Papermaking by a process using a combination of boiled mulberry bark, hemp, old linens, and fish nets was developed during the Han dynasty. These materials were then minced and water was added. A frame made of stitched twigs was dipped into the mixture and dried under sunlight. Additional dripping and refining provided the finishing touches. This produced paper.
- The invention of the compass, using lodestone capable of pointing north and south is also an invention produced during this era.
- Gunpowder was widely used in China before colonisation. It was based on recipes for fireworks, ammunition for trebuchet and cannonballs.
- Printing was also developed during this era. The development in printing moved to bronze and later a movable type printing was produced on vitreous enamel. These original ideas enabled the world to create better, almost perfect technologies that are useful in the daily routines of different people (China Private Tour Guide Service n.d)

The many contributions from people across the world into what has further developed into *modern science* or *western science* show how their knowledge contributed to science. The scientific and philosophical knowledge transferred from

other cultures, including the Arabic-Islamic civilisation, were translated by medieval Europeans into the indigenous languages of Europe and this helped to capture the interest of most Europeans in the course of Western intellectual development. Latin as the language of science gave way to the indigenous languages of Europe. Scientists in England and Italy published their major works or translated classical works into the vernacular so that laymen and ordinary people could be drawn into the circle of scientific discourse. This point emphasises the importance of understanding concepts in indigenous languages by the indigenous people. The modern science that emerged in the West became increasingly universal in that it was available to all the people of the world. It was applied to bodies of knowledge throughout the world. It grew because of its ability to tolerate those innovative ideas that were otherwise not acceptable to some religious and theological groups (Huff 1993).

Sandra Harding insists that science is in fact multicultural; many traditions from all over the world have been subsumed into what is now known as modern science. According to her, the view that modern sciences as knowledge systems are uniquely successful and are European is rooted in the fact that they have eliminated cultural fingerprints from their research results. Modern science according to Sandra Harding has evolved from many cultures, including the mystical philosophy of the Egyptians and the pre-modern alchemical traditions (Harding 1994).

3.3 Science, technology and society

The global success of science, according to Sillitoe, is due to the fact that it has achieved what appears to be a good approximation of understanding natural processes. Many scientists and non scientists have however participated in the development of some technologies e.g. the Wright brothers, generally regarded as having had a significant contribution to air travel as well as the initial stages of the polymer industry from rubber. Air travel space travel, various technological developments, computers and robotic technology as well as advances in medicine, including organ transplant surgery, are regularly celebrated as scientific and these advances have allowed science to flourish and to be widely celebrated (Sillitoe 2007). Knowledge that science has made available has also made various

technologies possible that have led to the invention of machines that make manual work lighter for many people around the world.

In spite of these celebrations brought about by science, Avery insists that, science and technology are capable of doing great good or producing great harm. He calls on the traditional wisdom of humankind to partner with science in order to help ensure that the material progress of science will be beneficial rather than disastrous to man and the environment (Avery 2007). This happens for example when science is taught without taking ecological and human consequences into account, as is the case currently where science is taught in compartments that exclude human beings and the environment, the whole learning process according to Odora takes on a particular "tint" (Odora 1993). Science then becomes harmful and dangerous to people and the environment. Science and the resulting technologies have been implicated in many problems that afflict humanity and the environment. It would appear that when science disengaged from nature it disregarded everything that was human, and possibly it objectified humans as it did the environment. It is this orientation of science that requires wisdom on humanity and the environment in order to keep it from causing further destruction and channel it to good uses. The integration of modern science and indigenous knowledge systems becomes important at this point because it is here that indigenous knowledge can share with modern science the insights that informed its ability to maintain the world almost undisturbed until the advent of modern science.

The following examples outline the use or rather the abuse of scientific knowledge and the consequences of not factoring in ecological as well as human consequences in the production and use of scientific knowledge.

3.3.1 Food production technologies

Technologies have made growing large quantities of food easier through mechanisation, fertilisation of the soil for increased yields and the use of pesticides to protect crops from insects. These large-scale farming methods requiring mono crop farming for ease of use of machinery, in turn demands that the farmers use more and more lethal insecticides. These processes eventually enter the food chain and

affect man (Shiva 1993). In most developing countries food production has almost been taken over from subsistence farmers by multinational corporations where these countries are lured into signing contracts that acquire large tracts of land where they plant mono crops (Peat 2008). The inability of these communities to produce their own food leads to the communities having to buy food, meanwhile losing the skills and technologies to grow food, prepare it and even preserve it the traditional way. It also means that they have no say in how food is produced, preserved and priced. They become victims on the most basic need of every human being - food.

Rosenburg recalls how in 1962, the biologist Rachel Carson alerted the world to the health hazards caused by pesticides, fungicides and insecticides used in large scale food production, challenging the right of corporations to make profits at the expense of people's health. That year the World Health Organization estimated that 80% of cancers were due to synthetic carcinogens in food, water, air, homes and workplaces. In 1979, the US National Institutes of Health Report stated that environmental factors were thought to be the cause of most cancers. In 1993 the International Agency for Research on Cancer identified a number of health-damaging environmental agents. These included chemicals, mixtures of different chemicals, radiation, drugs and industrial processes or occupational exposure. Rachel Carson died of cancer a few years later (Rosenburg 2005).

Other technologies, like the self-terminator seed technology, while promising food yields greater than those produced by traditional methods, undermine the tradition of seed harvesting, thereby denying poor people the opportunity to harvest seed from their yield. This means that poor people have to buy seed year after year from big corporations that produce such seed. Nature has provided seeds for sustainability, but changing the nature of seeds is disempowering to communities and creates a poverty trap for people who would otherwise choose to grow their own food. It has also been suggested that these genetically modified seeds may release toxins and allergens into the food chain (Steinbrecher & Mooney 1998).

3.3.2 The environment

Many technologies make use of non renewable energy- coal, oil; and this almost always results in pollution of one kind or another: air, water or soil. Pollution and

destruction of the natural environment have increased with advances in scientific knowledge (Morgenthau 1972; Masters 1987). Research has shown that the quality of food, water and air, in correlation with socio-political influences, affects the health of a population (Illich 1976). The following are examples of some of the disasters associated with science and technology disasters, affecting society in a negative manner:

- Bhopal: The Union Carbide gas leak in Bhophal, India, in 1984;
- Chernobyl: Russian nuclear plant explosion;
- Seveso: Italian dioxin crisis;
- A long list of marine oil spills -These oils spills were the result of accidents and wars. They have had disastrous consequences for the environment and marine life;
- The Love Canal chemical waste dump in 1920;
- The Baia Mare cyanide spill in Romania;
- European BSE (Bovine spongiform encephalopathy or mad cow disease) (List of industrial disasters n.d.)

3.3.3 Racism in the name of science

Dr Josef Mengele and scientists like Eugen Fischer (1874-1967) turned what they called race into a scientific study, supported by racist theories of the time. These studies led to many people suffering in the name of "scientific research". Eugen Fischer (1874-1967) carried out one of the most vicious genocides in what was known as German South-West Africa as part of his study on race by beheading Herero men and sending their skulls to Germany for scientific research (Medical Experiments n.d; Namibia n d.; Namibian bones n.d.). This is an example on how science is allowed permission to carry out inhumane studies on human beings, who essentially belong to the human race. The idea of racism in fact contradicts the atomic theory, a theory on which the whole of science is based.

3.3.4 Science and war

The atomic bombing of the Japanese cities of Hiroshima and Nagasaki in August on ordinary people, making them victims in a war decided upon by rulers, unbeknown to them. The Hiroshima bombings represent the most sinister development in the use of scientific knowledge in warfare during the 20th century (Turnbull & Holmes 2012). Many people have argued that science has not made any contributions towards peace and has in fact contributed mainly to war and strife (Morgenthau 1972). The scientific research that goes into creating weapons from scientific knowledge has led many people to question the values as well as objectives of science education.

3.4 Science education

Over the years the study of science has been encouraged in many countries, not least in South Africa. The performance of learners in science has, however, been discouraging, with very high percentages of learners failing to obtain a pass in science. Large budgets in developing countries are spent on promoting science (Nganunu 1992). Despite all this the average citizen or learner knows little about how science affects him and finds it difficult to apply the science he learns and to make evaluations about contemporary scientific controversies (Masters 1987).

Science education has its roots in modern science, sometimes referred to as Western science. According to Sandra Harding, western science was largely influenced by the expansionist ideas of the Europeans. The kind of knowledge sourced by them was therefore confined to only the knowledge they needed for expansionism; this included knowledge of concepts like oceanography and navigation, as well as knowledge that was useful for domination in the lands they conquered and knowledge useful for their survival when meeting cultures in those lands that they explored and eventually dominated (Harding 2008).

Science, as a body of knowledge has over the years been structured to include only those aspects of nature and natural processes that are of particular interest to the scientist in the West while ignoring other aspects of nature that many other people

adhere to such as spirituality, intuition and feelings. Observations made by people outside the circle of scientists have yet to be openly acknowledged or included in the body of scientific knowledge. The curriculum of science education has selected those aspects of science that have specific relevance to the leading ideology of the times, handed down by scientists and their institutions, to the exclusion of what people outside science regard as knowledge of nature.

Through colonisation, with further developments in science education in the countries of the colonisers, the science education that evolved in those colonised countries became the curriculum for the colonies before and after their liberation from their colonisers. The current Nuffield science education curriculum, for example, was influenced mainly by the sputnik era and the pursuit of technological advancement through science (Tema 2002) and the need to expand technical know-how. This curriculum, designed by Europe and America, has been exported to various countries through colonisation in response to the perceived need to "modernise" or "civilise" the Africans. In South Africa, as in many countries in Africa, this homogenous curriculum, dispensed throughout the country, is managed through a national exit examination. This curriculum is kept pretty much within the expectations of international standards through comparative testing in international tests such as those that are regularly conducted to assess South Africa's level of performance in relation to that of other countries.

Surprisingly, the science education exported to former colonies has not brought these countries the envisaged level of development, technical prowess and modernisation promised by the massive introduction of science education. They have largely become consumers of the technologies and modern goods supplied by their former colonisers as imports. Problems like hunger, war, environmental degradation, housing and disease have in many cases led to African governments' becoming wholly dependent on aid. In receiving science education Africans appear to have forgotten or abandoned their own ways of dealing with the challenges that they are now experiencing. Most of these are challenges that they never experienced before colonial times, when they were still relying on their own knowledge systems.

3.4.1 The Nuffield curriculum

The Nuffield curriculum is a science curriculum that was designed in America by the Nuffield Foundation between 1960 and 1970 for use in the United States of America and Britain after the Second World War. The materials developed by scientists turned out to be materials presenting abstract concepts that had no social dimensions at all (Fensham 1997). This curriculum has been criticised in Europe and America for leaving out the application of science in society and its application to the individual. This omission meant that there was no basis for evaluating the role of science and its limitations and strengths. This science curriculum therefore did not empower people to make decisions about the effects of science and technology on their lives (Fensham 1997). After liberation, however, most countries adopted this curriculum to differing degrees, in some cases with variations.

Disciplines, which are a distinctive feature of Western knowledge, are still being used in the South African education system. In schools, subjects are still being used to transmit education. Science is taught in the various disciplines and further divided into chapters and concepts (Life Sciences are divided into Botany, Zoology, and Agricultural Sciences and Physical Sciences are likewise divided into Physics and Chemistry). These subjects taught are supposed to give learners an understanding of nature. Knowledge on nature has been distributed across these subjects.

Indigenous knowledge on the other hand is taught in a holistic manner, not in compartments like chemistry, physics, and biology. The organisation of knowledge in indigenous knowledge systems is organised in a manner different to knowledge in modern science. Knowledge is organised according to use. This organisation however is able to accommodate sections and aspects of disciplines in a natural manner. For example in dealing with healing; aspects of botany, biochemistry, agricultural science, biology, spirituality, chemistry and many more compartments of western knowledge are infused. The knowledge is therefore recalled as and when it is needed and when it is relevant.

Science in most of Africa is still taught in the manner in which it has been handed down by the West. The methodologies of indigenous knowledge like storytelling and orallity have yet to be included in the education systems of indigenous people. Indigenous people running the departments of education in Africa have been schooled in the Western ways of learning and teaching and they are simply reproducing what they have learned themselves – often abstract and out of context. The manner in which science is taught; its language, methods and packaging, represents what Hoppers and Richards call an

> alienating experience; culturally, and epistemologically
> (Hoppers & Richards 2011:85)

Indigenous knowledge systems do not form part of assessment in the examination-driven curriculum in the South African education system. This has the potential to minimise the urgency of learning about indigenous knowledge systems and its importance to learners whose main goal in learning is mainly to pass the examinations. The methods of teaching and assessment are strictly pen and paper. Constructivist approaches to learning, which incorporate oral transmission of knowledge, are not included in the methodologies of teaching and learning, which are still examination-driven.

What follows are criticisms of science education and some suggestions on how science education could be reformed.

3.4.2 Dewey on science education

Dewey in *Democracy and education* contends that the manner in which science is taught in schools isolates learners of science from significant experience by keeping them away from nature. Learners in schools acquire only a technical body of information without the ability to trace its connections with objects and operations with which they are familiar and often this information is expressed in a peculiar vocabulary (Dewey 2001) that is different from the vocabulary that the learners and their communities are accustomed to.

His criticism of science education was that "learners learn science" instead of learning the scientific method which they could use to arrive at their own conclusions about nature. According to him, learners of science actually copy second-hand results which scientists of previous generations have already reached instead of conducting their own experiments, designed by them and producing results which could bring new knowledge to their generation. This argument is supported by Freire in *Pedagogy of the oppressed* when he argues against the "banking concept of education" where learners learn facts that they do not do anything with, except to reproduce them during an examination.

Dewey advocated for a science where learners find solutions to the problems they are experiencing, using the known facts of science to do so as opposed to memorising the facts of science for examination purposes. Laboratory work, according to him, is unnatural since scientific apparatus are only found in the laboratory and nowhere else, certainly not in the everyday lives of learners. He believed that learning should be active and learners should construct knowledge themselves (Dewey 2001).

3.4.3 Julius Nyerere on science education

Nyerere's critique of science education was that the science learnt in schools consists of facts and more facts and learners are not able to do anything with the scientific facts they have mastered and in the meantime are denied opportunities to learn from their communities and cultures as well as their everyday circumstances. In his description of science for self-reliance in the policy on science education in his country, he cautioned against mistaking the results of science for science itself. He described science in the following manner as quoted in McCormick,

> Science is a way of thinking;
> Science is NOT a list of discoveries;
> Science is a way of looking at the world around us;
> Science is NOT a scheme of naming plants and animals (McCormick 1976:7).

Further

> Science is the process through which people must go in order to find out things for themselves. It is this process, together with more conscious correlation of a multitude of

> experiences that children should continue as part of their primary school experience (McCormick 1976:7).

Science according to him therefore, education should allow learners to continue making discoveries instead of memorising discoveries already made elsewhere at different times. Learners should engage in knowledge production using the scientific method. He also noted how in the learning of science, issues of self reliance were excluded. He had advocated for education for self reliance as a necessary component of education.

3.5 Challenges of science education

3.5.1 Application

Many scholars argue that the average citizen or learner knows little about how science affects him and finds it difficult to apply the science he learns and to make evaluations about contemporary scientific controversies (Masters 1993). This also includes science learners. Scientific innovations and inventions as modernising tools are promoted and supported by the ruling class of any given society (Hines 2003, 2005) the impact of such innovations and inventions on society are never evaluated by students of science. If innovation and invention do not feature in the curriculum, including the South African curriculum to the extent where learners can start seeing themselves as innovators or inventors from an early age, this will lead to generations of consumers of innovation from other countries – at a cost. The use of knowledge to solve problems in the reality of everyday living has not taken root in the examination-driven curricula in most African countries, including South Africa.

3.5.2 Science development and innovation

The science education that learners receive has also been criticised internationally for failing to teach students how science affects the global economy and the environment and how people use science to promote causes that could be destructive as well as beneficial (Hines 2003, 2005). Masters concedes that today's scientific explanations of the world often seem unrelated to the concerns of the average citizen; the students studying science are not encouraged to evaluate the impact of science on their lives or on the lives of their communities, and according to him these learners remain

largely ignorant (Morgenthau 1972; Masters 1987) despite the factual information on science they acquire at school.

The science curricula in developing countries have been criticised for failing to provide knowledge and opportunities that lead to inventions and innovations. Curricula often lack the aspect of innovation which could encourage learners to build technologies relevant to their lives instead of being consumers of western products. The science taught does not give its recipients any opportunity for self-employment using what they have learned at school. Ogunniyi (1996) wonders whether secondary school products are employable, especially since some of the technical graduates are actually jobless. It appears that the claim that science is important is not accompanied by knowledge as to what kind of science and what kind of curriculum translates into wealth and improvement in the quality of life in Africa. The impacts of imported technologies on the social, economic and ecological aspects of society are not always mediated before technologies flood communities or countries. Many of the decisions made about the importation of technologies, especially in the name of trade, could harm the population of the countries concerned (Brown 1986). The ever-changing technology that poor countries always buy from developed countries does not make economic sense, especially when the products of these technologies cannot be repaired by the users when they break but have to be replaced at a cost (Illich 1974). In Africa, these expensive technologies are sometimes produced from material mined in Africa, sent overseas as ore, now returned as expensive finished products.

3.5.3 Language and science

The majority of learners in South Africa receive their schooling in a language that is not their first language (Pan South African Language Board (PANSALB 2000). The language of learning and teaching in South Africa is English or Afrikaans from the intermediate phase up to the end of high school. African learners who are learning in either of these languages are frequently “pathologised” because educators tend to interpret language differences as deficiencies (O'Connor & Geiger 2009). In some cases the African learners feel alienation since their home language and culture do not have a place in their learning. In a study done by Feza on how learners feel about

being taught science in a language that is not their mother tongue, the students have expressed the need to be taught in their own language as they feel this plays a critical role in their understanding of the subjects they are learning (Feza 2012).

Research carried out by Matlou (2011) to establish the extent to which the use of English as a medium of education could influence the learning and teaching of science for people whose first language is not English showed that English as a medium through which to learn science disadvantages learners because they have to grapple with the language itself (English) and the technical terms they encounter in their science texts. It emerged that both teachers and learners grapple with a language that neither speaks at home. He concluded that expecting children and adults to acquire knowledge and skills when they are taught through a language they do not understand was an impossible task that robs the people being taught of an opportunity to be empowered by building upon their linguistic heritage (Matlou 2011).

In his analysis he further concluded that education cannot possibly be equitable and non-discriminatory when the language of learning and teaching is foreign to educators and learners and when the majority of the population is required to receive their education through a language of the dominant minority (Matlou 2011).

3.5.4 Shortcomings in science education in Europe: The Nuffield curriculum revisited

In 2006, two seminars held in London, convened by the Nuffield Foundation involving science educators from nine European countries investigated the extent to which the issues on science education were common across Europe, the similarities and differences between countries, and some attempted solutions and remedies. The seminars revealed that the shortcomings in science education experienced in Africa were actually not unique to Africa. Europeans learners are also experiencing the same problems in science education in more or less the same manner as other learners all over the world. A report sent to the Nuffield Foundation by participants of the conference revealed the following views of students about science education in Europe:

- The science curriculum can appear as a “catalogue” of discrete ideas, lacking coherence or relevance, with an over-emphasis on content that is often taught in isolation from the kinds of contexts that might provide essential relevance and meaning.

- The goals and purpose of science education are neither transparent nor evident to students.

- Assessment is based on exercises and tasks that rely heavily on rote memorisation and recall, and are quite unlike those contexts in which learners might wish to use science knowledge or skills in later life (such as understanding media reports or understanding the basis of personal decisions about health, diet, etc).

- The relationship between science and technology is neither well-developed nor sufficiently explored.

- There is relatively little emphasis, within the science curriculum, on discussion or analysis of any of the scientific or environmental issues that permeate contemporary life.

- There is an over-reliance on transmission as a form of pedagogy with excessive use of copying (Osborne & Dillon 2008).

These findings show that there are issues about science education that need to be looked into if it is to be relevant to societies in general. This also means that science education needs to be reworked by all in order to make it useful and relevant to those studying it.

In support of the idea of changing the manner in which science education is being taught, the Nuffield Foundation- sharing almost the same insights as Julius Nyerere- has since suggested that a science curriculum which serves the needs of developing a scientifically literate public would be:

> significantly different from that is currently offered throughout most of Europe. It would recognise that, for the overwhelming majority, their experience of learning science in school will be an end-in-itself – a preparation for living in a society increasingly dominated by science and technology and not a preparation for future study. Its content and structure could then only be justified on this basis. It would represent an introduction to the cultural

> capital offered by science, its strengths and limitations, and develop an understanding, albeit rudimentary, of the nature of science itself. Our view is that all students, including future scientists, need this form of education at some stage of their school career. (Osborne & Dillon 2008:21).

The points raised above show that science as a knowledge system, while containing useful insights about nature, is taught in a manner that does not make it relevant and easy to apply for learners. This naturally leads to a need to rethink new ways of packaging this information so that science education can achieve relevance, especially in schools.

The following discussions will show that the inadequacy of science education has long been realised by communities. This has led to a variety of projects all aimed at making science relevant to school children. The study will focus on only a handful of such projects as examples.

3.6 Suggestions on alternative forms of science education

Several projects have over the years tried to make science education relevant. The following segment presents a sample of such projects as well as the thinking behind some of the projects.

3.6.1 Science literacy

Science literacy has been advocated by many people and associations as an alternative to the forms of the Nuffield curriculum. Included below are suggestions on what science literacy should entail.

- The American Association for the Advancement of Science 1989 Project 2061 defined science literacy as

> being able to use scientific knowledge and way of thinking for personal and social purposes (p 20).

- In *Project synthesis* (Harms & Yager 1989), science literacy is described as knowledge of science based on 1. Personal needs 2. Societal issues 3. Academic preparation and career awareness, and a science education that should produce informed citizens who are able to deal responsibly with science-related social issues.

- The Biological Science Curriculum Study and Social Science Education Consortium (BSCS/ SSES 1992) called for practical science literacy in the form of knowledge and skills needed to maintain our way of life while civic literacy deals with understanding of science as a major human achievement and an integral part of our general culture.

3.6.2 The African worldview

The science taught to African learners is still framed in a world view that the African does not necessarily share. This is an approach which creates frustrations for the African learner. The epistemological frameworks of the current science curriculum excludes the epistemological frameworks of Africans and other indigenous societies (Hoppers 2005), making their knowledge redundant and making them seem devoid of any knowledge on nature. In learning science, African children learn about their environment using prior knowledge situated within their non-Western worldview. This prior knowledge becomes a handicap when a Western world view is used as a framework for learning science and technology (Jegede 1998). It is therefore up to the departments of education in African countries to make the development of curricula their own and take from the existing body of knowledge of science that which is relevant and useful to the Africans. It must be a curriculum that builds on what the citizens already know and support them in acquiring knowledge that they need for their well being. Science education should ideally be infused into the education system that first of all recognises the African worldview and also serves the Africans.

A curriculum that embraces the learner's worldview has been advocated for by scholars like Jegede. He believes that the learner's understanding of any new meaning is strongly influenced and determined by prior knowledge, which is in turn

determined by cultural beliefs. He argues that the social context acts as scaffolding, providing assistance that fosters co-construction of knowledge. He considers the following to be part of the scaffolding:

1. Meaning is affected by the viewpoint of a culture.
2. Social interactions within the community define meaning.
3. Although meanings are socially determined, the individual uses an idiosyncratic pattern to make meaning personal where there is individual experiences interplay between cognition and affect (Jegede 1998).

3.6.3 Science as a lived culture

Brock-Utne describes the absence of IKS in the curriculum as a lack of innovation on the part of curriculum planners, which happens because communities are excluded in the colonialist education currently being offered. When the population is not included in the identification of its needs, the programmes developed appear to address the wrong issues. This education, she argues, educates Africans away from their cultures (Brock-Utne 2008). The cost of teaching and learning science, while considerably higher than the cost of teaching other subjects because of the need to buy equipment and to build laboratories, has not yielded appreciable returns in the lives of communities. There have been calls to teach science in a real-life context, these calls have yet to be realised.

Because the lived experiences of learners are ignored and science is taught under artificial conditions, which cost governments a fortune in terms of laboratories and equipment, the science curriculum is transmitted as abstract and does not translate to the social conditions of learners. Volmink has warned that society cannot continue to send children to school to pursue knowledge for its own sake. The socioeconomic and political realities on our continent are such that students must pursue knowledge for life and school science must become science that has value in their lives instead of being esoteric, decontextualised, abstract and useless knowledge (Volmink 1998). An education that takes into consideration the knowledge and the knowledge system of learners has been deemed the most desirable by scholars. Hoppers contends that

> by maintaining silence over whose normative heritage is being transmitted through education, by avoiding to discuss the philosophical basis for education, and by evading the issue of self reliance as a core imperative for any development, educators have voted to participate in this framework by encouraging the misrecognition of this violence (Hoppers 1998: v).

Quality education should therefore be appropriate for the local, social, cultural, historical, epistemological and ecological contexts relevant to the particular economy (Meyer, Nagel & Snyder 1993). African education system, including the South African education system should infuse the heritage of their citizens, self reliance as well as innovation in the curriculum.

Conclusion

This chapter shows the route taken by science in its development of knowledge throughout the ages. This knowledge, now known as modern science, evolved from natural philosophy, which was a study of nature. The epistemological and ontological frameworks of knowledge production in modern science, unlike in indigenous knowledge systems as demonstrated in the previous chapter, demonstrates a development of knowledge that has over the years divested itself of responsibility towards social issues, especially the spirituality aspect, despite the fact that people have over the centuries held on to their spirituality.

In its quest to produce knowledge based on facts of the material world alone, the brilliant discoveries of science have been dwarfed by its neglect of the human agency, which has resulted in large-scale abuses of both human beings and the environment, through supporting wars through the use of this knowledge and the objectification of nature and man as discussed.

This chapter fulfils another one of the objectives of this study, which is to provide an overview of modern science. This is an important chapter as it provides insights into the nature of science and its impact of humanity. The views on science education

show a need to review the manner in which this knowledge system is transmitted in the education of Africans.

Chapter 3 also provided grounds for reconfiguring the manner in which science is taught and contributes to the ultimate design of the model, which is another objective of this study. Science as facts that are presented out of context to be memorised does not have values towards communities. The important discoveries on the material world are not properly communicated to learners to allow for integration into local knowledge systems so as to support communities.

The next chapter, chapter 4, demonstrates alternative thinking on science education and showcases projects that have in the past attempted to alter science education. The knowledge produced, whether indigenous or as part of modern science, is based on the laws of nature but, as this chapter shows, the different ontological frameworks largely determine the direction of the innovations made possible by the knowledge produced. The next chapter showcases models that show that science can be taught differently and it can be taught in a manner that will make it serve humanity.

CHAPTER 4: A RETHINK ON THE SCIENCE EDUCATION CURRICULUM

This chapter looks at what education could bet for Africans. It also looks at an Alaskan model in which their indigenous knowledge and modern science are integrated. The call for the Africanisation of the curriculum has been made by many Africans in their attempt to move away from curricula originating from the colonial era. From the early sixties Africans saw colonial style education as education that was not only disempowering to them but was also making them dependent on their former colonial masters. Changes have been attempted with varying degrees of success in Africa. In attempting to usher in change, Africans all seem to have followed European models of education in the transmission, and examination as well as management structures of education; as a result an African curriculum has not been achieved (Mazonde 2001).

This study on the integration of modern science and indigenous knowledge systems is a contribution to the many voices that have called for the recognition and inclusion of African education, knowledge and methodologies in the education of African youth. In this chapter we look at the numerous projects that have either tried to infuse African values into education or have tried to reconfigure the manner in which modern science is taught and learned in schools.

The policies of the Department of Education in South Africa will be examined to identify the changes that are intended to inform change in education in South Africa. This should provide guidance on the envisaged model of the integration of the two systems of knowing, guided by the policies of the Department of Education.

4.1 The 1961 Addis Ababa Conference of African States on the Development of Education in Africa

This conference, organised by UNESCO and the Economic Commission for Africa, called on African educational authorities to revise and reform the content of education in all aspects of the curriculum so as to take into account the African environment, child development, cultural heritage as well as the demands of

technological progress and economic development, especially industrialisation in Africa (Ayotunde 1998). Some aspects of this vision are noticeable in the education systems of some African countries to varying degrees

4.2 The 1962 Conference of African Ministers of Education on the Development of Higher Education in Africa

The conference, which was held in Madagascar, stressed the importance of developing local expertise in the areas of science and technology in Africa (Ayotunde 1998). It should be noted, however, that South Africa was not a participant at either of these conferences as it had been expelled for its apartheid policies. South Africa was only readmitted to the United Nations after 1994.

Many African countries around that time sought to design their own curricula despite resistance from some of their countrymen. After the liberation of Tanzania for example, the then president of Tanzania sought the type of education that would free Tanzanians. That education was not just about preparing the people of Tanzania for employment in a capitalist economy. It set out to make them masters of their own lives, so that they would be able to take up the reins of running their own country and shaping their own future. This type of education was called “Education for Self Reliance” (Nyerere 1968). Julius Nyerere was concerned with learners who complete their schooling without having acquired any skills at all, even the basic skill of growing their own food (Nyerere 2004). The goal of education for self-reliance was to make Tanzanians appreciate their land and control the means of production in their own country.

Nyerere’s in his criticisms of Western education raised the following points:

a) Formal education distracts the attention of the youth from the realities of their everyday lives, like growing food, despite the fact that they need food daily.
b) The education system divorces its participants from the society for which they are supposed to be trained. It has nothing to do with their way of life in their societies; it ignores important knowledge in their culture, alienating them from their own people, culture and customs.

c) The system breeds the notion that education is synonymous with formal schooling, and people are judged and employed on the basis of their ability to pass examinations and acquire paper qualifications.
d) It promotes contempt for manual labour, depriving their own communities of a workforce made up of their adolescent children, who are spending their days in school doing little or no work with their hands.

His vision was that education should work for the common good, foster cooperation and promote equality. Further, it was to address the realities of life in Tanzania. The following adaptations to formal education were proposed:

- It should be oriented to rural life, especially to the growing of food.
- Theory and practice had to be integrated into learning so that learners could be problem-solvers in their own communities.
- Alternative forms of assessment were to be adopted.
- Primary education at school should be capable of serving the needs of learners in their current situations rather than be an education that would serve them later in life.
- Education should produce self-reliant, confident members of society, able to solve their own problems.

4.3 Suggestions by traditional doctors from Southern Africa

A study published in the *African Journal of Research in Mathematics, Science and Technology Education*, carried out by Dr Mariana G Hewson and entitled *" Traditional healers' views on their indigenous knowledge and the science curriculum in Southern Africa"* revealed the traditional healers' views on the education that their children were receiving in science classrooms. The traditional doctors interviewed expressed their dissatisfaction with the science curriculum as taught in schools (Hewson 2012).

According to this research, the traditional healers expressed the wish for a curriculum that would teach the following:

1. The negative effects of colonialism and modernisation;
2. The African heritage;
3. The utility of plants and animals to humans;
4. The interdependence of all living things and the need for sustainable agriculture;
5. Healthy living and appropriate sexual practices;
6. IKS methods of teaching in integrated IK/science classrooms;
7. The importance of research on indigenous knowledge systems;
8. Teaching methods in integrated IK/science classrooms;

On the methodological aspects, the traditional healers expressed a wish to be included in the teaching of their own children, who spend the better part of their days in classrooms learning modern science instead of learning indigenous science in their environments. They expressed their wish to participate in the teaching of their young so as to impart to them a vast amount of knowledge, along with the values that they would wish to see in their young where they can use their indigenous methodologies to pass on the knowledge they have (Hewson 2012).

4.4 The culturally responsive science curriculum: Alaskan model of indigenous education

The culturally responsive science curriculum of Alaska, attempts to integrate Native and Western knowledge systems around science topics with goals of enhancing the cultural well being and the science skills and knowledge of students. It assumes that students come to school with a whole set of beliefs, skills and understandings formed from their experiences in the world, and that the role of school is not to ignore or replace prior understanding, but to recognize and make connections to that understanding. It assumes that there are multiple ways of viewing, structuring, and transmitting knowledge about the world—each with its own insights and limitations. It thus values both the rich knowledge of Native Alaskan cultures and of Western science and regards them as complementary to one another in mutually beneficial ways. According to their website the following are characteristics of a culturally responsive science curriculum:

- It begins with topics of cultural significance and involves local experts.

- It links science instruction to locally identified topics and to science standards.
- It devotes substantial blocks of time and provides ample opportunity for students to develop a deeper understanding of culturally significant knowledge linked to science.
- It incorporates teaching practices that are both compatible with the cultural context, and focus on student understanding and use of knowledge and skills.
- It engages in ongoing authentic assessment which subtly guides instruction and taps deeper cultural and scientific understanding, reasoning and skill development tied to standards. (Culturally responsive curriculum n.d.)

Culturally responsive science considers cultural knowledge, language and values as an integral part of the schooling system. Science is presented within the whole of cultural knowledge in a way that embodies the culture of the students and demonstrates that science standards can be met in the process. A culturally responsive science curriculum is concerned with connecting what is known about Western science education with what local people know and value. It has to do with accessing cultural information, correlating that information with science skills and concepts, adjusting teaching strategies to make a place for such knowledge, and coming to value a new perspective. This integrates the two knowledge systems in a manner that does not compromise either. Modern science as in Newtonian mechanics is used in areas of convergence to explain the daily occurrences of everyday life like rowing a boat (using vectors) as well as carrying wood (using force), for example.

4.5 Methodology and assessment in culturally responsive science

Elders are used for teaching from the cultural perspective, using cultural methodologies and also using the language that learners speak. Learning takes place in the area where the concept is being learnt; for example, if learners are learning about medicinal plants, they go out with the elder to pick the plants, using the cultural ways of doing this and where science is applicable references to science are included while explaining the knowledge.

Examples of topics taught in this model

- medicinal and edible plants
- weather
- river dynamics
- seasons
- food gathering and preservation
- navigation
- animal behaviour/habitat
- tides
- erosion and relocation
- tools and technology
- snow and ice
- land forms
- shelter and survival
- anatomy
- use of local materials

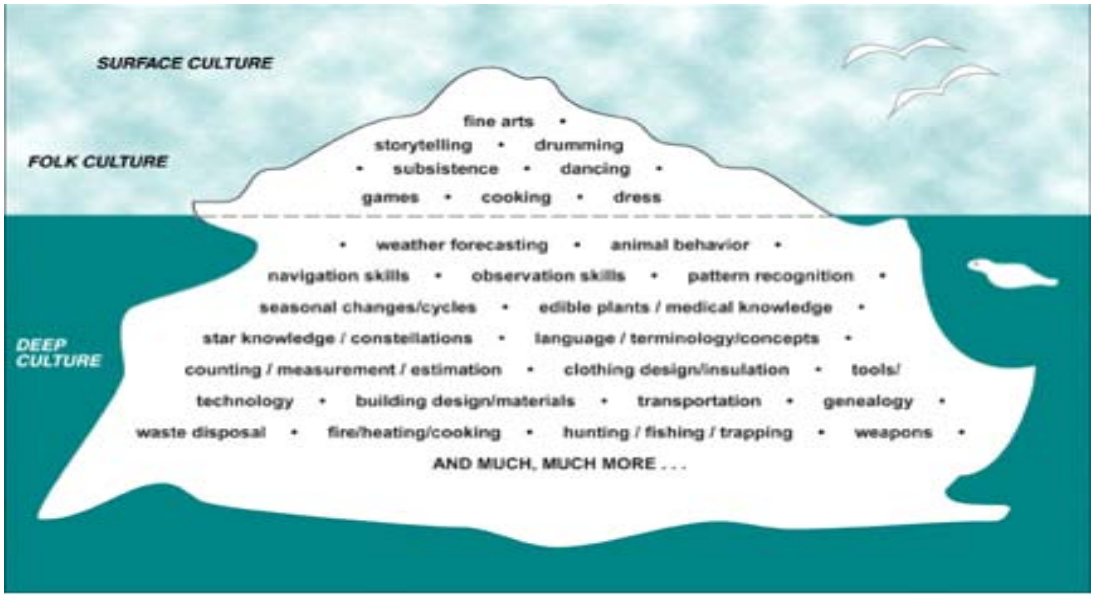

Figure 2 : Content in the culturally responsive model of Alaska

Knowledge dealt with in this model both contains aspects of indigenous knowledge systems and lends itself easily to in-depth study of the basic principles of biology, chemistry, physics and mathematics, particularly as they relate to areas such as botany, geology, hydrology, meteorology, astronomy, physiology, anatomy, pharmacology, technology, engineering, ecology, topography, ornithology, fisheries and other applied fields (cf. Carlson 2003; Denali Foundation 2004). (Culturally responsive curriculum n.d.).

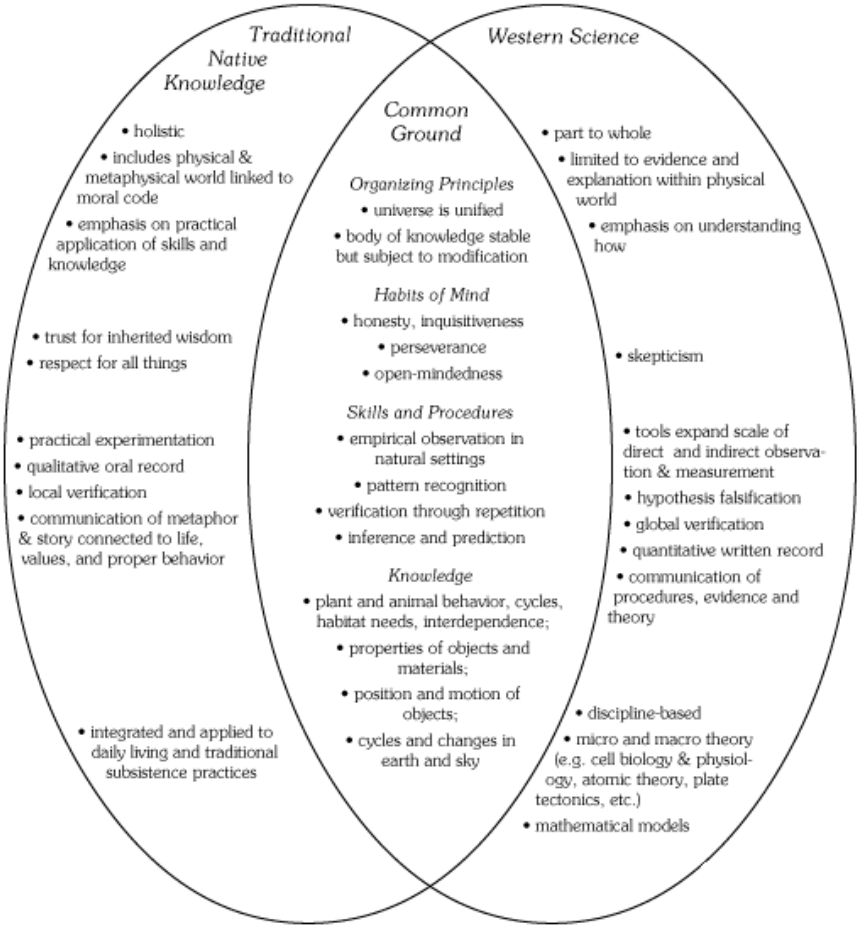

Fig 3: Integrating Traditional Native

Knowledge and Science (Alaskan Model)

This content is integrated in a manner depicted by the diagram above. Where it is not possible to integrate the Alaskan indigenous knowledge with modern science, the topics are taught as they exist, either as indigenous knowledge or as modern science.

4.6 South African science education policies revisited

The South African science education policy can be traced back to the programme in which it was located, namely the Reconstruction and Development (RDP) Programme of the South African Government of 1994. The Reconstruction and Development Programme (RDP) is a policy framework for integrated and coherent socioeconomic progress. It sought to mobilise South Africans and the country's resources towards the eradication of the results of apartheid with the associated socioeconomic and political challenges. Its goal was to build a democratic, non-racial

and non-sexist future and it represented a vision for the fundamental transformation of South Africa by:

- developing strong and stable democratic institutions;
- ensuring representativity and participation;
- ensuring that our country becomes a fully democratic, non-racial and non-sexist society;
- creating a sustainable and environmentally friendly growth and development path**.**

Former State President Nelson Mandela, first President of a democratic South Africa, in his Inaugural Address to a Joint Sitting of Parliament on 24 May 1994 said the following about the Reconstruction and Development Policy:

> My Government's commitment to create a people-centred society of liberty binds us to the pursuit of the goals of freedom from want, freedom from hunger, freedom from deprivation, freedom from ignorance, freedom from suppression and freedom from fear. These freedoms are fundamental to the guarantee of human dignity. They will therefore constitute part of the centrepiece of what this Government will seek to achieve, the focal point on which our attention will be continuously focused. The things we have said constitute the true meaning, the justification and the purpose of the Reconstruction and Development Programme, without which it would lose all legitimacy.
> — President Nelson Mandela in his Inaugural Address to a Joint Sitting of Parliament, 24 May 1994

Freedom from want should ideally begin with freedom from the want of basic needs such as food, shelter and health care. The schooling system should ideally equip learners to attain this "freedom from want" by the time they leave school.

The following as stated in this policy are the expectations on education:

> 1.3.1 Six basic principles, linked together, make up the political and economic philosophy that underlies the whole RDP. This is an innovative and bold philosophy based on a few simple but powerful ideas. They are:

1.3.2 An integrated and sustainable programme. The legacy of apartheid cannot be overcome with piecemeal and uncoordinated policies. The RDP brings together strategies to harness all our resources in a coherent and purposeful effort that can be sustained into the future. These strategies will be implemented at national, provincial and local levels by government, parastatals and organisations within civil society working within the framework of the RDP.

This programme is essentially centred on:

1.3.3 A people-driven process. Our people, with their aspirations and collective determination, are our most important resource. The RDP is focused on our people's most immediate needs, and it relies, in turn, on their energies to drive the process of meeting these needs. Regardless of race or sex, or whether they are rural or urban, rich or poor, the people of South Africa must together shape their own future. Development is not about the delivery of goods to a passive citizenry. It is about active involvement and growing empowerment. In taking this approach we are building on the many forums, peace structures and negotiations that our people are involved in throughout the land.

This programme and this people-driven process are closely bound up with:

1.3.4 Peace and security for all. Promoting peace and security must involve all people and must build on and expand the National Peace Initiative. Apartheid placed the security forces, police and judicial system at the service of its racist ideology. The security forces have been unable to stem the tide of violence that has engulfed our people. To begin the process of reconstruction and development we must now establish security forces that reflect the national and gender character of our country. Such forces must be non-partisan, professional, and uphold the Constitution and respect human rights. The judicial system must reflect society's racial and gender composition, and provide fairness and equality for all before the law.

As peace and security are established, we will be able to embark upon:

1.3.5 Nation-building. Central to the crisis in our country are the massive divisions and inequalities left behind

by apartheid. We must not perpetuate the separation of our society into a 'first world' and a 'third world' – another disguised way of preserving apartheid. We must not confine growth strategies to the former, while doing patchwork and piecemeal development in the latter, waiting for trickle-down development. Nation-building is the basis on which to build a South Africa that can support the development of our Southern African region. Nation-building is also the basis on which to ensure that our country takes up an effective role within the world community. Only a programme that develops economic, political and social viability can ensure our national sovereignty.

Nation-building requires us to:

1.3.6 Link reconstruction and development. The RDP is based on reconstruction and development being parts of an integrated process. This is in contrast to a commonly held view that growth and development, or growth and redistribution are processes that contradict each other. Growth – the measurable increase in the output of the modern industrial economy – is commonly seen as the priority that must precede development. Development is portrayed as a marginal effort of redistribution to areas of urban and rural poverty. In this view, development is a deduction from growth. The RDP breaks decisively with this approach. If growth is defined as an increase in output, then it is of course a basic goal. However, where that growth occurs, how sustainable it is, how it is distributed, the degree to which it contributes to building long-term productive capacity and human resource development, and what impact it has on the environment, are the crucial questions when considering reconstruction and development. The RDP integrates growth, development, reconstruction and redistribution into a unified programme. The key to this link is an infrastructural programme that will provide access to modern and effective services like electricity, water, telecommunications, transport, health, education and training for all our people. This programme will both meet basic needs and open up previously suppressed economic and human potential in urban and rural areas. In turn this will lead to an increased output in all sectors of the economy, and by modernising our infrastructure and human resource development, we will also enhance

export capacity. Success in linking reconstruction and development is essential if we are to achieve peace and security for all.

Principles related to education:

1.3.7 Democratisation of South Africa. Minority control and privilege in every aspect of our society are the main obstruction to developing an integrated programme that unleashes all the resources of our country. Thoroughgoing democratisation of our society is, in other words, absolutely integral to the whole RDP. The RDP requires fundamental changes in the way that policy is made and programmes are implemented. Above all, the people affected must participate in decision-making. Democratisation must begin to transform both the state and civil society. Democracy is not confined to periodic elections. It is, rather, an active process enabling everyone to contribute to reconstruction and development.

1.3.8 An integrated programme, based on the people, that provides peace and security for all and builds the nation, links reconstruction and development and deepens democracy – these are the six basic principles of the.

The basis for curriculum transformation development was provided by the Constitution of the Republic of South Africa, 1996. The aims of the Constitution have been adopted by the Education Department as a basis for education in the country. The White Paper on Education and Training captured the aims of the Constitution, in order to provide a basis for policy development for various sections of the Education Department. The new education in South Africa was not only concerned with mastery of content but was also expected to be a vehicle for social transformation. The science education policies, like all subject policies, were drawn directly from the White Paper on Education and Training of 1995.

The extracts from the White Paper that will be discussed below reflect the education system as envisaged by the South African government in its quest for transformation. In the design of the model for the integration of IKS and modern science, the White Paper, the National Curriculum Statement, the policies for science subjects in the

curriculum as well as the IKS policy of 2004 are being revisited with the aim of incorporating them into the model.

4.6.2 The White Paper on Education and Training (1995)

The following are extracts from the White Paper on Education and Training:
On the location of education in South Africa: The Purpose and Scope of This

Document

> The document locates education and training within the national Reconstruction and Development Programme, and outlines the new priorities, values and principles for the education and training system (DoE 1995).

On the need for an integrated approach to learning: Why Education and Training?

> An integrated approach implies a view of learning which rejects a rigid division between "academic" and "applied", "theory" and "practice", "knowledge" and "skills", "head" and "hand". Such divisions have characterised the organisation of curricula and the distribution of educational opportunity in many countries of the world, including South Africa. They have grown out of, and helped to reproduce, very old occupational and social class distinctions. In South Africa such distinctions in curriculum and career choice have also been closely associated in the past with the ethnic structure of economic opportunity and power Point 4 (DoE 1995).

On the civic responsibility of education: Transforming the Legacy of The Past

> Appropriate education and training can empower people to participate effectively in all the processes of democratic society, economic activity, cultural expression, and community life, and can help citizens to build a nation free of race, gender and every other form of discrimination (DoE 1995).

On the holistic nature of the envisaged education: Past and future

> In a democratically governed society, the education system taken as a whole embodies and promotes the collective moral perspective of its citizens, that is the code of values by which the society wishes to live and consents to be judged. From one point of view, South Africans have had all too little experience in defining their

> collective values. From another, our entire history can be read as a saga of contending moralities, which in our era has culminated in a historic agreement based on the recognition of the inalienable worth, dignity and equality of each person under the law, mutual tolerance, and respect for diversity (DoE 1995).

On the community involvement in education: Values and Principles of Education and Training Policy

> Parents or guardians have the primary responsibility for the education of their children, and have the right to be consulted by the state authorities with respect to the form that education should take and to take part in its governance. Parents have an inalienable right to choose the form of education which is best for their children, particularly in the early years of schooling, whether provided by the state or not, subject to reasonable safeguards which may be required by law. The parents' right to choose includes choice of the language, cultural or religious basis of the child's education, with due regard for the rights of others and the rights of choice of the growing child (DoE 1995).

On the need to preserve the environment and methodologies of teaching:

- Environmental education, involving an inter-disciplinary, integrated and active approach to learning, must be a vital element of all levels and programmes of the education and training system, in order to create environmentally literate and active citizens and ensure that all South Africans, present and future, enjoy a decent quality of life through the sustainable use of resources.
- An active approach to learning must be a vital element of all levels and programmes of the education and training system, in order to create environmentally literate and active citizens and ensure that all South Africans, present and future, enjoy a decent quality of life through the sustainable use of resources.
- Two operational principles – sustainability and productivity – are given strong emphasis in the Reconstruction and Development Programme. They need to be upheld in the development of plans and programmes for the reconstruction and development of the education and training system.
- The expansion of the education and training system must meet the test of sustainability. The education and training system has not been given an open cheque

> book by the government. Development needs to be planned for, and balanced across the full range of needs, from early childhood to postgraduate study. Unsustainable development is not development at all, but a kind of fraud practised on the people. However, sustainability is not just a financial concept. True sustainability occurs when the people concerned claim ownership of educational and training services and are continuously involved in their planning, governance and implementation (DoE 1995).

On curricula that respond to the needs of communities:

> School-based "micro" adaptations can be an important means of professional development and INSET, as well as expressing particular interests of the school and its community (DoE 1995).

The white paper envisaged an education system that would provide for all aspects of the education of the youth of this country. The vision espoused by the White Paper was that of an education system that went beyond content but allowed the learner to be prepared for life in the community and in the world. Civic education was a strategic attempt by the White Paper to educate South Africans about democracy and participation in government processes as a way of ensuring the upholding of democratic principles in a country that had had a very bad example of democracy from the apartheid government, a country that had been ravaged by corruption, hatred among the different cultural groupings as well as violence by the state on its own people.

4.6.3 The National Curriculum Statement

The aims of the Constitution appear in all National Curriculum Statements, otherwise referred to as the NCS. The Preamble to the Constitution states that these aims are to:

- heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights;
- improve the quality of life of all citizens and free the potential of each person;
- lay the foundations for a democratic and open society in which government is based on the will of the people and every citizen is equally protected by law; and

- build a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations. (DoE 2003)

The following principles were expected to be reflected in every subject:

- social transformation;
- outcomes-based education;
- high knowledge and high skills;
- integration and applied competence;
- progression;
- articulation and portability;
- human rights, inclusivity, environmental and social justice;
- valuing indigenous knowledge systems; and
- credibility, quality and efficiency (DoE 2003).

The Reconstruction and Development Programme, the White Paper and the National Curriculum Statement, as policy frameworks for education in this country, express a determination to move away from the education system that South Africa had been exposed to before liberation. A new design is therefore expected. An education that is capable of infusing all the principle as mentioned as well as the provisions of the White Paper and the RDP; should therefore be allowed to be organised differently from an education that never promoted these.

4.7 The South African indigenous knowledge systems policy and the implications for the science curriculum

The Indigenous Knowledge Systems (IKS) policy of 2004 was developed by the Department of Science and Technology. The following departments: Agriculture, Arts and Culture, Education, the Environment and Tourism, Health, Land Affairs, Provincial and Local Government, Science and Technology, Sport and Recreation, Trade and Industry and Water Affairs were represented on the committee which participated in the formulation of this policy. The policy was adopted by Cabinet in 2004 (DST 2005:30).

The IKS policy was developed in order to provide a basis upon which IK can be used to make more appropriate interventions, According to the then minister of Science and Technology, Mosibudi Mangena, indigenous knowledge has been recognised as knowledge that continues to be the primary factor in the survival and welfare of the

majority of South Africans. The IKS policy was seen as a policy that was to celebrate and integrate African perspectives into South Africa's knowledge systems as a matter of redress and was expected to create new research paradigms and mental maps and also enrich existing ones (DST 2004).

The policy in its conception took note of the need for South Africans to understand the biases of globalisation in its endeavour to impose a homogenous worldwide culture as observed for example in the rapid language diversity attrition across the world. The different ideas and values in the global village which have the potential to challenge the autonomy and policymaking capacities of nation states like South Africa require the nation states to find the best possible opportunities for their states. It is through a policy like the Indigenous Knowledge Policy of 2004 that South Africans are in a position to face the challenges and opportunities of globalisation and solve their own problems using their own knowledge systems.

The Department of Science and Technology (DST) had wanted the policy to be integrated into the education and qualifications framework, and into national research and development. There was a need to integrate IKS policy with other policies, while affirming its protection and its role within the global intellectual property (IP) infrastructure. The policy was seen as a national asset, with links to the National Innovation Strategy and the promotion of public awareness and understanding. The DST acknowledged the challenge of mainstreaming IKS within the education system in view of the influence of the hegemony of Western forms of knowledge protection.

The DST established the National Indigenous Knowledge Systems Office (NIKSO) to nurture national IKS priorities through proactive engagement in the field of science and technology, and to open up academic opportunities. Several government departments are part of the core team that meets regularly with NIKSO to discuss initiatives as well as insights in the integration of IKS in their respective departments.

The policy has the following key drivers:

- Affirmation of African cultural values in the face of globalisation.
- Development of services provided by indigenous knowledge holders and practitioners, traditional medicine and indigenous language developers, folklore and agriculture.
- Contribution of indigenous knowledge to the economy, employment and wealth creation.
- Interfacing Indigenous Knowledge Systems with other knowledge systems, in order to increase the rate of innovation.
- Developing a coherent and consistent government approach in aligning the IKS policy with other regulatory frameworks (DST 2004:12–16).

The integration of the indigenous knowledge systems into education and the National Qualifications Framework was expected to:

- infuse the values and principles of IK into the national curriculum.
- transform the curriculum from a primarily content-driven approach to one of problem solving.
- promote agricultural and industrial enterprises, particularly in rural areas.
- augment grassroots innovations by promoting cooperative ventures between indigenous and local communities

The Department of Education has made it mandatory for all subjects, from grade R to grade 12, to "value Indigenous Knowledge Systems". This research set out to explore a model for integrating the two systems of knowing, as a contribution to the ongoing research on how IKS and modern science can be integrated. The integration of the two knowledge systems that have come to be perceived as different requires a theoretical framework that will make such integration fair to both systems of knowing and useful to humanity.

Conclusion

This chapter provides grounds for an education that is different from the education provided by South Africa before the democratic election of 1994. This chapter highlights the aspirations of Africans to integrate the cultural knowledge into the current forms of knowledge. As this study aims to integrate the two knowledge systems, modern science and IKS, the examples of such integration as well as the

views of Africans on the education of their children provide important insights into how the indigenous communities in Africa would prefer to have their children educated.

The Alaskan model provides an example of how IKS can be integrated with modern science in the provision of an education that serves communities while bringing into the knowledge pool of such communities insights and new knowledge on the laws of nature and the intricacies of the material world as discovered by science. This model opens up insights into how a model of the integration of the two knowledge systems can be developed, thereby supporting one of the objectives of this study. The Alaskan model shows that if the two knowledge systems are to be integrated, a different manner of organising knowledge in education offers a better option. In this model scientific knowledge is embedded within indigenous knowledge where possible. The science concepts are used to explain the everyday lived culture instead of science being applied in abstract scenarios. The organisation of knowledge in the Alaskan model does not follow the usual practice of teaching science as subjects but rather teaches science within culture because these laws of nature are universal, observable to indigenous people as well and can therefore be demonstrated within most everyday activities.

The policies of the Department of Education require a form of science education that is able to impart values to the recipients of such an education. Science education in the Western tradition is dissociated from human values, and focused only on the material aspects of being. The challenge of inserting values into science education might be overcome by embedding science in the culture of communities instead, as the values will already be embedded in this culture. Science in this case does not become the driver of knowledge; the culture drives knowledge and science merely serves the purpose of furthering an understanding of the material aspects of being. This is an important contribution to the integration of the two knowledge systems as it justifies an alternative manner of organising knowledge so as to accommodate the two knowledge systems. In this model, the facts of science can be recalled when needed.

The next chapter discusses a framework that has the capacity to allow for the production and dissemination of knowledge in the integration of indigenous knowledge systems and modern science. It is a framework that provides a platform for the integration of the two knowledge systems. This framework should be capable of deconstructing the scenarios that facilitated the knowledge production mechanisms that led to the indigenous knowledge system being allocated an inferior status in the hierarchy of knowledge. At this point it becomes necessary to investigate the tools that were used to lead to the subjugation of IKS.

CHAPTER 5: AFRIKOLOGY, AFRICAN INDIGENOUS KNOWLEDGE SYSTEMS AND MODERN SCIENCE

This chapter provides a theoretical framework that allows for the integration of the two knowledge systems. The framework is necessary to support the model of integration that this study aims to produce as one of its objectives. Indigenous knowledge systems incorporate knowledge whose framework lies within the African culture whereas modern science represents knowledge whose framework is consistent with European culture. A theoretical framework that is capable of supporting both cultures and their associated worldviews is therefore necessary. Afrikology is hereby seen as such a framework.

The appropriateness of Afrikology as a theoretical framework for the study on the integration of indigenous knowledge systems and modern science is explored. The chapter provides insights into how indigenous knowledge systems came to be marginalised in the domain of everyday knowledge. The processes as well as acceptable practices that facilitated the marginalisation of the indigenous knowledge systems are explored. These discussions are important to this study as a way of recognising systems and processes that caused its marginalisation in the first place.

5.1 Afrikology as a theoretical framework for the integration of indigenous knowledge systems and modern science

Theoretical frameworks provide a particular perspective, or lens, through which studies are undertaken (Trent University n.d.). This study; "The integration of modern science and indigenous knowledge systems", requires a post-colonial theoretical framework as a means of debunking the myths and assumption that have been developed about Africans using Eurocentric theories to describe and evaluate Africans, and their being. One can therefore conclude that the approved methods of research, usually dubbed "scientific methods", express the interests and ways of knowing of the West to the exclusion of the interests and ways of knowing of the other, in this case, the Africans. In working towards the aim of this thesis, the interests and the ways of knowing of all need to be accommodated.

In the past, colonial theoretical frameworks have produced knowledge based on how the West views Africans as opposed to how Africans view themselves and how they would like to present themselves. Throughout colonial history, knowledge produced using these theories has legitimised the opinions and attitudes that have informed practices that subjected Africans to the inhumane and barbaric treatments that they came to endure (Trent University n.d.), and possibly even the manner in which Africans view themselves.

According to Nabudere, the epistemology of Afrikology and transdisiplinarity recognises the fact that all people are creators of knowledge and this knowledge is created as a response to the environmental stimuli experienced through our senses and perceptions. This knowledge is created through words which according constitute the language of the community and are related to our cosmic forces and reason. Afrikology as a theoretical framework therefore seems the most appropriate for the purposes of producing knowledge from the perspective of the colonised and formerly marginalised Africans (Nabudere 2010). Afrikology recognises the need for Africans to produce knowledge about themselves, as previously discussed, and therefore embraces the standpoint that people from exploited groups, in this case people who have lived under colonial rule, because of their understanding of the subtleties of discrimination which are not always visible to people from dominant groups, are in the best position to produce their own knowledge and should be part of the process of producing knowledge and policy formulation (Harding 2010).

Afrikology is a favourable theoretical framework because of its insistence of putting humanity first in knowledge production. It posits itself as a humanistic approach to knowledge production. Afrikology encompasses the philosophical, epistemological and methodological issues—all seen as part of the process of creating an African self-understanding which is crucial if Africans are to emerge from the stereotyping that has pervaded their existence since colonial times and to a large extent defined their futures. It provides a platform that allows Africans to emerge as proud members of the global society (Nabudere 2010) on the strength of knowledge they have created as opposed to knowledge they have learned mainly from their former masters.

Afrikology as a framework in education should address the challenges faced by communities in their everyday life. Educating for employment cannot continue to be the sole purpose of education, especially in the light of rising unemployment (Hoppers & Richards 2011). Training for employment in the light of ever-changing technologies sounds more like fattening cattle for slaughter. One wonders how teachers can be expected to train learners for employment when they have no realistic idea of the nature of the jobs their learners will be exposed to, especially because most teachers have never worked in any other environment than the school environment. The ever-changing technologies mean that employers are in the best position to train their own labour force (Robinson & Robinson 1989). Training for employment should therefore ideally be left to employers. Schools should rather train learners for self-reliance, and impart skills and values that help them to look after themselves, their families, their communities and the world. They should be encouraged to be innovative and to know where they can find knowledge that they need to solve problems and to survive in their environments.

For the purpose of challenging the Eurocentric world view in the interpretation of nature in science and accommodating the African world view, Afrikology as a theoretical framework provides for an epistemology that is not necessarily African-centric or Afrocentric but a universal scientific epistemology that goes beyond Eurocentrism or other forms of ethnocentrism. This epistemology recognises all sources of knowledge and is therefore able to accommodate sources of knowledge in modern science and indigenous systems. It accepts knowledge as valid within its historical, cultural or social context and seeks to engage everyone in a dialogue that can lead to better knowledge for all. It also recognises that people's traditions are fundamental pillars in the creation of cross-cultural understandings in which Africans can emerge as the forebears of what is now known as the Greek or European heritage. The universality of this epistemology, according Nabudere, stems from the understanding of Africa as the cradle of humankind (Nabudere 2010).

Nabudere proposes that African scholars should

> pursue knowledge production that can renovate African culture, defend people's dignity and civilisation achievements and contribute afresh to a new global agenda

> that can push us out of the crises of modernity as promoted by the European enlightenment. Such knowledge must be relevant to the current needs of the masses, which they can use to bring about social transformation out of their present plight. We cannot just talk about the production of 'knowledge for its own sake' without interrogating its purpose (Nabudere 211:2)

Africans should therefore see themselves as producers of knowledge as opposed to consumers of knowledge.

5.2 Integrating indigenous knowledge systems and modern science

The integration of IKS and modern science in this study will be looked at in terms of knowledge production. Scientific knowledge is largely knowledge that has been acquired through the scientific method, documented and archived. This knowledge is what is generally taught as science in schools (Dewey 2001). Scientific knowledge has produced and still produces knowledge even if there is no obvious need for such knowledge in the communities. Indigenous knowledge production, on the other hand, has always produced knowledge to address a need. In this integration of the two knowledge systems they will both be employed in producing new knowledge as they both engage in a dialogue to solve an existing practical problem.

Standpoint theories promise to mediate between views held by opposing camps on the values in science. Their methodologies oppose the conventional frameworks of research disciplines, which have generally been organised in ways that satisfy the groups that support and fund them, thereby serving the interests and desires of those groups (Hartsock & Smith 2004). They allow for productive new debates which present the desirable relations of experience to the production of knowledge (Jameson & Harding 2004). It is these methodologies that are employed in the production of knowledge from the integration of IKS and modern science. Modern science and IKS will engage in productive debates as they work towards the co-creation of knowledge to solve a problem, taking all aspects of the solution of this problem into consideration.

5.3 Afrikology and deconstruction

The history of Africa and South Africa shows the distortions in power production caused by the political realities of both apartheid and colonisation The relationship between IKS and Afrikology stems from the need for Africans to redefine their world so as to understand both the world around them and their cosmologies. It is only when Africans create knowledge that promotes this understanding that they will be able to transform themselves. The methodological aspects of knowledge production should therefore be created within the Afrikology framework so as to avoid tools that produce the same type of knowledge that has sustained colonisation and the hierarchical structures that have also alienated people. This production of knowledge concerns a whole new way of looking at the world and involves the relationship between the temporal and the spiritual world (Nabudere 2010), elements that are generally not part of knowledge production in modern science.

According to Nabudere, the process of re-awakening and recovery must be one of deconstruction, where Africans delve deep into the implications of the burden of domination that continues to bedevil what he calls the "African personality" to organise themselves and move forward in history (Nabudere 2010). Scientific knowledge, while visibly the most dominant form of knowledge, is only one sort of knowledge among many other epistemic and intellectual projects, which are different from scientific knowledge (Rescher 1984). Because of this dominance, indigenous knowledge has lost its place as a means of solving problems. Indigenous people have had to remain students and learners forever and this has implied socioeconomic challenges for indigenous people in general. Science as a dominant body of knowledge has overpowered its opponents by force and not by argument (Volmink 1998) as will be demonstrated in the following sections. In the integration of the two knowledge systems, both knowledge systems will be allowed to present their evidence in the courts of justice of a democratic society.

Knowledge from an oppressive past, colonisation in the case of Africa, is structurally transmitted through a system that is deeply implicated in a past marked by inhumanity and injustice (Martin 2012). By accepting the systems of the coloniser, the structures of humiliation and injustice are repeated; only this time the "othering"

is practised by the same people who have been oppressed (Freire 1989) on their fellow human beings. Deconstructions are therefore necessary as a way of moving away from colonisation and its methods, structures and traditions. The duty of constructing knowledge that is liberating is important for Africans so that they will be aware of oppressive practices and be able to avoid them (Freire 1989). Afrikology is seen as an attempt to reform the assumptions about, nature of, and scope and validity of knowledge (Martin 2012).

5.4 Indigenous knowledge systems and Afrikology

The history of colonisation in Africa has supported theories on the manner in which knowledge about the indigenous people was collected, classified, presented to a Western audience and then, using the lenses of the coloniser, represented back to the colonised, causing them to see themselves in a way that suited those who oppressed them. According to Hoppers, this method of producing knowledge is still perpetuated by most research institutions in South Africa (Hoppers 2002). The knowledge produced about the African was used to exploit the non-European peoples, colonise them both mentally and geo-strategically and subordinate the rest of the world to the designs and interests of the European (Nabudere 2010). If Africans continue to apply this knowledge and the associated theories without questioning them, they could bring about their own re-colonisation. Concepts that are important and necessary to the African cosmology are brought back into the lives of Africans through this new process of knowledge construction.

Framing the epistemology in Afrikology allows for the protection of IKS as they are integrated and also salvages indigenous knowledge from processes such as the “scientization” and “mathematization” of knowledge, both of which tend to either alienate knowledge from the knower or exclude what is considered knowledge from the knowledge base of the indigenous people if it does not fit in with the disciplines of science and/or mathematics (concepts discussed in chapter 2). This framework would also allow for the use of indigenous languages in the production of knowledge because speech and tradition are the sources of knowledge and wisdom to the African. According to traditionalists, speech is divine in origin, and therefore the use

of traditional languages as sources of knowledge and instruction should play a central role in this epistemology (Nabudere 2010).

Afrikology embraces transdisciplinarity (Nabudere 2010), a feature that is absent from mainstream Western constructed studies of science. Transdisciplinarity is an important feature of indigenous knowledge systems. It is consistent with the interrelationships notion of indigenous knowledge. Section 3 of the transdisciplinarity charter describes transdisciplinarity in the following manner:

> Transdisciplinarity complements disciplinary approaches. It occasions the emergence of new data and new interactions from out of the encounter between disciplines. It offers us a new vision of nature and reality. Transdisciplinarity does not strive for mastery of several disciplines but aims to open all disciplines to that which crosses them and that which lies beyond them (The Charter of transdisciplinarity 1994)

The problems with which Africa is faced cannot be reduced to either the humanities or the natural sciences (Hoppers 2006), nor are they about a particular discipline. In solving these problems of Africa, a transdisciplinary approach is the best, if not the only, option. In working towards a model, this study follows the transdisciplinary approach and does not confine the integration of IKS and modern science to education alone; the study goes beyond the discipline of education; science and indigenous knowledge and as far as possible explores the factors that impact on the integration of IKS and modern science, including the factors that influenced the separation and hierarchization of indigenous knowledge systems and modern science and eventually led to the subjugation of generations of people and their knowledge, resulting in misery and the absence of peace for generations.

Hoppers describe transdisciplinarity as follows:

> As the prefix “trans” indicates, transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines and beyond all disciplines. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge. The other imperative is the generation of knowledge that has transformative heuristics (Hopper 2006:36).

Science as an expression of human creativity ought therefore to be a pluralistic enterprise and not be restricted to Western-programmed science. It should include the knowledge systems of diverse cultures in different periods of history (Hoppers 2006). It should embrace all humanity, especially if knowledge constructed through science affects all of humanity, the environment and agreements between humans across continents, countries and cultures.

The Western disciplines confine science as a study of nature to compartments that do not always accommodate aspects of indigenous culture that do not exist in Western thought, practice, language and being. These disciplines as taught in education to the African learner therefore continue to impart knowledge that is stripped of the African worldview and the African indigenousness. It continues to make African learners into what Hoppers has called call "an inverted image of the west" (Hoppers, 2002). As the purpose of this study is to integrate the indigenous knowledge systems and modern science, we cannot continue working in modern scientific disciplines as they might exclude indigenous knowledge that was never classified in any of the dominant Western academic disciplines. The study of science in a transdisciplinary manner gives us space to talk about

> what is between the disciplines, across the different disciplines and beyond all disciplines (Hoppers 2006:36).

Transdisciplinarity, as a feature of Afrikology (Nabudere 2010), is inherent in the holistic nature of IKS as described elsewhere in this thesis. The production of knowledge in Afrikology pursues knowledge that serves communities (Higgs 2003) and it recognises that all forms of knowledge are valid within their historical, cultural or social contexts (Nabudere 2010). Yunkaporta refers to Indigenous pluralism, which he describes as a traditional way of knowing that draws down knowledge from many surrounding language groups, as opposed to dominant cultural thinking that favours a monocultural approach to education (Yunkaporta 2007). The hegemony of a single knowledge system in a multicultural society is characterised not only by what it includes but also by what it excludes and in the process of exclusion renders marginal and ultimately inferior (Volmink 1998). It also leaves out the

interconnections that are not taken into consideration by a particular discipline because of the restrictions of its scope in addressing an issue. An example is a chemist who produces a molecule that kills insects and does not know anything beyond the purpose of his invention. The consequences on the environment and people might not be important but could have dire consequences that strike deep into the social, political and cultural lives of people. DDT is an example of the lack of transdisciplinarity in the use of scientific knowledge.

Transdisciplinarity as an answer to inadequacies in interdisciplinarity provides solutions to problems that humanity is currently struggling with (Saunders 2011). It can enable us to overcome the pitfalls of reductionist principles as contained in science and recognises that the experts who qualified from narrow disciplines alone cannot solve the complex problems of today (Hoppers 1998).It also dictates that real-world problems should be identified and solved instead of remaining in the ivory towers of self-contained academic discourse (Meyer 2007).

Transdisciplinarity promises the following:

- A combination of perspectives that does not confine itself to disciplines but includes knowledges and methods from different disciplines in solving problems.
- Participation of stakeholders who include multiple non-scientific stakeholders participating in a practice-oriented approach.
- A problem-oriented approach to research dealing with scientific problems derived from tangible, real-world problems, as opposed to problems originating from within science rather than external developments in the “living world”.
- A solution-oriented approach. The research primarily achieves the implementation of research results and the development of concrete solutions for practice as opposed to producing new, cutting-edge knowledge (Pregernig 2006).

This approach to knowledge production is therefore desirable.

5.5 The marginalisation of indigenous African knowledge systems by modern science

The marginalisation of indigenous knowledge is a well-orchestrated plan that continues to bedevil the recognition and affirmation of indigenous knowledge as knowledge in its own right. Africans born under colonial rule might not recognise the impact of their lack of indigenous knowledge and its contribution to lagging development and neo-colonisation in their countries. This discussion, it is hoped, will give policy makers and implementers the lenses required to deal with the integration of indigenous knowledge systems and modern science.

The marginalisation of IKS began with the dehumanisation and subjugation of the colonised Africans even before most Europeans set eyes on them. The lies told by those who had travelled to Africa back to the people in Europe distorted images of Africans, conjuring images of Africans as animals in the form of humans.. The following extract depicts the way Africans were described to those who had yet to set eyes on them:

> Of the Ethiopians there are diverse forms and kinds of men. Some there are toward the east have neither nose nor nostrils, but the face all full. Others that have no upper lip, they are without tongues, and they speak by signs, and they have but a little hole to take their breath at, by which they drink with an oaten straw.... In a part of Afrikke be people called Pteomphane, for their king they have a dog, at whose fancy they are governed ... And the people called Anthropophagi which we call cannibals live with human flesh. The Cinamolgi, their heads are almost like to heads of dogs ... Blemmyis a people so called, they have no heads, but hide their mouth and eyes in their breasts. (Quoted by Thabo Mbeki, former President of the Republic of South Africa in his address at the United Nations University.)

Racism, a feature of many forms of colonisation, is used to dehumanise the other. This is mainly achieved by emphasising those features that colonialists possess as features of superiority and features of the colonised as features of inferiority (Carnoy 1974). In South Africa people with dark skins and curly hair were placed at the bottom of the social and economic ladder because they were perceived as inferior by

the Nationalist Party government. The "pencil" test was used to classify those who were not obviously black or coloured, Indian or white under the Population Registration Act 30 of 1950.[10]

The film *Skin*[11] epitomised the trauma and the barbaric use of pseudoscience masquerading as knowledge for discrimination against people by supporting the flawed notions about race to separate people of the same species, who are essentially a species of the human race. This unscientific classification of race was allowed in the public domain despite many scientists in South Africa being aware that it was scientifically flawed. It eventually informed the policies and laws of the apartheid state (Tobias 1961).

The colonisation of Africa, a cruel and violent system that sought to dehumanise the colonised applied a variety of methods to subdue the African people. These acts of aggression that came with colonisation delegitimised IKS on two levels: firstly, by denigrating the African as a human being with dignity, and secondly, by undervaluing the knowledge possessed by Africans. One can conclude that colonisation created an order for Africans where the colonisers were the teachers and leaders and the Africans were the learners and followers.

During colonisation and domination, which included forced occupation, invasion, servitude, apartheid and ethnic imperialism, indigenous knowledge systems were often referred to in a negative or derogatory manner, using phrases such as "primitive, backward, archaic, outdated, pagan and barbaric" (Ocholla 2007). People using IK were treated as inferior to those who followed the Western ways. In order for an individual or community to be admitted into "civilised" or "modern" society they had to stop using IK. Accordingly, this knowledge was illegitimated, illegalised, suppressed and abandoned by some" (Ocholla 2007). It follows, therefore, that under colonialism people were not free to embrace this form of knowledge.

[10] A law that made it illegal for blacks, whites, Indians and coloureds to live in the same areas.

[11] The movie highlighting the worldview's irrationality of racism. The movie SKIN is based on the 'true' story of a coloured child called, Sandra Laing, who was born in the 1950s to white parents and rejected at the age of ten, Sandra is rejected by her white society. The film follows Sandra's thirty-year journey from rejection to acceptance, betrayal to reconciliation, as she struggles to define her place in a changing world and triumphs against all odds.

5.5.1 Capitalism and development

Capitalism is an economic system in which investment in and ownership of the means of production, distribution and exchange of wealth are made and maintained chiefly by private individuals or corporations, especially as contrasted to cooperatively or state-owned means of wealth (Dictionary.com, 2013). Capitalism is about capital which means money. This economic system has extended to the ownership of production to include even the production of basic needs like food! These are now firmly in the hands of capitalists. Elements central to capitalism include capital accumulation, competitive markets, and a price system (Capital accumulation n.d).

African leaders have wrestled with the ideology of capitalism since independence. The impact of capitalism on the poor and as a tool of neocolonisation in Africa has been articulated by many African leaders. Julius Nyerere, in the 1967 Arusha Declaration, cautioned against development that needed capital investment rather than human investment. He argued that poor countries end up burying themselves in debt through the use of capital, which actually means money that they do not have. His contention was that the rules of capitalism are decided by those with capital, in many cases, their former colonisers, who define the rules of the game and ultimately the agenda of their former colonies. He advocated human capital development, where the people use what they already have and do what they are able to do (Arusha Declaration), as opposed to relying on foreign countries with their expensive technologies.

Thomas Sankara, the former leader of Burkina Faso, described debt by Africans to former colonizers as “a cleverly managed re-conquest of Africa”. His argument was that the origins of debt lie in colonialism and that after indebting Africa colonisers now masquerade as “technical assistants” when in his opinion they were actually “technical assassins” (Thomas Sankara n.d.).

Kwame Nkrumah, the first president of Ghana, once warned that

> for as long as capitalism and imperialism go unchecked there will always be exploitation, and an ever-widening gap between the haves and the have-nots, and all the evils of imperialism and neo-colonialism which breed and sustain wars (Nkrumah n.d.).

He also warned against dependence on capitalist global institutions such as the United Nations Organization (UN) and the Bretton Woods institutions such as the IMF and the World Bank. Regarding the UN, he reminded people that the UN is the tool of the elite states which control the Security Council and that it is just as reliable an instrument for world order and peace as the Great Powers are prepared to allow it to be" (Nkrumah 1958).

This view is shared by Hoppers, who describes these relationships as structural violence due to the conditions that are usually attached to aid or donations (Hoppers 1998). Peat, in *Gentle Action*, describes how help from these institutions is usually predetermined without proper consultation with the people being helped, and usually arrives together with highly paid consultants from the sources of such aid, who do not serve any appreciable purpose (Peat 2008) but get paid substantial amounts of money from the very aid destined for the destitute.

The violence of capitalism was evident in South Africa after the discovery of gold. Draconian laws and exploitation, which forced the indigenous people of South Africa to work in the mines, saw masses of South Africans, mostly males, leave their homes to work in the gold mines as cheap labour, far from their traditional ways of living. This further destabilised their homes, communities and traditional way of life. These laws, like the pass law, the poll tax law and the migratory labour laws, were laws specifically designed to force the Africans to work on the mines for the capitalists at wages so low that one could just as well speak of free labour (Ticktin 1991; Mathews 1986). Many other oppressive laws were approved by the minority cabinet to justify the oppression of blacks in South Africa, imprisoning those who "broke" such laws. This dislocation of the Africans from their customary way of life and their families meant that they had to adjust to lives in the mining compounds and the sociological changes brought about by such lives. Far away from their cultural bases and ways of

life, their indigenous practices and culture slowly gave way to the newly imposed conditions under which they had to live (Mathews 1986).

Capitalism has become a way of life for many people in Africa. While the initiation of countries into capitalism involved their being the recipients of capital loans, this trend of dealing in capital has now extended to individuals within countries, where individuals owe money to banks, lenders and sometimes one another. Capital has become the only universal form of exchange.

According to Fägerlind and Saha, it was the need to rebuild Europe after the Second World War, as well as the simultaneous emergence of the new nations of Africa and the growth of old nations in Latin America and South-East Asia, that brought into focus the importance of the factors necessary for social and economic development. This development was necessary to rebuild Europe after the ravages of war, but it was sold to the world as development of Africa and the Africans. The extension of development in Africa became important so as to satisfy the needs of Europe in terms of raw materials and labour (Fägerlind & Saha 1989). This development in Africa took place with Africans as bystanders and funders of this development, which was controlled from elsewhere. It ignored traditions, values and African knowledge as it "advanced" Africans to the Western style of development (Shibanda 2006). This kind of development, one can conclude, reduced Africans to the status of paying bystanders in the development of their countries.

Development after colonisation was still decided from outside African countries. Structural adjustments, a term denoting a process and conditions by which money is lent by the IMF and the World Bank to developing states, were introduced after the Second World War to assist countries to develop. These loans were given for specific programmes, usually agreed upon by the organisations. Concessions that were extracted from the countries receiving the loans usually left the countries with no power to influence policy changes in a manner that suited their own needs. The various concessions included political reforms and adherence to economic policies such as the following:

- Curbing of government salaries;

- Devaluing of salaries where they were considered overvalued in order to allow cheaper exports from Africa to the rest of the world;
- Disallowing African countries from restricting imports;
- Privatisation of state-owned enterprises;
- Raising rates of interest offered by banks (Manson 2010).

This development has come at a high cost in human, ecological, health and economic, political and social terms (Hall & Rosenberg 2000).These Western development models delinked the African indigenous knowledge systems, leading to development without grassroots participation, which eventually led to ineffective results (Shibanda 2006).

The World Commission on Environment and Development (WCED) has defined sustainable development as development that meets the needs of the current generation without compromising the ability of future generations to meet their needs and aspirations (WECD 1987). Many Africans are not able to meet their needs and aspirations, resulting in unstable democracies, war, unemployment and general strife, forcing Africans to settle outside their own countries

Modernisation theorists often saw traditions as obstacles to their economic growth. The modernisation of people affects their whole way of life; this includes but is not limited to what they eat, how they have to eat their food, what they wear, where they are expected to live and all aspects of their social lives. One can conclude that the net effect of modernisation for some societies is the replacement of traditional poverty by a more modern form of misery (Gavrov 2004). On the other hand, advocates of modernisation point to improvements in living standards, physical infrastructure, education and economic opportunity to refute such criticisms (Modernization theory n.d.). The imposition of this new knowledge served to displace the products of local industries, based on endogenous knowledge, to favour the products of metropolitan industry, based on modern science (Houtondji 2002).

Schools, as exclusive institutions that expose children to novel cognitive tasks that facilitate widespread access to products of modern Western science and technology (Odora 1993:96) facilitate the modernisation process, with the kind of education that totally excludes the indigenous knowledge of the people being taught. The

modernisation process extends to goods, curriculum and technologies that flood African markets from overseas countries.

5.5.2 Discourse on the scientization of life-world knowledge

Agrawal describes scientization as a step which involves distinguishing the descriptive from the analytic, the anecdotal from the systematic, and the mythical from the factual when dealing with the two knowledge systems (Agrawal 2002). Scientization of knowledge, according to Böhme,

> consists in delegating specific acts of daily living to scientifically educated experts (Böhme 2005: 376).

Scientization of knowledge, according to Böhme, presupposes that:

> Scientization improves life-knowledge, makes it more precise, eliminates superstition and error (Bohme 2005:376).

In his essay on "Midwifery as science", Böhme argues that childbirth, for example, despite the fact that it is as old as mankind, has now been completely removed from life-knowledge into the synthetic environment of the hospital, where even normal birth is assumed to take place under the same conditions as a difficult birth or a pathological case. In the meantime, knowledge of childbirth has been completely removed from people who are not trained in the modern scientific ways, with the result that ordinary people have to pay dearly for a process as natural and as old as childbirth (Böhme 2005). This is an example of how indigenous knowledge, by naming a few concepts of the knowledge itself in a different language, renders the indigenous people ignorant.

The thinking behind the scientization of life knowledge overlooks the possibility that life-knowledge might be simply performing different functions from those performed by modern science. It also demonstrates how the enormous efficacy that is attributed to scientific knowledge, although such knowledge has been constructed from a narrow conceptualisation, has been given prominence as the dominant public conception of knowledge over life -knowledge. This reflects the diminishing role of

the non-scientific conception of knowledge (Stehr 2005), and constitutes the marginalisation of indigenous knowledge.

As a result of the monopoly of science on knowledge and authority, scientization is able to encourage the constitution of various social entities as organised, rule-making and empowered actors in deciding what knowledge will be used and how it will be used. In this environment, scientists are in a position to create incentives and requirements for forceful collective rule-making which culminates in policies, laws and treaties and for elaborate organisation on a global scale. This has allowed globalisation to drive the scientization of knowledge (Ellis 2005). In the case of indigenous knowledge, this scientization of knowledge diminishes what indigenous people know and turns whole generations of Africans into perpetual learners, who cannot learn anything from their own communities but need to be removed from their communities to be "taught", "civilised" and "modernised" and taught science. It creates a perpetual dependency and helplessness as well as powerlessness among Africans and makes them poor relations of the educated, even if they themselves are educated in terms of their own knowledge (Fairclough 1995).

5.5.3 Mathematization of knowledge of nature

Leroy Little Bear, in his foreword in *Native Science: Native laws of interdependence,* argues that Western paradigmatic views of science are largely about measurement using Western mathematics, even though nature is not mathematical. Mathematics has, according to him, been superimposed on nature like a grid and then examined within that framework. This, he argues, excludes many aspects of nature that other knowledge systems consider in their dealing with nature (Cajete 2000).

In his essay entitled "What did mathematics do to physics?" Gingras outlines the challenges experienced by natural philosophers in the eighteenth century and in the first half of the nineteenth century in Europe as more and more domains of physics lent themselves to mathematical formulations based on Newtonian mechanics. Having distilled knowledge into science and non-science, the mathematization of physics further distilled the knowledge of nature that had been the domain of

philosophers. According to him, mathematization of knowledge excluded many people who were not mathematically inclined from discussions about nature. It also excluded those aspects of nature that did not lend themselves to mathematical expressions. He outlines the following negative consequences of the mathematization of knowledge about nature for the social, epistemological and ontological knowledge of production and understanding of nature:

1. **Socially**: the use of mathematics in explaining nature excluded actors from legitimately participating in discourses on natural philosophy.

2. **Epistemologically**: the use of mathematics in dynamics (as distinct from its use in kinematics) had the effect of replacing explanations by calculations.

3. **Ontologically**: by its ever more abstract treatment of phenomena, mathematization led to the vanishing of the concepts used to explain phenomena.

All this led to the "rise of private science", accessible only to those with prowess in mathematics. The rest of the public could no longer be considered legitimate contributors to knowledge on nature as they were regarded as having a superficial understanding of how things worked. Later, as physics became institutionalised, the qualitative explanations were no longer acceptable and physics institutions became the only legitimate bodies for describing and explaining nature to everyone (Gingras 2001). This also contributed to the marginalisation of indigenous knowledge systems.

5.5.4 The death of African languages

Speech is the medium for the commonality of thought. Language is a socially and culturally determined commonality with application to families, schools, nations or linguistic communities (Brand 2011). Indigenous knowledge is embedded in indigenous languages (Nabudere 2010; Emeagwali 2003), **and** without the use of indigenous languages, knowledge as well as values could be lost. During colonisation and apartheid, indigenous languages were not recognised as official

languages. In some cases indigenous people were not allowed to speak their own language but were forced to learn the language of the coloniser. With the loss of indigenous languages, it follows that indigenous knowledge as well as concepts unique to indigenous groupings, namely customs, practices and indigenous attitudes were lost.

The exclusive use of English and Afrikaans not only stands in the way of internalising science knowledge for African learners but makes it difficult for them to participate in many other processes of their democratic life as citizens in a democratic society. The failure rate among African learners has been ascribed to language difficulties that make it difficult for them to understand the content knowledge and express themselves in English or Afrikaans in their examinations. Understanding and ownership of all aspects of society, including the legal systems, by the majority of South Africans poses enormous obstacles and difficulties for them if all the information is presented in a language that they do not understand or speak (Brand 2011).

In most African states the language of learning and teaching is never an indigenous language. In South Africa, English and Afrikaans are the languages of learning and teaching from higher primary schools to university level, despite the fact that these languages are spoken by only a minority of South Africans. When the languages of indigenous people are not used, concepts that are characteristic of their cultures and being and are embedded in their languages are likely to be lost forever. When Africans give up the right to their own languages as languages for negotiating knowledge they become complicit in the loss of their own knowledge and technologies and can therefore be said to be complicit in their own subjugation.

Conclusion

Afrikology as a theoretical framework that embraces not only the ambitions and needs of the formerly subjugated Africans but also progress that has already been made in the scientific knowledge arena presents the best framework to facilitate the integration of modern science and IKS. This framework allows room for a dialogue that is able to facilitate an integration of the two knowledge systems as they interact

in an effort to provide solutions to challenges faced by humanity. This framework facilitates agreements as well as disagreements on what knowledge is and how this knowledge should be produced, managed and disseminated.

Vigilance against processes that led to the exclusion of indigenous knowledge in the public domain is necessary as a way of ensuring success in the integration of the two knowledge systems is required for the success of this integration. Capitalism, for example, which is inextricably linked with modernity, has not always proved to be in the best interests of indigenous communities as Richards in a speech at the conference held at Unisa in 2012 warned,

> "capitalism in particular needs to be tamed, and new forms of social exchanges need to be considered" (Richards 2012).

Aspects that led to the marginalisation of indigenous knowledge in the first place are a necessary contribution to the study as they inform the model that will eventually be produced for this integration.

The decision by Africans to abandon their languages in the transmission of knowledge after liberation reflects the rigidity of science in its present form when it comes to accommodating indigenousness. This seems to ignore the fact that knowledge does not have a language and knowledge can in fact be expressed in any language. Language expresses the needs, aspirations and interests of people. When Africans give up the right to their own languages as languages for negotiating knowledge, they could also be giving up their right to express their needs, aspirations and interests. This is an important consideration in the construction of a model of integration. This loss of usage of their own language by Africans in the education of their children makes them complicit in the loss of their own knowledge and technologies.

All these considerations must be taken into account in the development of a model.

CHAPTER 6:RESEARCH DESIGN AND ANALYSIS

Research is the systematic process of collecting and logically analysing data for some purpose to find new knowledge (Hammersley 1995; McMillan & Schumacher 2006). This research aims to find a way of integrating IKS and modern science without compromising the integrity of either knowledge system.

The design of this research has taken into consideration the aim, objectives and research questions that need to be answered. The choice of methods in this research has taken into consideration the fact that indigenous knowledge as used by the average African may have been somewhat influenced by scientific knowledge. The design was chosen so as to be able to source facts on indigenous knowledge and modern science that are not a hybrid of the two systems of knowing. This was also important in enabling the researcher to clearly express the similarities and differences in the two systems of knowing while working towards a model of integration.

6.1 Exploratory research

Exploratory research is particularly useful in cases when a researcher has a limited amount of experience with or knowledge about a research issue and it rarely yields definitive answers (Neuman 2006) in this case - the integration of modern science and indigenous knowledge, it is deemed as the most appropriate research. Since exploratory research is especially desirable because it is creative, open minded and flexible, it also adopts an investigative stance and explores all sources of information allowing the researcher to use any information and ask any question in the research process. It therefore provides greater understanding of a concept or a problem rather than providing precise measurement or quantification from a narrow perspective. It uses qualitative techniques for gathering data (Neuman 2006).

Agreeing with Neuman above, Webb also points to a high degree of flexibility and a lack of formal structure as one of the characteristics of exploratory research. This according to Webb helps the researcher to avoid being blinkered by any preconceived notions (Webb 1992), characteristic of pre determined structures. This study on the integration of the two knowledge systems need to avoid using

established logic, structures, methodologies as well as assessment practices of modern science. It therefore avoids the possibility of being subsumed by the established practices of modern science and ultimately forcing knowledge production processes of indigenous people into scientific structures. In this way exploratory research allows for the researcher to uncover the boundaries of the environment in which the problems, opportunities or situations of interest are likely to reside and to uncover the salient variables that may exist and are relevant to the research project (Webb 1992).This study will investigate the many factors that are related to the integration of the two knowledge systems. It will therefore investigate not only the nature of the two knowledge systems but the many social dimensions that impact on the two knowledge systems.

6.2 Qualitative research

Qualitative research assumes that there are multiple realities that are socially constructed through individual and collective perceptions. It is concerned with the understanding of social phenomena from the participants' perspective (McMillan & Schumacker 2006). The multiple realities have evaded knowledge construction and produced knowledge that was not universally representative. Despite these omissions, scientific knowledge has been applied to everyone and has become a dominant scientific discourse that shapes the world as we know it. Because of these omissions, modern science is the most visible form of knowledge in use while IKS on the other hand, although used in various fields like health and agriculture, are not acknowledged. IKS exist side by side with modern science in a relationship of "mute juxtaposition" and "mutual ignorance, exclusive of all dialogue and exchange" (Hountondji 2002). This kind of relationship points to power relations between the two knowledge systems as a result of the geo-political hierarchies on knowledge and intellectual property laws—a legacy of colonisation and apartheid that continues to oppress indigenous people. This study takes into consideration pluralism, multiculturalism, transdisciplinarity and holism in its discussions on the integration of modern science and indigenous knowledge systems as concepts that are consistent with indigenous knowledge systems. This it is hoped will help to reintroduce the missing aspects of being into knowledge construction.

Qualitative research is an umbrella concept covering several forms of inquiry that help us to understand and explain the meaning of socio-cultural phenomena without disrupting the natural setting. It is based on the view that there is a contrast between reality and individuals interacting with their socio-cultural worlds. If we contrast qualitative research with quantitative research, quantitative research is seen as research that takes apart a phenomenon to examine the component parts (which become variables of study), while qualitative research reveals how all the parts work together (Merriam 1998). A qualitative methodology focuses on the qualitative aspects of meaning and is employed in order to explore the meaning, or describe and promote understanding, of human experiences. Qualitative work, according to Lindsay Prior, was developed by anthropologists while examining life in non-literate societies (Prior 2003). The knowledge, ideas, attitudes and voices of the indigenous people can therefore be reflected in the explanations about themselves, their beliefs, cultures, traditions and their own idea of what knowledge constitutes. Brink (2006) describes qualitative methodology as an appropriate and effective methodology for researchers who wish to explore the meaning or describe and promote understanding of human experience that is not easy to quantify. A qualitative research design is deemed more appropriate for this study than a quantitative research design because the approach towards finding the integration of the two knowledge systems is the beginning of a dialogue between the two systems of knowing.

In this study, the meaning of modern science and IKS will be explored. The distinctive features of each knowledge system will be explored. The understanding of nature from both knowledge systems will be constructed from literature on the understanding that qualitative research is based on constructivism, which assumes that multiple realities are socially constructed through a multiplicity of perceptions and views of the same situation. Experiences of indigenous people in Africa have been largely influenced by colonisation. It is therefore appropriate that these experiences and the effect that colonisation has had on them be fully explored. The knowledge that indigenous people had in pre-colonial Africa is explored and brought to the fore as examples of what Africans in pre-colonial Africa knew as a way of reclaiming what they knew, what they could do.

6.3 Critical theory as a Meta theory

Merriam describes three types of research paradigms: positivist, interpretive and critical theory. The qualitative research for this project is best located as a critical research paradigm which emanates from critical theory. Critical theory is a school of thought that stresses the reflective assessment and critique of society and culture, using knowledge from the social sciences and the humanities. Max Horkheimer described a theory as critical in so far as it seeks "to liberate human beings from the circumstances that enslave them" (Horkheimer 1982:244).

This theory is important as it allows for liberation in post-apartheid South Africa. The integration of modern science and indigenous knowledge systems should bring about liberation through education as a result of its acknowledgement of the knowledge held by indigenous people.

The assumptions of critical theory are the following:

- Certain people in society are oppressed and need to be empowered.
- All fundamental categories of all disciplines should be questioned to achieve emancipation.
- The human capacities of individuals must be developed and linked to democracy to improve society.
- Technology is not always negative, but it is negative when its interests take priority (and thus it may become unethical).

Critical theory becomes relevant in unearthing the power relations that have informed science education, marginalised indigenous knowledge systems and rendered indigenous people powerless and devoid of any useful knowledge in the education system and public arena in their own countries. In integrating indigenous knowledge systems and modern science, an attempt is made to work towards a body of knowledge that helps liberate people from the constraints that enslave them.

The relationship between indigenous knowledge systems and modern science has been dictated by the powers that have influenced the lives of Africans as a result of

colonisation. The organisation of everyday knowledge into disciplines in science will be explored and the manner in which it turned whole generations of Africans into illiterates will be investigated.

6.4 Collection of Secondary data using Documents analysis

Document analysis is a systematic procedure for reviewing or evaluating documents, both printed and electronic (Bowen 2004). Minnich, in the preface to *Transforming Knowledge*, points to the fact that books and articles are not the only sources of ideas that change us. Accordingly to Minnich, the ideas that change us more often come up in conversation and when references are given in written texts, conversations are usually omitted. This inaccurately and unfairly privileges those who write books and articles over those who think, talk, act and teach but do not write these thoughts down, and unfairly confers "ownership" of such ideas on the people who write books and articles (Minnich 1990). The secondary documents in this instance are deemed as necessary as they bring to this discussion the narratives from a wide array of individuals through books, journals as well as internet resources. This method will only be used for data collection and not for the analysis of data.

For the purpose of this study, the policies will not be analysed. The purpose of this research is not to analyse the policies but to use the existing policies to inform the model. The type of analysis that will be used will therefore be a thematic analysis, where the themes emanating from these policies are used to inform the model. This it is hoped will offered an alternative model to translating education policies.

In an effort to find a model that can successfully integrate IKS and modern science in the school curriculum for South African schools, it becomes necessary to use the policies of the South African education system, working from knowledge and source clues that support the integration. Samples of policy documents will therefore be used as a means of aligning the model with the existing policies of the Department of Basic Education.

The policies of the Department of Education are herby scrutinised for themes that support the envisaged model. The themes emanating from literature will also be used to construct the model.

The following documents (either the entire documents or the relevant parts) will be discussed:

- The Reconstruction and Development Programme.
- The White Paper on Education and Training, South Africa 1998.
- The National Curriculum Statement.
- The Indigenous Knowledge Policy of 2004.
- Policy on Protection of Indigenous Knowledge using IP System.
- Secondary literature on indigenous knowledge and modern science.

Immersion is one of the methods of supervision that I have been exposed to in SARChI. This method involves meeting with many experts in their particular fields where we share conversations about our research, views on world issues and the areas in which they are specialists. The experts were a transdisciplinary mix and included professors from universities across the world, holders of indigenous knowledge, and researchers in indigenous knowledge systems. They in turn shared their knowledge and experiences and listened to my ideas without trying to change my views, but it was usually after these sessions that new ideas emerged and some ideas were abandoned. My thoughts have therefore been shaped not only by what I have read but also by what came up during conversations with these knowledgeable people I was exposed to as well as by the papers they read at the conferences held by SARChI during these immersion periods.

6.5 Knowledge transmitted through basic education as a unit of analysis

The unit of analysis for this study is: **Knowledge transmitted through basic education**.

6.6 Critical discourse analysis (CDA)

Critical discourse analysis is a type of discourse analytical research that primarily studies the way social power abuse, dominance and inequality are enacted, reproduced and resisted by text and talk in the social and political context. Critical discourse analysts adopt explicit positions, and thus want to understand, expose and ultimately resist social inequality (Van Djik 1998). Fairclough defines CDA as discourse analysis which aims to systematically explore how relations of power and struggles over power give rise to practices, events and texts that exert their power over social groupings in societies; it also explores how the opacity of these relationships between discourse and society is itself a factor securing power and hegemony. CDA therefore aims to expose the often opaque relationships of causality and determination between discursive practices, events and texts, as well as social and cultural structures, relations and processes (Fairclough 1995).

CDA aims at making transparent the connections between discourse practices, social practices and social structures, connections that might be acceptable due to their opaqueness to the average citizen. Critical Discourse Analysis's locus of critique is the nexus of language/discourse/speech and social structure. Researchers in CDA uncover ways in which social structure impinges on discourse patterns, relations, and models (in the form of power relations, ideological effects, and so forth). These dimensions are the object of moral and political evaluation in CDA. By analysing them and exposing the power abuse inherent in such relationships, societies can be empowered to change their situation.

Critical discourse analysis also refers to the use of an ensemble of techniques for the study of textual practice and language use as social and cultural practices (Fairclough 1992). It draws from the following three broad theoretical orientations:

1. Poststructuralism: discourse operates laterally across local institutional sites, and texts have a constructive function in forming up and shaping human identities and actions.

2. Bourdieu's sociology: actual textual practices and interactions with texts become "embodied" forms of "cultural capital" with exchange value in particular social fields.

3. Neomarxist cultural theory: these discourses are produced and used within political economies, and produce and articulate broader ideological interests, social formations and movements within those fields (Hall 2000).

Discourses make up a dense fabric of spoken, written and symbolic texts of institutional bureaucracies (e.g. policies, curriculum documents, forms) and their ubiquitous face-to-face encounters (e.g., classroom interaction, informal talk). These discourses become part of the everyday accepted norms of being and functioning as many people grow up accepting them as the only way reality should be. Institutions as spaces of power over human subjects define and construct generic categories, such as "children" and "teachers" or "workers", "employers", "standards" etc and more specialised and purposive historical categories such as "professionals", "adolescents", "linguistic deficit" or "preoperational". These discourse constructions act both as institutional "technologies of power", implemented and enforced by official authorisation, and as "technologies of the self" (Foucault 1980). These categories with their nodal points become a reality for the subjects. Nodal points are defined here as "'privileged' signs around which a discourse is organised", inserted in a particular discourse (Jorgensen & Phillips 2002) and accepted by all.

According to Foucault and Derrida, language and discourse are not transparent or neutral when they describe or analyse the social and biological world. Rather, they effectively construct, regulate and control knowledge, social relations, institutions, scholarship and research. By this account, nothing is outside of or prior to its manifestation in discourse. The world into which many are born, and are raised, used/abused and die in South Africa is a world that has been constructed and regulated in the dominant scientific knowledge to the exclusion of the marginalised indigenous knowledge systems (Jorgensen & Phillips 2002).

CDA is especially useful for the analyses of data because it is in the use of words and concepts that the reality is enacted. For example an analysis of the use of language to define and describe nature will be explored to show “purposive historical categories” as well as “nodal points” that are responsible for making the current interpretation of nature as science function as well as define knowledge in the current education. The use of a language that does not sufficiently capture the African interpretation of knowledge, nature, education and cultural norms and being will be discussed to show how this act alone robs them of their own interpretation of nature while plunging generations of African children into an interpretation that does not sufficiently represent their worldview and therefore limits their leadership abilities and their capacity to manage their own affairs, especially natural resources. The following features of discourse: power, dominance, hegemony, ideology, class, gender, race, discrimination, interest, reproduction, institutions, social structure and social order, embedded in language, policies, procedures and the law, will be investigated in my analysis of everyday acceptable procedures. In my analysis I will show these features, veiled as “the usual” or “acceptable” and “standard practice” and describe how they impact on humanity.

6.7 Model

Models can be used in all research approaches, in conjunction with all methodologies and at various stages of the research process.

- Models are usually used to organise our understanding of studies and to highlight key relationships and they help us to shape our research programme.
- Models can be developed to represent thoughts with or without reference to previous studies. If models are used without reference to any study, they are said to be used as a benchmark for other studies.
- They can be representations of reality or mental constructs representing what people think the world is like.
- They can also be used to represent research findings.

  Models can be constructed from

  - a literature review,

- data analysis,

or

- they can be based on theoretical intuition without empirical evidence

or from empirical evidence (Newby 2010).

In this study, the model will be developed from a theoretical intuition influenced by Afrikology.

The model that will be used in this study is constructed from themes emanating from the policies of the Department of Education and has also been influenced by the themes from data analysis. This should open up new vistas where knowledge can be defined by both science and the formerly colonised in a manner that leads to the realisation of the aims of the National Curriculum Statement. For the first time formerly colonised people can also define what education means to them. They can express what they expect the education of their own children to be and what they expect education to consist of. The model will present an alternative to the current model of education.

6.8 Thematic analysis

Thematic analysis moves beyond counting explicit words or phrases and focuses on identifying and describing both implicit and explicit ideas within the data, thereby identifying themes. Codes are used to represent the identified themes linked to raw data as summary markers for later analysis (Introduction to applied thematic analysis, n.d.).The analysis will be used to answer the research questions but will also be used to further explore the themes that emerged for analysis (Fereday & Muir-Cochrane 2006).

The model will eventually be drawn from the themes presented by the data, as well as the features of the policies of the Department of Education and the Indigenous Knowledge Policy of 2004.

Holism in indigenous knowledge themes from IKS data

Analysis of data on indigenous knowledge systems reveals holistic descriptions of relationships between nature and human beings in indigenous knowledge systems reveal desirable qualities in indigenous knowledge. These descriptions include spirituality as a driver of behaviours and protocols in governing knowledge production when dealing with nature and thereby affecting knowledge production. Education in indigenous communities expresses what Miller (2007) describes as a holistic curriculum, that is a curriculum that considers relationships between linear thinking and intuition, relationships between various domains of knowledge, and relationships between individuals and communities as well as with oneself. This accordingly allows the student to examine these relationships so that the student gains both awareness of them and the skills necessary to transform the relationships where appropriate (Miller 2007). This holistic curriculum contrasts with the modern science curriculum which is viewed mechanistically and in which students imbibe values, skills and knowledge (Miller 2007) without context. In the holistic curriculum, the community is a central theme in indigenous knowledge production and responsibility towards the community is a key factor (Higgs 2003).

It is for this reason that the integration of modern science and indigenous knowledge systems becomes the key to unlocking potential and innovation and affording recipients of this form of education a chance to be self-reliant and become knowledge producers at the same time (Freire 1989).

Conclusion

The methodology used to research this topic has revealed themes that show the desirable values in indigenous knowledge systems. These values, consistent with a holistic education, embrace the goals of the policies of the Department of Education. The themes emanating from modern science on the other hand, while displaying intricate knowledge on the workings of the material world, reveal some undesirable qualities, which are discussed in the next chapter, chapter 7.

CHAPTER 7: CRITICAL ANALYSIS OF MODERN SCIENCE

This chapter offers a critical analysis of modern science based on the themes from data on modern science. The analysis is important in answering the research questions and supporting initiatives to integrate the two knowledge systems.

7.1 Violence in modern science

All three forms of violence described by Johan Galtung are reflected in modern science in its interactions with society. Johan Galtung defines three forms of violence, which he says are interrelated: direct violence, structural violence and cultural violence (Galtung 1996). In his description of these forms of violence, he also asserts that they are interrelated in that one form of violence usually morphs into the other.

Direct violence, often expressed as physical or military power, usually kills quickly, and intends to do so. Science is implicated in direct violence when knowledge derived through scientific research is used in war and weaponry, including the many examples of nuclear attacks on people who are neither part of decision making on war nor aware of such decisions in modern day "democracies" where these technologies are discussed and eventually used. War destabilises countries, displaces people and causes suffering, making room for the atrocities associated with war throughout history. The results of war seldom find their way into the science curriculum. The compartmentalisation of this knowledge into physics, chemistry, biology, social science and history, makes it difficult to connect war and human suffering as well as the associated atrocities with the knowledge of science.

Structural violence is often expressed as economic power; it kills slowly, by corroding the basis for self-reliance and aggravating vulnerability. This kind of violence is not exerted wilfully by a person but instead by a structure created and perpetuated by a custom or law. The violence is built into the structures that do not give citizens equal power and life chances (*Galtung 1996).*

The structure of schooling, the use of language in teaching and learning and the assessment methodologies will be used to demonstrate cultural violence.

Science curriculum in the schooling system

In the schooling system where science is taught, the understandings of nature and natural laws that are found in science constitute the only knowledge that learners are required to have, irrespective of the applicability in the daily lives of the learners. The institution of schooling deprives learners opportunities for learning about nature in their own homes and from their own experience because they spend their young lives in classrooms, removed from nature itself (Dewey, 2008). The learners' understanding of nature is supposed to reflect only the Western model of nature, irrespective of what they see or what they have learnt from their elders. Those who do not succeed in passing examinations in this science education are denied opportunities in the economic structures that only recognise modern science as knowledge about nature. I would like to label this form of structural violence as **cognitive violence,** which I describe as denying people the acknowledgement and use of knowledge that they possess, thereby excluding them from participating in the economy of their country.

The failure of the science education curriculum to include core areas of social needed for any society in the curriculum (food production—a basic need of all people; health—another basic need—and the environment) makes education implicit in this violence. The education system that does not give learners these skills is complicit in preparing whole generations of learners for their economic fate as buyers of capitalist productions. When education ignores these basic areas, Nyerere is justified in his take on education when he describes it as diverting the attention of the youth from issues that affect them (Nyerere 1967). This exclusion of knowledge makes whole populations dependent on capitalists to produce food and sell it to them, at prices determined by them, and with the food grown under conditions determined by them alone.

Where health issues are excluded from the science curriculum this means that only doctors have the privilege of deciding who is sick and how the sick should be treated

(Illich 1976). The patient is not able to have a dialogue with the doctor on matters concerning his/her diagnosis. This seems to suggest that all doctors always have the best interests of the patient at heart and they are immune to medical malpractice.

The lack of environmental education for every child means that the average child grows up in an environment where the child does not even know the names, life cycles or use of plants that grow in the neighbourhood or the interrelationships between environmental systems. It is these learners who grow up working in government and have to make decisions on behalf of everyone when they know very little about how the world around them functions. They make decisions on mining, development, modernisation projects, bilateral agreements involving their own environment with insufficient knowledge of and insight into how the average citizen is affected.

Biopiracy is a form of cultural violence, when indigenous knowledge is used to inform knowledge that profits pharmaceutical companies through patents and the sale of medicine is derived from knowledge sourced from indigenous communities without compensation, this constitutes cultural violence. This activity, which takes place under a variety of names, such as bioprospecting, constitutes structural violence (Khor 1995) towards indigenous holders of such knowledge. Modern science sees its role in researching and producing medicine as an important role in society, with which everyone agree, but at the same time it violates the cognitive space of indigenous knowledge by pretending that indigenous knowledge is not knowledge, thereby deceiving the public, who see scientists as the sole holders of knowledge on healing (Shiva 1993). There is never a mention of the role played by indigenous communities in the discovery of the plant whose chemical composition contains the active ingredient used for healing. This lead knowledge, which aroused interest in the plant in the first instance, is always excluded on leaflets that come with such medicine and are supposed to give information about the medicine itself. This omission is therefore epistemic violence. The language used and the methodologies used to patent such information have been crafted in a manner that leaves out essential information about the origin of such knowledge. In most cases, users are given scientific terminology that the average user does not understand.

This kind of violence is described by Vandana Shiva as fourfold violence, which she deconstructs as violence against the subject knowledge, the object of knowledge, the beneficiary of knowledge and against knowledge itself (Shiva, N.D.).

Cultural violence: by this is meant those aspects of culture, or the symbolic sphere of our existence that can be used to justify or legitimise direct or structural violence. It is epistemic in the sense that it violates the cognitive space while providing a knowledge base for legitimising the violence. Cultural violence works by:

- changing the moral colour of an act from wrong to right or to some intermediate meaning palatable to the status quo,
- making reality opaque, so that we do not see the violent factor, or when we see it, we see it as nonviolent,
- legitimising cultural/epistemic violence by finding language and telling those who wield power that they have the right to do what they do because the victims are pagan, savages, atheists, Kulaks and communists (Galtung 1996).

The language of learning and teaching as cultural violence

The use of English and Afrikaans as the languages of learning and teaching of the majority of learners who does not understand either language well leads to large-scale failures in examinations by the intended recipients of the knowledge of science in South Africa (Matlou 2011). These learners are taught in a language they do not understand well, assessed in the language they do not understand and graded in a hierarchy with learners who have absolutely no challenges in as far as their own worldview and language goes and then humiliated when they obtain low positions in this hierarchy of achievement after testing. When they do not succeed in completing this curriculum that is alien to both their worldview and their language and does not contribute to their livelihoods and self-reliance, they are not eligible for employment in the economic structures that place greater value on qualifications and proficiency in languages other than the indigenous languages. This use of a language that learners do not understand in teaching them content that they do not understand either, after which they are expected to pass an examination set and answered in this

language that they do not understand, constitutes structural violence. The excuse that there are no science books in indigenous languages has been used to legitimise this cultural violence (Brock-Utne 2008).

Many learners who achieve in these curricula have their worldview and personal interests ignored in the curricula. An integration of the two ways of knowing, paying particular attention to convergences and divergences, would serve Africans better. It would put their interests at the centre of education while exposing them to other worldviews so as to allow them opportunities to make decisions on the kind of development their countries require and deserve.

7.2 Disengagement from nature

Science as it is taught in schools bears little resemblance to nature. It is almost always about dissecting, opening up what nature has presented as whole in an effort to control nature. It does not seem to be education on how to live in harmony with nature as a whole as opposed to nature in parts. The average learner of science education knows little about nature, except the bits that are scattered around compartments called disciplines or subjects that do not always make up a whole (Kawagley 1995). Generally the average scientists, while revealing the mysteries of the innate nature of matter, have also been implicated in the destruction of nature. If science is the study of nature, how come the environment is being destroyed on such a scale? And if science is **not** the study of nature, does this mean that knowledge about nature is being excluded from the education of our own children? (Dewey 1971 &2008; Ezeabasili 1977, Fensham 1997; Martin 2002; Hines 2005). Science's stance of disengagement from nature as demonstrated by the history of modern science means that science is not a good custodian of nature but a spectator of nature if not a destroyer of nature. The separation of man from nature betrays an uncaring, unfeeling attitude towards nature, which might explain why nature has suffered so much from science technologies and science accidents, as demonstrated in chapter 2. Nature sustains life on earth, without learners understanding the value of natural relationships that lead to sustainability, nature will either cease to sustain life or humanity could be extinct.

The evolution of modern science, which has its roots in natural philosophy and its dislocation from spirituality during the Beaconian era, makes this knowledge alien to the indigenous people of the world, who are spiritual beings (Jegede 1998). Since the aspects of science that are excluded from the study of modern science are not necessarily lost to those people who know them, the exclusion of these knowledge systems makes the study of science an incomplete representation of nature for these people and for mankind. Science as taught in schools in compartments, without spiritual considerations, is therefore not an honest portrayal of nature for these people. It reflects a worldview that is not shared by a large section of the world population in which these young people grow up.

The systematic poisoning of the environment, mainly by multinationals in mining and refineries, using technologies inspired by science in Third World countries, is a glaring example of a lack of relationship with the environment. The processes that go into food production and preservation, which mainly include the use of chemicals, as well as the many toxic substances used in many manufacturing establishments, some of which have been implicated in diseases like cancer (discussed in chapter 2), have largely been ignored by the science curriculum.

Scientization and mathematization presents a field of discursivity of knowledge and makes ordinary day-to-day knowledge seem irrelevant to those who possess it. Beane points out that subjects are actually very small presentations of fields; according to him knowledge presented in these subjects is arbitrarily chosen and this implies that within every field large chunks of knowledge are left out over generations. If these subjects are presented year after year, what it means is that large amounts of knowledge on the various fields is left out of curricula, and these subjects are not able to capture all that is or that will be in the future (Beane 1995). People should rather know where they can find knowledge when they need it, instead of undergoing continued testing on knowledge that was proven by scientists hundreds of years ago. It would be better for them to continue with their own knowledge production in their interactions with nature (Dewey 2001).

Science seems want to recreate nature differently where all everyday observations are expected canto fit into some scientific description, no matter who makes the

observations and where they are made. This ignores many other causal relationships that have yet to be discovered, while reducing scientific knowledge to those observations written in the books of science. It discards the observations of many other people which might be different from the norm. This attitude is supported by examinations that demand the same attitudes, inclinations, beliefs and even observations by all; year after year of schooling. Schools run by the Education Department condition learners from an early age to accept only proven scientific theories which, although they might work, exclude other possibilities in ways of looking at nature and responding to it, thus impressing on their young minds that "truth according to science" is the only truth about nature. Science education displays what Freire called "banking'' education, where learners simply reproduce what they are told (Freire 1989). This takes away the possibility of innovation and creativity and excludes all experiences except those that have already been observed and recorded by scientists of the past (Dewey 2001). The natural association of being innovative as a way of solving problems in the learner's everyday life is simply removed from the learning of learners.

7.3 Alienation between science education and the lives of African communities

Higgs asserts that education in the traditional African setting "cannot, and indeed, should not, be separated from life itself". According to him, education among Africans is "a natural process by which the child gradually acquires skill, knowledge, and attitudes appropriate to life in his or her community" (Higgs 2003). Science education has been accused by many scholars of not teaching learners about life in their communities but instead teaching them about life outside their communities. The homogenous curriculum, no matter how well intended, can never hope to teach the millions of learners throughout South Africa in a manner that makes learning relevant to their individual social surroundings. The geographic-socioeconomic imperatives are too vast to allow for all learners to benefit from the same curriculum.

7.4 Institutionalisation of knowledge

The current form of schooling; the homogenous curriculum and examinations as the only spaces where learners are expected or rather allowed to receive knowledge,

means that knowledge is institutionalised in schools. According to Clabaugh and Rozycki, institutionalised education as in schooling is based on the idea that there are uniform standards that all students should meet, and that each individual's failure or success depends upon his or her ability to be moulded to this system. In this instance, knowledge is determined by the state or an institution; the learners lose control of what knowledge is appropriate to their situation. The institution now becomes the sole provider of knowledge (Clabaugh & Rozycki 1999). While some children are naturally able to thrive in this scenario, there are those who fall outside this model. The one-size-fits-all model of education makes little room for innovation. This one-size-fits-all approach, namely institutional education, has been criticised for:

- encouraging rote memorisation of facts which do not always have any use to learners after examinations
- frustrating those learners who are not able to thrive in an institutionalised education system, in other words hegemony in the provision of education
- placing learners who perform poorly in this form of education on low-expectation tracks that are difficult to get out of in terms of opportunities in the world
- not encouraging children to think independently about the world and make their own determinations
- forcing children to repress personal interests that are not part of the standard curricula (Clabaugh & Rozycki 1999).

7.5 African languages not used in knowledge production and dissemination of knowledge

The use of English and Afrikaans as the only two languages of learning and teaching shows a resistance to a celebration and recognition of indigenous languages as rights in a liberated South Africa and as important tools for communication by the indigenous people of South Africa. It also implies that the inherent fields of discursivity in the construction of the English and Afrikaans languages, which used these languages for the perpetuation of the history from which South Africa arose from an unequal oppressive state, is being carried on by the Africans, not only in their own marginalisation but in the creation of the other. According to McGovern, the use of language to express knowledge is an exercise of power. Language use has

the power to define meanings by choosing certain concepts or terms, particular ideas or theories and aspects and leaving out other concepts. According to him, in naming things, we conceptualise them; this means that in a dialectical understanding, a particular configuration of the social world (e.g., relations of domination and difference) is implicated in a particular linguistic conceptualisation of the world. What this means is that the African, despite the liberation, is still allowing his world to be conceptualised for him; presenting him with a particular configuration of the world which is most likely is in contrast to his cosmology.

Thus, discursive practices inherent in English and Afrikaans are likely to have major ideological effects and they can help produce and reproduce unequal power relations between (for instance) social classes, women and men and ethnic groups, through the ways in which they represent things and position people. These ideological loading of particular ways of using language and the relations of power which underlie them are often unclear to people (McGovern 1999).

Conclusion

The following are the two research questions in this study:

- In South Africa, how is the education system dealing with the two knowledge systems?
- What model can be used to bridge the two systems?

The analysis in this chapter has shown that the education system continues to ignore indigenous knowledge systems in its provision of science education. The chapter has shown that the schooling system only focuses on the Western model of the interpretation of nature, taught in a language that is not indigenous to Africans, thus ignoring the worldview of Africans and its own policies. This chapter has answered the first research question in this analysis.

The analysis in this chapter further points to weaknesses in the science education model that is used in schools. These weaknesses are important to note as they reveal what the development of the model needs to avoid or dismiss in the development of a

model of integration of the two systems of knowing. The holism in the indigenous knowledge systems analysis, for example, is at odds with the forms of violence found in modern science. The unintended consequences of science education for the recipients of this knowledge system would encourage an alternative manner of packaging this knowledge if it is to serve humanity in line with the Afrikology framework. While the analysis of indigenous knowledge in chapter 6 shows holism in indigenous knowledge systems, the analysis of modern science in chapter 7 shows some undesirable consequences of science and science education. These factors are taken into consideration in the development of a model of integration.

CHAPTER 8: THE INTEGRATION OF MODERN SCIENCE AND THE IKS MODEL

This chapter, which is based mainly on the analysis of modern science and indigenous knowledge systems, seeks to investigate the tensions in the two knowledge systems as a means of finding convergences and divergences between the two knowledge systems. In working towards the construction of the model, the study seeks to incorporate themes from the policies of the Department of Education as well as an education that is holistic, as is consistent with indigenous knowledge. The holism emanating from the analysis of indigenous knowledge systems in chapter 6 should produce holistic education.

8.1 Tensions and conditions for the integration of modern science and indigenous knowledge systems

The study set out to look at ways to integrate the two systems, namely modern science and indigenous knowledge systems. The study has shown the differences between the two knowledge systems. Indigenous knowledge systems are characterised by a holistic view of knowledge production, where members of societies determine individually and collectively what knowledge they need and make it their responsibility to source the knowledge or to be innovative and creative in finding solutions to their everyday challenges (Jegede 1998; Hountounji 2002; Higgs 2003; Volmink 1998).

The analysis of data on modern science reveals that while science has brought about insights into the intricacies of the material world, various forms of violence are associated with this form of knowledge. Knowledge in modern science is characterised by disciplines, leaving very little room for infusion of values because of the nature of these disciplines and the processes that led to the development of this knowledge. Science education in the South African curriculum, for example, is divided into chemistry, physics, life sciences and agricultural science. How does one infuse values into these subjects, which were constructed without taking values into consideration in the first place? Scientific knowledge is largely knowledge that has been acquired through the scientific method, documented and archived. This

knowledge is what is generally taught as science in schools (Dewey 2001). It shed its association with spirituality, feelings and intuition many years ago.

On the methodology aspect of these two knowledge systems, education in indigenous communities is both formal and informal; content is dictated by the needs of communities and to a large extent involves doing things, for example building houses, herding cattle or growing food. Assessment is usually part of learning, and takes place at various times during learning. At the end of the learning experience, all learners have achieved to varying degrees but they have all been exposed to the learning content. Science education, on the other hand, is taught in a formal setting of classrooms and laboratories, and the content is usually decided by government, irrespective of the needs of communities. Assessment takes place through examinations set by educators and marked to determine whether learners are able to recall the facts that they were taught in class.

This creates tension in the integration process since these divisions do not exist in indigenous knowledge systems. The holistic notion of indigenous knowledge includes spirituality, civic education, culture and everything and everyone in these indigenous societies. Knowledge is revealed, and produced by everyone; it is also fluid and not static.

It is obvious that the integration of indigenous knowledge systems and modern science requires new thinking about what knowledge is. It is important to define new paradigms in knowledge production. According to Hoppers, this integration of the two knowledge systems requires a "holistic knowledge framework for societal development" (Hoppers 2002:13). Knowledge production under these conditions requires knowledge that serves humanity in order to alleviate the burden under which populations in Africa battle for survival. This means that new concepts and new organisations in knowledge are required. These organisations of knowledge will imply new methodologies and assessments. The model for integration adopts the stance that knowledge should be constructed around the needs of society. This model therefore concerns itself with issues that affect society in general as a basis for basic education.

The model is made up of four quadrants, viz health, the environment, commerce and innovation, Civic education, arts and languages as well as history and culture, the history of IKS and the history of modern science. These quadrants are seen as inclusive of all aspects of human needs and are therefore seen as representing a holistic approach to knowledge production, where values can be mediated as learning of content takes place. The section below explains the quadrants.

8.2 Health

All the people of any society need a functional understanding of their bodies and knowledge about health, the environment and innovation. This quadrant comprises topics on health, which include knowledge of food and many related concepts. This knowledge is sourced from both IKS and modern science in a dialogical relationship. The relationship between food and health is sourced and presented from both the indigenous perspective and from the scientific perspective.

In this quadrant, citizens are empowered to have a say in how food is grown. Learners are taught the skill of food production, processing and get involved in all topics on food. They are able to also participate in the debates about food, health practices and procedures. The choices of citizens should not be directed and driven by campaigns but by knowledge institutionalised in them and negotiated and understood by them.

8.3 Environment, economy and innovation

The environment is everyone's habitat. Understanding how the environment works and how to look after the environment is knowledge that serves the environment and humanity best if it is within the reach of everyone. When people are empowered on the environment from the perspective of both the indigenous knowledge systems and modern science, they are able to negotiate development in an atmosphere where everyone understands and is able to observe the nature of the environment. Decisions are based on facts that support the environment. Empowered communities are able to be innovative on how to balance the fragility of the environment against the demands of trade and the economy. They are also able to monitor the effect of the economic

activities that affect the environment. They become the custodians of their own environment.

Innovation as a driver of any economy should be introduced with an awareness and understanding of the environment because almost all economic activities impact on the environment. It is this balance between the environment and the economy that will determine the state of the environment and make it possible for all citizens to be custodians of the environment. This should allow citizens to develop protocols on whether to undertake certain activities. If everyone is empowered, discussions between the top decision makers in government and the ordinary citizens will be able to take place in a fair and just manner.

Knowledge about nature that could lead to sustainability has not been achieved by humankind, despite the many disciplines of science education and many conferences organised worldwide. The ignorance about nature seems to suggest a chaotic organisation in nature that is not understood and the relegation of duty by governments and citizens. Instead of trying to dominate nature, indigenous knowledge education tries to understand it and to exist in harmony with it.

8.4 Civic education, arts and languages

Civic education, whenever and however undertaken, prepares people of a country, especially the young, to carry out their roles as citizens. The overall goal of civic education is to promote civic participation and support for democratic and participatory governance. Learners leaving high school in the current education system assume roles in governance which they are uninitiated for. Civic education can be used to address a wide variety of political and governance issues (e.g. corruption, civic apathy or post-conflict reconciliation) as well as important social issues (e.g. domestic violence, drug abuse, and HIV/AIDS) that afflict communities. The life skills should ideally form part of the learners education before they assume the role of public service after high school. Educational policy should also strive to equip educators to shoulder the responsibility of shaping the characters of the children in their care.

Civic education is concerned with civic knowledge, civic skills and civic disposition.

- Civic knowledge refers to citizens' understanding of the workings of the political system and of their own political and civic rights and responsibilities (e.g. the rights to freedom of expression and to vote and run for public office, and the responsibilities to respect the rule of law and the rights and interests of others).
- Civic skills refer to citizens' ability to analyse, evaluate, take and defend positions on public issues, and to use their knowledge to participate in civic and political processes (e.g. to monitor government performance, or mobilise other citizens around particular issues).

Civic disposition is defined as the citizen traits necessary for a democracy (e.g. tolerance, public spiritedness, civility, critical mindedness and willingness to listen, negotiate, and compromise) (Stanford university encyclopaedia n.d.).

Civic education is important for all communities, especially South Africa. It is in this quadrant that all citizens learn what is expected of them by their government. South Africans born before 1994 have had an extremely distorted example of democracy as a form of government, having lived under the worst example of democracy under white minority rule. Many of the learners leaving school assume political positions in government with little understanding of what government is about, how it is structured, how it functions and what its responsibilities towards its citizens are. If they have never been taught the principles of democracy and if they have not lived with democratic principles, they are unlikely to know how to apply these principles when in government office.

Traditional education in the African context included as part of children's education instilling desirable attitudes, dispositions, skills and habits in children by recounting the oral traditions of the community (Higgs 2003). Desirable human attitudes are learnt and education must create space for this learning. The current education

system should not assume that all children will acquire these habits without any teaching.

Learners require the right to artistic expression for their well-being, entertainment and enjoyment. The artistic expression of all cultures has a place and meaning in folk history and serves to enlighten us all. This engagement of plurality can help remove stereotypes and foster an appreciation for each other. With community innovations, these expressions could give joy to communities.

Language as an important aspect of communication is also an important feature of people's culture. The most baffling experience relating to the liberation of African countries is that while many nations in the world speak many different languages, Africans have chosen to remain with the languages of the colonisers, despite the fact that many people in these countries do not speak those languages well or do not even speak them at all. These languages have remained as languages of learning in all forms of education and have occupied positions of importance in many of the organisations of African governments. Africans also place those Africans who speak these languages at a higher pedestal to those who do not.

8.5 History and culture, history of IKS, history of modern science

It is difficult to imagine that any social transformation can take place without all citizens understanding the role of history in their repression. Since the culture of the dominated is the first casualty during domination, for transformation to happen, it needs to be quickly recalled and understood after repression has taken place. According to Cabral, history teaches us that domination can be maintained only by the permanent, organised repression of the cultural life of the people concerned (Cabral 1970). The structural organisations of culture, unless replaced by the culture of those who were formerly oppressed, continue the domination even after transformation has taken place (Carnoy 1974). The cultural life of South Africans need to occupy a prominent place in the curriculum, drive the knowledge production processes of South Africans and not be relegated to traditional dances, weaving baskets and beads only.

Learners need to understand how history shaped their present. They should learn about the history of their own knowledge and knowledge production processes, how their knowledge changed though the years and how this has affected their current thinking and circumstances. The history of modern science also needs to be understood so that learners will be able to critique the methods and conclusions of science and draw inferences from the methodologies involved. It is only through such interrogations that learners can understand the limits as well as the gains of science and by so doing learn to appreciate it.

Transformation in South Africa can only take place when the knowledge transmitted to generations through education is interrogated and sanitised of the historical oppressive epistemologies and omissions that render the African dependent on the former coloniser even after years of freedom. Africans need to reclaim their knowledge systems as the only weapon against imperialism, strife and instability. It is only when South Africans are able to understand the effects of the domination of modern science and how it is constituted that its impact on the life of the average citizen can be understood by all and only then can such knowledge be prevented from dominating the manner in which reality is perceived (Foucault 1980).

From the analysis of data, it is obvious that science, while it has brought amazing insights about nature, has also subjected humanity to structural violence. Science education therefore needs to be embedded in a holistic curriculum so as to keep its effects on humanity in check. The transdisciplinarity that is a characteristic of a holistic curriculum ensures that science is able be accountable to the impacts of its inventions and creations. The model suggests that science should be taught within a holistic curriculum so as to direct the construction as well. In the following model, science education is applied in a problem-solving context, that is to say, the concepts of science are not taught as concepts without contexts; these come into focus when problems need such concepts.

MODEL

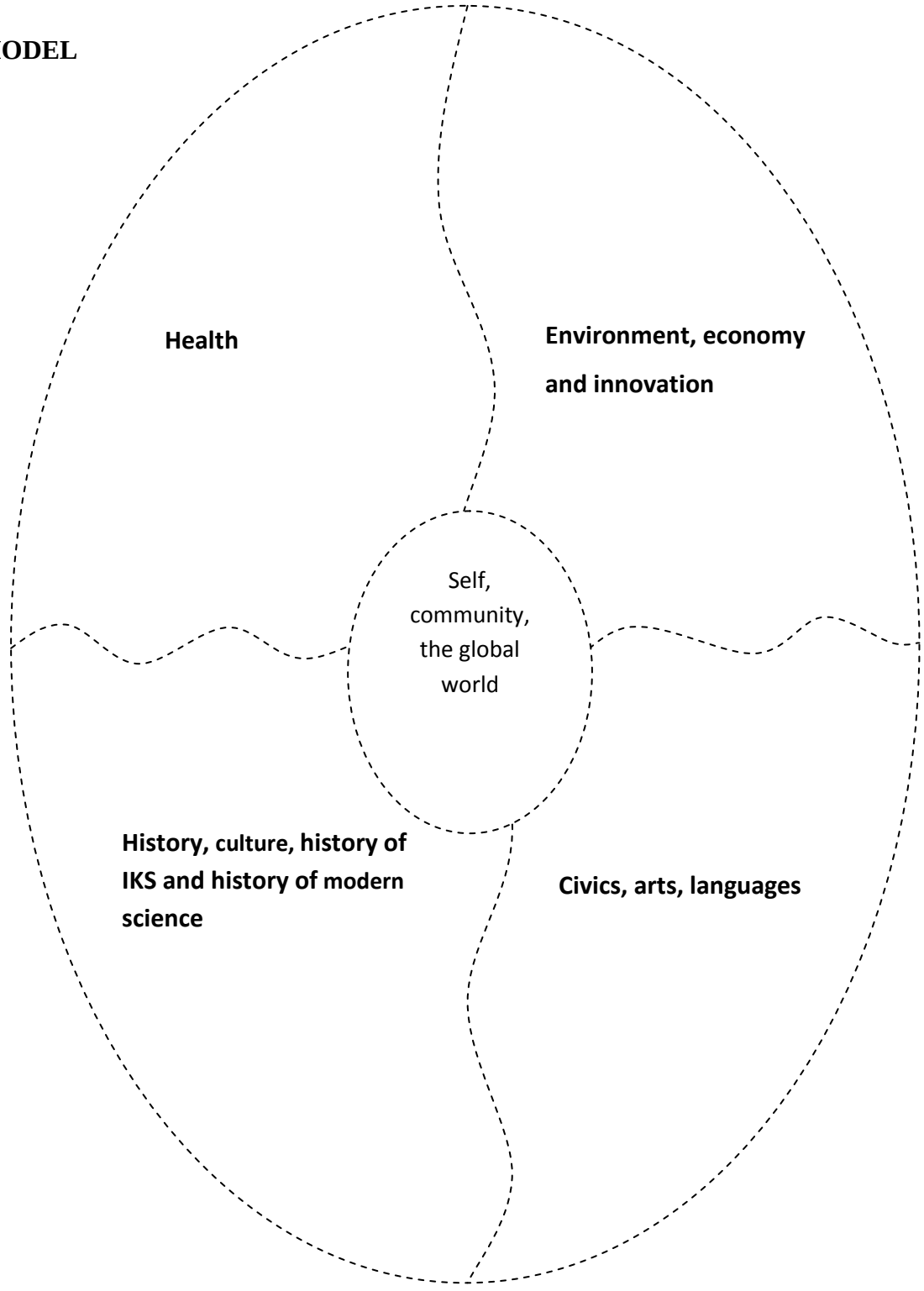

Fig. 4.: The holistic curriculum with science education embedded

8.6 About the model

8.6.1 The diagram for the model

- **The big dotted circle**

  This shows the vastness and interconnectedness of knowledge possibilities; this knowledge that is open to more knowledge that can be drawn into the sphere of human activities from outside this circle. The dotted line shows the possibility of this knowledge entering human perception, as demonstrated through the development of both modern science and IKS. New knowledge is revealed through either science or indigenous ways of knowing and includes transcendental knowledge.

- **The small circle**

  Humankind, community and the world at the centre of knowledge production call for knowledge to be used in the service of humankind, communities and the world.

- **Wavy lines between categories of knowledge**

  The irregularity line shows the lack of defined and fixed differences between the various areas of knowledge; the broken line shows the permeability between areas of knowledge. Knowledge about all quadrants is not contained in rigid quadrants of the circle; this knowledge is not compartmentalised. The relationships will always be there to be discovered.

- **The dotted inner circle**

  This represents the openness of communities to knowledge from whatever source it comes to reach the self, communities and the world. It encourages a relationship between communities including reciprocal relationships between learners and communities, where learners see adults as sources of knowledge and vice versa.

In the framework of Afrikology, the model uses education as a vehicle that empowers people to use knowledge to solve their everyday problems, such as those relating to health, food and peace, and to be able to look after their environment. In this model, the outcomes of education are based on what needs to be done and science education gets embedded in the activity. This model takes the burden from government in providing knowledge and allowing citizens to provide for themselves as a form of self reliance and efficacy.

Activity	**Examples of knowledge from existing subjects and IKS dialogue as well as tacit knowledge**
1. **Identification** of problem	Discussions to identify the problem. (No subject equivalent) IKS. This is an activity where everyone participates, both the communities and the scientists. Values are infused during these discussions. Knowledge is exchanged.
2. **Discussions:** on The problem at hand, in this case hunger— causes and solutions	History of the village/city/school; national/regional/international bodies dealing with hunger; debates on hunger; discussions on drought. Life Sciences, Agricultural Science. IKS. The transdisciplinarity approach yields more insight into the problem. Opportunities to locate such problems within the global structures give learners insight into factors that affect their everyday lives. This creates awareness and insight into world issues. Where relevant, issues relating to land could be discussed. Learners appreciate the importance of land.
3. **Planning:** Financial considerations, project management	Accounting, Business Economics, Budgeting. IKS. Skills are passed on to learners on how to plan for projects.
4. **Decision making** : The choice of vegetables to be planted and the division of labour in looking after the plants	Research activities presented; managing the process. Relationships between food and nutrition as well as food and diseases. Democratic processes, where learners learn to be tolerant to opposing views and the co-creation of solutions is demonstrated. Learners learn to listen to opposing views.
5.Activities : Identifying the seed	Agriculture, Life Science history where appropriate concerning the origin of the vegetable. Stories about the use of the vegetable in the world. Discussions on GMO.

	Research findings on GMOs, IKS.
5. **Activities** : Discussions on planting season, quality of soil	Geography, Agricultural Science, Chemistry, Life Sciences and IKS; texture and quality of soil. Learners learn the intricacies of soils using senses like touch and smell where appropriate. They learn the indigenous interpretations of seasons and many other aspects of farming, including their belief systems. Practices associated with planting.
6. **Activities** : Preparation of soil, fertilisers and testing for acidity, etc	Agriculture, Chemistry, Life Sciences and IKS, Geography, organic and inorganic fertilisers, making compost heaps. Indigenous methods of testing soil. Discussions on effects of fertilisers on the quality of food and health.
7. **Activities**: Planting the seed	Life Sciences, Agriculture and IKS debates about seeds and intellectual property.
8. **Activities**: Routine care for the seeds	Life Science, Agriculture, Chemistry and IKS, art forms; understanding of life cycles of plants. Differentiation of physical structure of plants. Learning the different parts of the plant.
9. **Activities**: Harvesting	Harvesting of the vegetables. Seed harvesting and storage. Geography, Agriculture, Chemistry Life Science and IKS. Debates on seed harvesting and patenting.
10. **Activities**: Processing, food preparation, packaging of the vegetables	Chemistry, Physics, Life Sciences, Home economics, hospitality studies, Agriculture and IKS; chemicals used for food processing and preservation. Safety issues on food processing, preparation and packaging; their effect on health, packaging.
11. **Activities** : Preparing the vegetables for the local, national and export markets; international marketing, including forex exchanges	Accounting, Economics, Business Sciences, Home Economics, Life Sciences, Chemistry and IKS. Legal requirements for selling nationally and internationally. Food distribution.

Fig 5. Example of an activity in a *"Holistic education with science education embedded."*

The holistic curriculum focuses first and foremost on human beings, the nature of life and basic human needs. This curriculum allows for engagement with the community as well as global issues as the learners grow older. The science education embedded

in the holistic curriculum allows learners to engage with issues that affect them and with policies as well as the laws that govern them.

Knowledge transmitted through this model is framed in the epistemology of Afrikology, where knowledge is produced to solve problems as well as educate in the context of the issues and challenges that exist in communities (Nabudere 2010). This knowledge will inevitably be determined by the communities. In order to integrate the knowledges, the disciplines will have to be released from their compartments, and the knowledge used in the solving of problems that affect communities. Both science education and indigenous knowledge are integrated into this curriculum; both forms of knowledge are made available to learners and they use both forms of knowledge to solve the problems on hand, using what they have in terms of material resources, and preferably using the minimum of financial resources.

The topics in these sections merely serve as examples and therefore the list is not exhaustive. Case studies on some of the topics would be encouraged. Knowledge that is packaged as content in disciplines as well as subjects as taught in schools is collapsed into knowledge that informs projects and case studies in this model. The epistemological frameworks agreed to by all direct the choice of content. The integration of modern science and IKS takes place to the extent dictated by the needs of a topic.

8.6.2 Content in the quadrants (examples)

Health quadrant

The body

- Anatomy and physiology;
- Physical, mental and emotional changes with growing, ageing;
- Diseases;
- Disabilities;

Food

- Nutrition and health;
- Food preparation;
- Food production, e.g. cultivation, preparation, packaging and accessing markets;
- Land issues;
- The chemistry of food;
- The food economy;
- Debates on food, e.g. genetically modifies foods;
- Laws of food production and transportation;

Materials and you

- Materials around you and their uses (clothes, polymers, furniture and appliances) and health;
- Conventions and treaties on chemical compounds in materials used in the home;
- Building materials and conventions regarding materials;
- Technologies in your area and country and their scientific principles.

Environment, economy and innovation quadrant

- Natural resources (air, water, soil, animals, plants, minerals, oil, coal etc and how to take care of them);
- Plants in your area;
- Electromagnetism;
- Natural phenomena, e.g. electromagnetism and forces in nature;
- Ecological relationships;
- Animals and plants, plants and insects in your area, their life cycles and their relationship with the environment;
- Environmental systems;
- Energy types, sustainability;
- Pollution;

- Transportation systems and the environment;
- Roads: making roads, repairing roads and naming roads;
- Habitat: Land, buildings, materials, sanitation and roads;
- Economic activities;
- Intellectual property;
- WIPO;
- Development;
- Manufacturing;
- Innovations, creativity;
- Trade: new and ancient forms of trading, the role of science and IKS in trade;
- The monetary system and science in IKS.

Civic education, arts and languages

- Citizenship;
- Civic education and history of modern science and indigenous science;
- South African government and government departments: their functions and the individual;
- The Constitution;
- Knowledge of nature;
- Forms of government (democracy, communism, socialism, tribal forms of governance);
- The South African justice system, science and IKS;
- World organisations and your country (AU, UN, IMF etc) and their reliance on or relationship to science and IKS;
- Treaties and conventions on science and IKS;
- War and peace and their relationship with science and IKS;
- War crimes;
- Languages: indigenous languages and foreign languages;
- Indigenous games and art;
- Theatre;
- Songs;
- Ceremonies;

- Story telling.

History, culture, history of IKS and history of modern science

Cultures and cosmologies

- Cosmologies, life and death;
- The history of Africa: pre-colonial Africa, colonisation and apartheid;
- History of your village, city, town, school etc;
- History of continents of the world;
- History of science from ancient to modern science;
- Replacement of IKS with modern science through the ages;
- Effects of modernisation on lives in Africa;
- Epistemologies.

8.6.3 Teaching and learning

Topics will be further refined, customised and developed, in accordance with the needs of communities. Learners are taught using various mediums, such as elders, camps, books, videos, Skype, teachers, specialists in areas of interest, knowledge holders and each other's experiences. Knowledge starts with local knowledge, and is then extended to the country and finally, where topics are appropriate and necessary, having regard to the age group of the learners, international practices are discussed.

Content that is relevant to communities

Content should ideally be mediated by communities (Volmink 1998; Brock-Utne 2008), with the national priorities as articulated by government policy included. Learning in this model will take the form of problem solving, where learners learn information in order to use it to solve their problems in the environment or chosen projects. Learning begins with problem-solving in the home, and in communities, and as the learners grow older, discussions on global problems are entered into, with the learners well grounded in local, regional and country needs and aspirations (Freire 1989).

In this way, students could have a truly rich and relevant education where they view concepts, issues, events and themes from the perspective of diverse cultural and ethnic groups, instead of demeaning or subjugating either knowledge system. Everyone passing through this system of education completes basic education with a broad knowledge of himself/herself, the immediate environment and the world.

8.6.4 Methodologies in the holistic curriculum

According to Nabudere (2012), the epistemology of Afrikology and transdisciplinarity aims at breaking down disciplinary boundaries between the different academic disciplines as these boundaries inhibit man's capability of looking at realities in a comprehensive and holistic manner. He contends that this leads to fragmented solutions to problems and inevitably fails to address issues afflicting humanity. Since knowledge is created holistically by the heart on the basis of sensory experiences of the five senses and perception (Nabudere 2012), learning should also take place in a holistic environment that mimics life. Constructivism is a dominant methodology in indigenous education and rote learning is also employed where names, songs or procedures have to be remembered. These methods will be used as and when necessary. The new way of teaching will not confine learners to a classroom, but learning about nature will invariably take place where the nature that is being studied is available. In this way all science concepts are learnt in context as opposed to being learned from a textbook. Books are used as references while learning takes place from the environment. The teachers will be knowledge holders drawn from the community and from scientific institutions. Orality as a method of teaching and learning should be investigated and used where appropriate.

The curriculum is largely determined by communities but central government can stipulate aspects of science that communities need to pick up from the content that they are doing. This means that there is no loss of homogeneity or of the important discoveries of modern science that help explains some aspects that were previously not understood. Central control is maintained but at the same time learners are exposed to other knowledge systems that are part and parcel of their communities. Schools or centres of information should have books written by indigenous communities about the knowledge that the elders have and would like to impart.

Learners contribute to knowledge by contributing towards a knowledge pool at the school, and schools could produce their own journals or encyclopaedias based on knowledge contributed by their own learners. The knowledge could be copyrighted and protected by government through intellectual property laws. This is an important way of protecting knowledge that is otherwise being harvested from unsuspecting communities. These books, written by indigenous communities, will be used alongside scientific texts in solving the problems that crop up or teaching learners about aspects of the content that they need to know. It should be noted that in this model science is taught within a holistic curriculum. Therefore, although the topic is science, spiritual, cultural, historical and civic elements (where applicable) of the topic at hand should be considered, as demonstrated in the above example which is illustrated in figure 2.

8.6.5 Assessment in the holistic model with science education embedded

The assessment will be based largely on the tangible outcomes of every unit. A presentation of a portfolio outlining activities should be a confirmation that learners have undertaken particular units of work as part of their education. A presentation of a portfolio that encompasses what has been learnt and how it has been applied serves as evidence of assessment. Recognising and solving problems in homes and communities could play a role in assessment, as could testimonials by community members. Assessment should be more developmental as opposed to punitive.

As part of managing learning, a minimum number of elements will be determined which learners will have to engage with in order to qualify for particular areas of employment or activities within communities. This model extends to lifelong learning, in that after doing a compulsory number of activities, learners are free to choose specialised areas, and after undertaking more projects in those areas they are considered to have achieved greater specialisation. The portfolio could include modules of work done and lessons attended and attendance at demonstrations of specific skills wherever possible. Ratings are done using a scale that measures attendance, knowledge acquired and articles produced or stories written as well as activities the learner participated in. Projects must be real problem-solving projects that involve the communities where learners live or the surrounding areas.

This model answers the second research question, which concerns the design of a model that is able to integrate the two knowledge systems.

Conclusion

This model is an answer to the second research question. It is also an interpretation of the policies that frame education in the South African education system. The model offers an alternative to the current thinking around teaching science. Influenced by the challenges associated with the relationship between science and society, the model offers an opportunity to teach and learn science within a holistic curriculum, a curriculum that takes care of human rights issues, environmental issues and ethical considerations in the use of science and its technologies. It allows for the natural integration of science and indigenous knowledge. Science is embedded within the socio-cultural dimensions of the recipients of this education.

One of the features of indigenous knowledge that is missing in modern science is holism, which addresses the broadest development of the whole person at the cognitive and affective levels (Singh 1996). This model integrates the two knowledge systems in a manner that incorporates holism into the education experience. The model also gives learners an opportunity to solve problems in their daily experiences. It allows for a natural integration where learners are exposed to worldviews and to current debates on issues that affect them both directly and indirectly. Scientific concepts from subjects are used as and when needed instead of being studied in isolation and out of context. In the course of their learning, learners solve problems that affect them in their homes, schools or communities. The advantage of involving learners in community activities is that working with learners gives the adults added dignity, as learners now see adults as knowledge holders even if they have not been to school. It also builds clean, safe and self-reliant villages. More importantly learners are groomed to take up the roles of leadership once they graduate from high school.

The success of schools can be measured by the way the communities in which the schools are situated are able to solve their problems using both indigenous

knowledge systems and scientific knowledge. Schools as the only institutions where learners spend all their growing up years should cater for all as they are ushered in to adulthood.

CHAPTER 9: FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

9.1 Findings

The research set out to find a way of integrating indigenous knowledge systems and modern science into the curriculum of the South African education system. In doing this, the following objectives were necessary to foreground answers to the research questions. The following objectives have been reached in this analysis.

Chapter 1 offers insight into my personal life growing up in apartheid South Africa. It explains the socioeconomic and political dimensions of the journey of South Africans from apartheid to the new South Africa.

Chapter 2 provides insight into the broad descriptions of knowledge. An overview of indigenous knowledge systems is provided and examples of what indigenous knowledge systems have been able to produce as knowledge are discussed.

Chapter 3 provides an overview of modern science. The challenges of science education as well as the alternatives forms of science education that have been proposed over the years are discussed.

In chapter 4, the desire of Africans to integrate their culture into an African curriculum are revisited. The factors that led to the marginalisation of modern science are explored as a way of informing the process of integration.

In chapter 5, Afrikology provides a theoretical framework on which it is possible to base the guidelines on the integration of these two knowledge systems, despite their almost divergent outlooks on nature. Afrikology as a theoretical framework takes into account the consequences of colonisation and its effect on the colonised, while providing a framework that is not African but humanist and universal. The features of this framework make it more desirable than the Western discourse, which implies a struggle between the interests and ways of knowing of the West and the interests and ways of knowing of indigenous people (Hoppers 2002). It is an epistemology that is relevant to the current needs of the people of South Africa and brings about

social transformation out of the present problems, which include the trappings of modernity as promoted by the European enlightenment. It promotes social cohesion. It is also an epistemology that is universal and goes beyond all the “isms” of identity and culture (Nabudere 2010).

The analysis **in chapter 6** explains the choice of methodology. The analysis of indigenous knowledge systems reveals holism as a theme that emanates from indigenous knowledge.

In **Chapter 7** the themes emanating from readings on modern science betray structural violence. A critical analysis reveals some undesirable consequences of science education.

Chapter 8 presents a construction of a model that promises to integrate modern science and indigenous knowledge. The model dictates a holistic education that firstly serves an individual and community and then extends to the world. In this model science concepts and indigenous knowledge principles are employed in solving the challenges faced by humanity. The compartments of science education are only used to inform the problems being solved and are not taught as knowledge itself. They are simply employed as and when a need arises to explain aspects of the material.

Chapter 9 contains findings, conclusions and recommendations.

Research Questions

Question 1

Which knowledge are we using in the South African schooling system, is it modern science or is it indigenous knowledge?

In all its subject policies the education system has encouraged the valuing of indigenous knowledge systems. Research done on the inclusion of IKS in the study of science shows the different interpretations of valuing by the teachers who

participated in the research that has so far been carried out on the aspect of integration of the two knowledge system. The structure still reflects a Western type of education structure that does not accommodate indigenous methods of teaching, learning and assessment.

The homogenous curriculum coupled with examinations, are alien components to indigenous knowledge, these lead to a curriculum that does not reflect the aims of IKS. The disciplines, a feature that is absent in indigenous knowledge systems, present constraints to indigenous knowledge education. In science education subjects are packaged in the CAPS; they are divided into Physical Science (Physics and Chemistry), Life Sciences (Botany and Zoology) and Agricultural Sciences. These compartments do not exist in indigenous knowledge.

In the documents that were consulted for the purposes of this research, namely the National Curriculum Statement and the policy on Indigenous Knowledge Systems, 2004, one notes the different terminology used to describe how one should deal with indigenous knowledge systems. The National Curriculum Statement speaks of "valuing indigenous knowledge systems" while the Indigenous Knowledge Policy of 2004 speaks of "integration of the two knowledge systems". This creates tension since the two directives are not synonymous. The Department of Basic Education needs to provide clarity on how it wants the indigenous knowledge systems to be valued or integrated.

The knowledge used in the South African education system is therefore modern science to the neglect of IKS.

Research Question 2: What model can be used to bridge the two systems?

The model calls for holistic education where education concerns itself with the needs of humanity in communities and in the world. The model proposes a type of education where knowledge is transmitted in themes. These thematic representations should ideally reflect the lives of those being educated. It must deal with issues that impact on humanity and in the present and in the future. It must also draw on the

experiences of those being educated to inform their past and future. The model is presented in chapter 8.

9.2 Conclusions

The overall aim of this study was to critically analyse the tension that exists between modern science and IKS generally in order to provide a model for the integration of the two systems of knowing in the South African science curriculum.

This has been achieved by providing overviews on both indigenous knowledge systems and modern science in chapters 2 and 3. The model is shown in chapter 8.

The objectives of the study were:

1. To provide an extensive review of the definition of knowledge and education.
2. To give an overview of modern science and the indigenous knowledge systems.
3. To describe the South African science education policies and the IKS policy.
4. To construct a model of indigenous knowledge systems in conjunction with modern science as a way of transforming science education through enlargement.
5. To present an analysis on the literature on modern science and indigenous knowledge systems and provide conclusions for future research.

The first two objectives were achieved in chapters 2 and 3. In chapter 2, the definitions of knowledge and education were discussed and an overview of indigenous knowledge systems was able to provide insight into what IKS is. Chapter 3 contains an overview on modern science.

Objective 3 seeks to describe the South African science education policies and the IKS policy.

This objective was achieved in chapter 3. The main policies that drive education, namely the RDP policy, the White Paper of 1995 and the National Curriculum Statement reflect the policies that should inform education.

Objective 4 was to construct a model of indigenous knowledge systems in conjunction with modern science as a way of transforming science education through enlargement. This was achieved in chapter 8 with a presentation of a model of integration.

Objective 5 was to present an analysis on literature on modern science and indigenous knowledge system and to provide conclusions for future research.

9.3 Limitations of the model

This model has not been applied anywhere in the world or in Africa and this presents limitations of its efficacy especially in the light that the current education system has afforded those with qualification in the current education system opportunities and rewards. Alsaka is the only known country so far that has a model close to this one. Changing from what seemed to have worked, even if it has worked for a small population will not be easily accepted by first of all those who have reaped the rewards of the current education system and those hoping to reap the rewards through obtaining the current form of education. Secondly the old and tested model is what many countries understand and accepts. Swaying public opinion to a model that has yet to be tested might be difficult.

9.4 Implications for policy

The model has in its construction relied heavily on the Reconstruction and Development Policy (RDP), The White Paper on Education and Training 1995 as well as the National Curriculum Statement (NCS). It presents a different interpretation of these existing policies. The model requires from the South African Department of Education a rethink and a reorganisation that is unprecedented in the history of the new democracy as well as both colonial and apartheid South Africa. It insists on a total breakaway in the manner in which education is conceptualised, administered and assessed. It challenges long held beliefs about what education is, and how it should be run. While it gives power to the citizens to decide on the philosophy and content of education; it goes against the grain of what has been accepted as education through centuries of western education.

This model has the potential to create tensions in the new political dispensation due to the limitations as discussed above as well as the long held notions of what education. The epistemological frameworks of the colonialists have remained with the colonised even after freedom. These frameworks have as already discussed nothing to do with the freedom or of the oppressed. They have at their core, the need to hierarchise, suppress, oppress and deny the cultural heritage of the oppressed. Continuing with these frameworks without proper interrogation and integration will without fail render the African a slave for ever.

This kind of envisaged change, influenced by the policies of South Africa, indigenous knowledge systems as well as literature from both indigenous knowledge systems scholars and critiques of the current system of education should be preceded by engagement between, institutions of higher learning, the electorate and all bodies and institutions that govern the South African public. It should be presented to the citizens of South Africa as a conversation that encompasses many factors that shapes society as already discussed in this study. Taking Paulo Freire's advice, the South African government should consider what he referred to as *conscientizacăo*; which he described as: as *a process of learning to perceive social, political and economic contradictions, and to take action against oppressive elements of reality* (Freire 1989). Education should offer freedom of thought as well as freedom from poverty and other social constraints.

Conclusion

The study has shown that modern science and indigenous knowledge as knowledge systems that essentially began with observations of nature have developed in ways that have made the two knowledge systems alien to each other over the ages. This has had major social and developmental implications in human history. The interests of humanity in knowledge production have yet to be recognised. It is only through an exercise that allows IKS and modern science to engage in an exchange in an education that gives each an opportunity to produce knowledge in the service of humanity. The knowledge should lead to liberation and peace.

The unfortunate abuse of scientific knowledge has led to the world as we all know it today, a world where there is environmental degradation, and people are alienated from nature and from one another. While scientific knowledge was initially hailed as knowledge that held the potential for emancipation from the church, it has in turn come to resemble the knowledge it sought to displace, with institutions that seem determined to exclude other forms of knowledge and thereby render those inside its fold prisoners of this knowledge, unable to disagree with scientific knowledge for fear of rejection by the scientific establishment (Peat 2008).

Indigenous knowledge systems as knowledge that is rooted in transdisciplinarity and has at its core service to humanity need to engage with modern science, in an organisation of knowledge that is capable of accommodating both systems of knowing. If the two systems of knowing are used in solving problems, the two systems are able to participate in finding practical means to solve problems rather than engaging in a dialogue or debates about what knowledge is or which knowledge is superior. The discoveries of science and the holism of IKS make this integration a desirable option in knowledge production and use.

The organising criteria for this integration should be situated in the outcomes, where the criteria are what need to be known and what is seen as beneficial by communities. Science phenomena as phenomena that are universal; universal here mean that Newtonian mechanics, which underpins science education essentially describes phenomena that people observe everywhere. Science however, usually describes these observations in a language of science (scientization of knowledge) and mathematics (mathematization of knowledge) which is generally unfamiliar to the average citizen. Science also draws from knowledge on the properties of matter, sometimes sourced through the use of instruments, and how these properties influence the behaviour and outcomes of the material world.

9.3 Recommendations

The Department of Education needs to supply clear answers on how indigenous knowledge is to be integrated as part of the curriculum. The National Curriculum

Statement speaks of “valuing indigenous knowledge” and the IKS policy mentions “integration”. This needs to be speedily resolved.

Further

- The department of education needs to articulate the philosophical basis of education in South Africa to all.
- The Department of Education should also consider conducting more research on the feasibility of the model produced in this research, so as to further refine it.
- Knowledge of nature containing solutions to everyday problems that is oriented to social benefits rather than personal or corporate profits is generally removed from such curricula. Schooling in its current form will have to be reconceptualised **with** the indigenous knowledge holders instead of **for** the indigenous knowledge holders by those schooled by the methods of Western education. This needs to be decided through dialogue between the two groups representing the two knowledge systems. Institutions of knowledge should take the form of depositories of knowledge, for recall when needed, instead of authorities on knowledge.
- More pilot programmes on the integration of modern science and IKS need to be undertaken as a means of fulfilling the mandate of the IKS policy and speeding up alternative education forms that are critical to the welfare of the global population and environment.
- More research needs to be conducted on the integration of modern science and IKS across all aspects of education, including the administration.
- The recommended model presents an opportunity as a crucial exercise of social transformation, where both modern science and the indigenous knowledge systems engage in a dialogue in the production of knowledge.

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