# TEACHERS' INTERPRETATION AND IMPLEMENTATION OF THE POLICY ON INDIGENOUS KNOWLEDGE IN THE SCIENCE NATIONAL CURRICULUM STATEMENT

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2010

**School of Science, Mathematics and Technology Education,**

**Faculty of Education**

**University of Kwa-Zulu Natal**

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**STUDENT NUMBER: 6903714**


**in**
**fulfilment of the**
**requirements for the degree:**

**DOCTOR OF EDUCATION**


**School of Science, Mathematics and Technology Education,**
**Faculty of Education**
**University of Kwa-Zulu Natal**

**February 2010**

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# DEDICATION

This study is dedicated to my mum, Parvathy Ramkaran who passed away during the course of my study and to my dad, Ramsaran Ramkaran for his unwavering support and belief in me.

# ACKNOWLEDGEMENTS

Many hands have assisted me on my journey into these uncharted waters.
I thank God for giving me the inspiration and courage to persevere towards the completion of this study.

I am indebted to my supervisor Professor Renuka Vithal and co-supervisors Dr. Farida Patel and Dr. Allan Pillay for their ongoing suggestions, comments, incisive critique and willingness to discuss different aspects of the study.

I thank the teachers who willingly participated in the study and for allowing me into their classrooms.

I would also like to thank my sister Indera Baijnath who encouraged me to register for this degree as well as for being a sounding board for different ideas.

I have also enjoyed countless discussions with a dear friend, Dr Nirmala Gopal.

Finally, I would like to acknowledge the role that my children Seran, Shane, Serena and Sandesh and other family members played in providing the motivation and encouragement to continue working on this thesis.

# DECLARATION

I .................................................................................. declare that

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination at any other university.

(iii) This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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Premella Devie Naidoo

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Supervisor: Professor Renuka Vithal Date

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Co-supervisor: Dr. Farida Patel Date

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Co-supervisor: Dr. Sathiaseelan Pillay Date

# ABSTRACT

In the new National Curriculum Statement in South Africa, there has been a strong drive towards recognizing and affirming the critical role of indigenous knowledge (IK), especially with respect to science and technology education. The Natural Sciences, Physical Sciences and Life Sciences curricula statements form the basis of this research. This study strove to establish how science teachers responded to the inclusion of indigenous knowledge systems (IKS) in their science classrooms.

My study began with 23 science teachers who completed a university module "Issues in Science Education," which included an IKS component. The study investigated firstly, what currently informed teachers' thinking, knowledge and action of IKS. Secondly, the research questioned how teachers interpreted and implemented IKS in the science classroom. A sample of three teachers were followed into their classrooms to investigate how they specifically implemented Learning Outcome Three related to IK in the Science Curricula Statements, and what approaches pertinent to the inclusion of IK were developed. That is, the study explored how shifts were being made from a theoretical phase at the university where teachers engaged IK to an actual phase of implementation in their school science classrooms. Finally I attempt to explain why the teachers interpreted and implemented IK in the way they did.

Production of data took place from 2006 to 2007, and used surveys, telephonic interviews, written assignments, face-to face interviews, classroom observations and reflective interviews. The three case studies involved three science teachers at three secondary schools in the province of Kwa-Zulu Natal, South Africa.

The study found that the three teachers used three very different approaches through which IKS was brought in the science curriculum: an incorporationist approach, that brings IKS into science by seeking how "*best IKS fits into science*"; a separatist approach that holds IKS "*side-by-side"* with scientific knowledge; and an integrationist approach that "*links"* and makes "*connections"* between IKS and science. The approaches developed by the teachers were found to be informed by their biographies, values, cultural backgrounds and worldviews.

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# GLOSSARY OF ACROYNOMS AND ABBREVIATIONS

| | |
|---|---|
| AAAS | American Association for the Advancement of Science |
| AS | Assessment standard |
| C2005 | Curriculum 2005 |
| RNCS | Revised National Curriculum Statement |
| NCS | National Curriculum Statement |
| GET | General Education and Training |
| FET | Further Education and Training |
| DoE | Department of Education |
| DST | Department of Science and Technology |
| IK | Indigenous knowledge |
| IKS | Indigenous knowledge systems |
| LO | Learning Outcome |
| NEPAD | New Partnership For Africa's Development |
| STME | Science, Technology and Mathematics Education |
| STS | Science, Technology, Society |
| STSE | Science, Technology, Society, Environment |
| TIMMS | Third International Mathematics and Science Study |
| UNESCO | United Nations Education, Science and Culture Organization |

# CHAPTER 1

## 1.1 INTRODUCTION TO STUDY

*Indigenous or traditional technologies and practices in South Africa were not just ways of working; they were ways of knowing and thinking. Much valuable wisdom has been lost in South Africa over the last 300 years, and effort is needed now to rediscover it and to examine its value for the present day. Given this history, it is fitting that traditional and indigenous knowledge systems should be included among the ideas the learner examines…Different worldviews are usually present in the classroom…people tend to use different ways of thinking for different situations. One can assume that learners in the Natural Sciences Learning Area think in more than one worldview. Several times a week they cross from the culture of their home, over the border into the culture of science and back again (DoE, 2002a: 10-12).*

Universally the curricula, teaching methodologies and assessment strategies associated with school science as it is currently being taught, projects predominantly one worldview[1] – a western worldview, which holds claims of superiority to other forms (Kawagley et al., 1998). Science curricula are remarkably uniform around the world (as evidenced by the applicability of testing programmes such as Third International Mathematics and Science Study [TIMSS, 1997; TIMSS-Repeat, 1998] (Howie, 2001); they neither recognise the variations among people nor the different worldviews that learners bring to the classrooms. Therefore the education of children in many Third World communities, South Africa included, has been impoverished in significant ways. The problem of cultural mismatch between different worldviews is further exacerbated by the myriads of cultures present in South Africa.

While there is literature internationally and locally to suggest that the use of indigenous knowledge (IK) contexts in science education provide motivation, self-esteem (Mckinley, 2005); relevance (Manzini, 2000); more peer interaction (George,

[1] Worldview in science education is defined as the "culturally dependent, generally subconscious, fundamental organization of the mind that manifests itself as a set of presuppositions that predispose one to feel, think and act in predictable patterns" (Cobern 1993: 58).

1999b; and Clark and Ramaphale, 1999); and positive learning experience (Machingura and Mutemeri 2004), there is also literature that continues to debate the “pros” and “cons” of different worldviews –indigenous knowledge (IK), and western modern science (WMS) – and their place in curricula (Purcell and Onjoro, 2002, Willams, 1999).

A number of critical questions have been raised about indigenous knowledge and indigenous knowledge systems concerning their meanings and their understandings. Different meanings and understandings both from a Eurocentric and South African perspective are explored in great details in chapter two on pages 49-50. In the South African context emphasis is placed on the National Curriculum Statement in Sciences. However, at this stage it is important for me to differentiate how indigenous knowledge (IK) and indigenous knowledge systems (IKS) would be used in this research. IK is used when referring to a cultural way of knowing itself and IKS refers to the combination of cultural ways of knowing relating to for example, education, agriculture, technology, medicine etc.

It is important to locate IKS in the context of the South African historical moment. What is the nature of the moment that has provided stimulus for an interest in IKS to such an extent that it can be used as a basis for future approaches to science education? Since science has failed to provide solutions to various problems, such as the destruction of the environment and the pollution that has resulted in dangerous developments like the hole in the ozone layer, and other problems related to developing countries (Corsiglia and Snively, 2000), it is time to re-look at the knowledge systems that have enabled people from the “developing world” to survive in spite of their alleged ignorance of science. Closer to home, the Daily News, January 14 2009, reported “the tidal waves, veld fires and storms that have wreaked havoc throughout Kwa-Zulu Natal in the past few months exposed the country’s shortcoming in the fields of science and technology.” Indigenous knowledge (IK) amongst other things is viewed as critical building blocks in fostering positive attitudes for equitable resource management, the preservation of biodiversity and consists of a wide range of knowledge that has largely remained hidden from the mainstream of education.

While its importance has been noted, however, over the last five centuries due to the colonising global spread of modern knowledge systems, technologies and institutions, the majority of the world's indigenous knowledge systems are "already extinct or teeter on the brink of extinction" (Prakash, 1999:164). Until quite recently, educators and researchers have not perceived these phenomena as a serious loss, given their western classification of indigenous knowledge systems as "primitive" or "non-modern" (Gerdes, 1996). Such ways of knowing and acting could contribute to the educational experiences of all students, but because of the "rules of evidence and the dominant western epistemology of knowledge production such understandings were deemed irrelevant" (Semali and Kincheloe, 1999:15). This western attitude of viewing IKS has denied its inclusion in the formal South African school curriculum before the democratic dispensation. The apartheid government furthered the suppression of IKS, which followed western colonization of South Africa because of the acceptance of western systems of thought as rational and universal and IKS as irrational and inappropriate. There have been arguments that IKS needs to be rediscovered and re-examined (DoE, 2002a; 2003; Semali and Kincheloe, 1999; Ntuli, 2002) which has over the last 15 years led to the accentuation of "different ways of knowing" and indigenous knowledge systems (IKS) globally, including South Africa post 1994.

IKS development is a unique opportunity to recognise and redress inequities created by past policies in South Africa. According to the National IKS Policy in South Africa (DST, 2004) school based education geared towards mobilising IK in a multicultural context of learning may be one such way that it can be achieved. IKS scholars, such as Odora (2000), Jegede (1999) and Onwu and Mosimege (2004) have argued that as a major national resource IKS should be made a part of education. The introduction of IKS in Curriculum 2005 (C2005), with its principles based on equality in line with the National Constitution has been heralded as an excellent means of promoting a culturally sensitive and relevant curriculum, catering, especially for the diversity of all learners in South Africa.

The purpose of this chapter is to provide a background for this study in terms of reform in science education curricula by relating it to the historical development of educational policies in South Africa. However, in providing a background to the study it is important to comment on the performance of South African learners in science testing programmes because science teaching for most learners during the colonial and apartheid eras was impoverished in many ways. In particular, I describe the new South African Curriculum 2005 (C2005) and related developments in reforms in science education. Integrated in the discussion is a rationale for studying how and why teachers interpret and implement IKS for the science curriculum. This is followed by the research questions and finally this chapter outlines the plan of the dissertation in terms of the purpose of the remaining chapters.

## 1.2 STUDENTS OR LEARNERS PERFORMANCE IN SCIENCE

By comparison with other middle-income countries, South African learners performed very badly in the 1997 Third International Mathematics and Science Study (TIMSS; TIMSS-R, 1998) and the repeat study (Howie, 2001). Howie and Plomp (2002), argue that this performance is attributed to a number of factors that may be found at both school and classroom level. These include language, socio-economic status, lack of resources, under qualified teachers, inappropriate curricula and teaching and lack of parental and community involvement in school governance. Historically in South Africa, all of these factors were associated with race and cultural background because the inequities of the apartheid system of education disadvantaged groups other than Whites.

Several studies, research and reports dealing with indigenous people in western education systems continue to paint a picture of despair and failure (Naidoo, 2002, Manzini, 2000; Jegede, 1999). Moving away from South Africa to other African countries, distanced from apartheid, countries such as Nigeria, Kenya and Tanzania have also been shown to do badly in science achievement tests at school and the recruitment of science students in tertiary study (Semali, 1999). The findings in South Africa seem not simply attributable to apartheid policies; instead, as Kawagley and Barnhardt (2000) point out, these are the general trends for students in indigenous societies around the world and are not peculiar to the South African context. Battiste, (2002) too argues that students in indigenous societies around the world have, for the most part, demonstrated a distinct lack of enthusiasm for the experience of schooling in its conventional form - an aversion that is most often attributable to an alien institutional culture, rather than any lack of innate intelligence, ingenuity, or problem-solving skills on the part of the students.

Of importance in the literature is identification of what is called “deficit models” where teachers believe the reason for students from some cultures performing poorly in schools is as a result of the cultural values, including the home and/or the student themselves, such as not making enough effort to learn the work (Carter, 2003; McKinley, 2005). In South Africa “blaming the victim” has been a similar strategy identified by Naidoo and Savage (1998: 83) “Conveniently, equity becomes seen in terms of individual failure to take advantage of opportunities, not as a failure of society to prepare individuals to do so.” Further literature suggests that the “underachievement” of indigenous students[2] in science education is amongst other things due to cultural conflict between home and classroom, low teacher efficacy and expectation, inadequate teacher subject, cultural and pedagogic knowledge, and a rigid curriculum framework with little space for culturally based pedagogy (Mckinely, 1996). A related issue in South Africa is that most African learners do not have access to science and mathematics in the secondary school or as part of university studies (Fredericks, 1999; Clark and Ramahlape, 1999; DoE, 2000c). Jegede (1995, 1996b) and Aikenhead (1996) suggest that a “gap” exists between home and school science and that it can be particularly wide for many indigenous students, and as such it may prevent them from learning science in a meaningful manner.

## 1.3 INAPPROPRIATE AND IRRELEVANT SCIENCE CURRICULUM

While the debate in the literature is dominated by publications in favour of multiculturalist approaches, teaching practices in science education have changed little (Aikenhead, 2004). Classroom practices appear to remain based on traditional western, universalistic views of the nature of science, and of science education. The

[2] Students from “ *politically underprivileged ethnic group, whose identity is different from the nation in power”* (http://indigenous.developmentgateway.org/community.

resistance of school curricula to reform efforts is well documented (Blades, 1996; Hodson, 1992).

In South Africa as noted, most African learners are not admitted to school science. For those who may have access, science is severely limited by not being mediated by their local experience resulting in a disjunction between their experience and their school science (Jedege, 1999). In time, an aversion to school subject matter sets in, leading to irregular school attendance and poor participation, especially in science courses. The fall in the number of those attaining passes in the gateway subjects, such as, Mathematics and Science continues to occur alongside disparities of race and gender.

There is increasing research locally and internationally to indicate that African learners tend to drop science and mathematics for softer options in the secondary school or as part of tertiary studies, in spite of their awareness of the opportunities for employment and further study that science creates (Fredericks, 1999; Clark and Ramahlape, 1999 and DoE, 2001b). Perhaps one of the most important factors identified by Quiroz (1999), that causes a high "drop-out" rate from schools, is the lack of relevance of the science topics taught at school. Relevance and participation in learning and performance go together: relevance in science encourages learners to participate in classroom processes more deeply, learning in their own ways and bringing together their ideas, interests and experiences. Research has identified a number of dimensions of relevance. For example Linkson (1999) makes a plea for cultural appropriateness, Fleer (1997) for inclusion of multiple worldviews and for the social and political aspects of science and Peacock (1997) and Terwel (2005) for linkage to children's everyday experiences. A science curriculum that includes aspects of relevant indigenous knowledge that recognises students' preconceptions and worldviews and affords a platform for discussion of "different ways of knowing" and encourages critical thinking is bound to attract and sustain more students in science (Govender, 2009).

Researchers (Manzini, 2000; Jegede, 1999; Odora, 2002 and Chetty, 1999) attribute this high "drop-out" problem in part to methods of teaching in science subjects that often fail to link the sciences with students' "prior" personal knowledge – the content and beliefs that the children have acquired from their different indigenous, scientific and mathematical cosmologies. Therefore there is a need then to ensure relevance of the students' experiences, interests and capabilities. Children do not come to school empty of science and technology. On the contrary, children usually enter school with a range of knowledge about plant, soil, bird, animal and insect life (Odora, 2000; Chetty, 1999). This knowledge is often ignored in school. In fact according to Jegede (1999:125), children have to leave this "cultural cloak" outside the science classroom. New content is presented without any effort to ensure that children understand it in relation to their lived reality (Odora, 2000). This issue of culturally irrelevant and conflicting approaches to the Science, Mathematics and Technology curricula in many African countries is well documented, where curricula were adopted and adapted from First World countries, since the 1960's, with little or no modifications (Mulemwa, 1999). There has since been a movement, not only internationally but also in South Africa, from replacing students' ideas based on traditional cultures to one of respecting those ideas and adding to them an understanding of school science.

## 1.4 CULTURE AND SCIENCE

As early as 1938 the principle of inclusivity was recognized by Raum, who in his book entitled "Arithmetic in Africa", stated: "Education… cannot be truly effective until it is intelligently based on indigenous culture and living interests." One of the principles of good teaching is that it "lays down the importance of understanding the cultural background of the pupil and relating the teaching in school to it" (Raum, 1938: 4-5 as cited in Gerdes, 1996). More recently Masingila (1993) emphasized that learning can be more effective provided it starts from cultural or cognitive experiences of students. Studies in culture and science education (Cobern, 1993; Aikenhead, 1999; Aikenhead and Huntley 1997 and Taylor and Cobern, 1998) have documented the significance of culture in learning science. Other studies propose "collateral learning theory" or "border-crossing" when students attempt to negotiate cultural borders in learning science (Aikenhead, 1996; Jegede, 1999; Jegede and Aikenhead, 1999). Taylor and Cobern (1998) propose a similar view; a perspective for science education which must recognise the need for mutual accommodation of beliefs, values and practices of modern sciences and the community's culture.

According to Michie (1999: 8):

> *"Until definitions of science become more harmonious with personal values, scientific knowledge will continue to be unappealing to many students. In our efforts to address these issues, we must take into account major world trends so that Africa does not continue to lag behind the rest of the world."*

The South African science curriculum, teaching resources and learning spaces have for a long time silenced indigenous voices and other cultural forms from effectively participating in education. Increasing calls have been made to challenge the usual portrayal of science and the knowledge-making process as being culture free (Aikenhead, 1997; Jegede, 1999; Gray, 1999). It is in this context, that "IKS" is being valued and recognized to make science education more relevant to African learners.

According to Malcolm (2001:10) the science curriculum should serve to support the needs of all students, ranging from those who see themselves as "potential scientists" to those who would prefer to remain in the rural villages, close to traditional belief systems. He elaborates that "both these groups of learners would be better served and supported if their experiences are incorporated into the classroom, and the philosophical underpinnings of western science and African science are surfaced and discussed with a view to a deeper understanding and critique" (p10) Curriculum design can be changed to offer a variety of perspectives. Malcolm (2001) also stated that the technical, mechanical and fragmented approach to western science sells science short: it gives students bits from the science culture, but does not help them to understand the whole, nor even its essence.

## 1.5 INTERNATIONAL INITIATIVES IN IKS

Globally we live in complex, challenging and rapidly changing times. The world stands at a crossroad in search of a new, human–centred vision of development in health, in preserving and conserving biodiversity, in human rights and in the alleviation of poverty. Several global imperatives have emerged to underpin the need for renewed attention to IKS in providing solutions to environmental problems. One of the first, the Tbilisi Declaration adopted in 1977 prioritised perspectives that embrace ethical, social and cultural aspects of human behaviour in addressing pressing environmental issues. http://www.gdrc.org/uem/ee/tbilisi.html.

Following on from Tbilisi was the The United Nations Conference on Environment and Development, also known as the Rio Earth Summit of 1992, which addressed Agenda 21, which dealt with issues associated with indigenous knowledge (IK). Chapter 26, of the Agenda sees the following as one of its objectives:

> *"recognition of [their] values, traditional knowledge and resource management practices with a view to promoting environmental sound and sustainable development" http://www.worldsummit2002.org/index.htm.*

Soon after Rio some of the Western world countries "speedily organized" themselves to contribute to deliberations on the significance of institutionalising of IK (Van Damme and Neluvhalani, 2004). More recently all the agencies of the United Nations seek to promote paradigms of sustainable human development that build on knowledge resources that exist in communities and recognise the value of IKS as part of its commitment to universal human rights (Odora, 2002; Tema, 2002).

The growth of the international IK movement had an influence on science. A recent cornerstone cue for change in science emanates from the preamble of the UNESCO Declaration on Science and the Science Agenda Framework, adopted in Budapest, Hungary (1999). This declaration urged member countries to define a strategy to ensure that science responds better to society's needs and aspirations in the twenty-first century. It reiterated the need for political commitment to the scientific endeavour and, especially to make science more responsive and more inclusive. The declaration amongst other things called for sciences to transform and become more inclusive of women and other forms of knowledge in terms of its culture (Odora, 2002).

## 1.6 EMERGENCE OF IKS IN SA

Following on from the Rio Earth Summit, South Africa, like many countries globally, has responded to calls to institutionalized IKS. The recent interest in IKS in South Africa cannot be separated from the new atmosphere of optimism and confidence made possible by the dismantling of apartheid in 1994. The new government, which came into power in South Africa in 1994, brought about concerted efforts to end suppression and distortion of IKS in general. In Africa both the African Renaissance and the New Partnership for Africa's Development (NEPAD) representing a vision and strategic framework for Africa's renewal have identified "indigenous knowledge (IK) as a key continental imperative" (DST, 2004:13) that continues to be the primary factor in the survival and welfare of majority of South Africans. In keeping with international trends the South African government has adopted a broad and holistic Indigenous Knowledge Policy. Cabinet adoption of the National IKS policy put in place the first important milestone to "recognise, affirm, develop, promote and protect IKS in South Africa." (DST, 2004:3). Besides serving to redress past imbalances the policy aims to creatively advance the course of IKS within the education system (National IKS Policy, 2004). It is therefore critical to ensure that the national education system's strategy is synergistic with and nurturing of IKS.

The emergence of IKS thus gained momentum with the notion of African Renaissance, called by the former president of South Africa, Thabo Mbeki; the formation of the African Union; the NEPAD programme, and many similar initiatives. This endeavour also impacts on knowledge systems and Ntuli (2002: 56) says of the African Renaissance "that as a rebirth it requires us to re-examine our knowledge systems anew." He further elaborates that it is important for Africans to assert their indigenous cultural traditions and to retrieve their repressed histories, and knowledge systems, which have sustained them as healthy communities. In addition, according to him the African Renaissance affords the opportunity to examine African knowledge in relation to scientific knowledge and to other knowledge systems. It is therefore natural that IKS discourse should be part of the political and emotional episteme of post-apartheid South Africa (Nel 2005).

## 1.7 IKS IN SOUTH AFRICAN EDUCATION

As a continent, Africa is seeking its own renaissance aimed at building a deeper understanding of Africa, its languages and its methods of development. In South Africa, the new Constitution is now supreme law in the country and amongst its provisions in its preamble, the Constitution provides the following:

- This country needs a new national system, which will redress injustices of the past in educational provision,
- Advance democratic transformation of society,
- Protect and advance diverse cultures and languages, (SA Constitution, 1996).

In South Africa the emergence from apartheid, the promulgation of a new constitution strongly based in human rights for individuals and groups, and research findings concerning achievements in mathematics and science education have resulted in increasing attention to "culture in science". This review in the science curriculum was part of the larger climate of change in education in South Africa. Government has responded with policy initiatives such as the White paper on Education (DoE, 1997), the Employment Equity Act, (DoE, 1998), Curriculum 2005 (DoE, 1997), The National Strategy in Mathematics, Science and Technology Education (DoE, 2001) and the National Curriculum Statement (NCS) in 2002. In addition the White Paper on Arts, Culture and Heritage (1996) views education as part of culture and acknowledges that culture itself is transmitted through education. These policy documents are directed to improve the effectiveness of education and gives recognition to notions of culture.

The first White Paper (DoE, 1995) provoked debates about the role of culture in education and its recommendation forced government's commitment to a unified and integrated approach to education. One of the key ideals of the African Renaissance[3] is

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[3] The African Renaissance is the concept that African people and nations overcome the current challenges confronting the continent and achieve cultural, scientific, economic, etc. renewal. This concept was popularized by the former South African President Thabo Mbeki during his rein in the 1990s and among other things it draws attention to preservation and continuation of African cultural traits (Ntuli, 2002).

the elevation of learners to the highest level of human development in line with the conviction in the new curriculum, C2005. Lombard and Grosser (2004), argue that this is a challenge that needs to be addressed by the education and training sector by providing the necessary capacity and conditions to ensure sustainable holistic development and growth amongst all levels of learners. In response to this challenge Asmal, in his message as minister of education, argues that Curriculum 2005, if successfully implemented, represents the most liberating element of our education system, which will enable all children, regardless of their backgrounds, to fully realise their potential (DoE, 2002c).

Revolutionary shifts in the South African political landscape now require teaching of IK philosophies, practices and languages to become institutionalised within all educational spheres from kindergarten to university. In the process IKS will be respected, valorised and internalised as part of social transformation in South Africa. This in turn will give new direction to future development and research and since teacher development (understanding and pedagogy) is a central feature of educational transformation this study focuses on teachers. Another contemporary concern that forms a backdrop to this research is the call for endogenisation (indigenisation) which according to Crossman and Devisch (2002), is a rethinking of ways of knowing, “deconstruction of old epistemologies,” and the concomitant demand that there be a transformation in our education, in how we teach and what we teach. Societal changes are putting new pressures on teachers and schools, including the need to meet the academic needs of indigenous and other students with markedly differing cultural, social and economic backgrounds (Linkson, 1999).

South Africa’s new education system, Outcomes Based Education (OBE) mandates education that is outcomes-based and learner centred. By intention, a single set of outcomes applies to all schools, although outcomes are defined broadly enough to allow local interpretation to suit different contexts and cultures. The first guiding principle of C2005 is human rights, social justice, inclusivity and a healthy environment. In the development of the National Curricula Statements, there has been a strong drive towards recognising and affirming the critical role of IK, especially with respect to the Sciences, Technology and Arts and Culture Learning Areas. By this inclusion, learners who have a tenuous knowledge of indigenous cultural capitals are not disadvantaged in the General Education and Training (GET) band for Grades R-9 and Further Education and Training (FET) band for Grades 10-12.

The Outcomes Based Education (OBE) represents the country's commitment to promoting the principles enshrined in the Constitution and catering for the full potential of learners of all cultural groups (DoE, 2002a,b and c). An important feature of curriculum reform included the transformation of science education. Curriculum changes were undertaken in three main stages or waves. This heralded major changes in the teaching of science. The first involved the "cleansing" of the curriculum of its racist and sexist elements in the immediate aftermath of the election (Chisholm, 2003). This could only be done through fundamental overall - a revamp of science resource material and textbooks, the removal of stereotypical portrayal of scientists as White men to representation of diversity in culture and females. The second involved the implementation of outcomes-based education through Curriculum 2005. The third involved the review and revision of C2005 three years later in the light of recommendations made by a Ministerial Review Committee appointed in 2000 (Chisholm, 2003). The revision of C2005 resulted in the Revised National Curriculum Statements[4] (RNCS) for Grades R-9.

It appears that policy in post apartheid South Africa displays broad international trends and the discussion increasingly centres on providing "science for all" rather than "science for the privileged". Prior to the RNCS and NCS schools taught the three "traditional" sciences, General Science, Biology and Physical Science. General science has been changed to Natural Sciences and Biology is called Life Sciences. The content must be made more appealing by linking it to the students' immediate experiences and making it relevant to their daily activities. One way of achieving this contextualized curricula and at the same time increasing its relevance is by the recognition and inclusion of IKS. For Ng'etich, (1996), recognition of IKS in the classroom will exploit the "positive virtues" of both the indigenous and western approaches encouraging equality, mutual respect, support and cooperation. Odora (2002) adds that inclusion is also crucial if IKS is to fulfil their potential for

[4] During the course of this study the Revised National Curriculum Statement Natural Sciences became known as the National Curriculum Statement. In this study I will use the term Revised National Curriculum Statement (RNCS) for GET (Natural Sciences) and NCS for FET (Life Sciences and Physical Sciences).

contributing to human and social development in a rapidly changing global context. While the intentions of the inclusion of IKS in education causes little debate, the matter of what this process would look like in practice, and how one might go about developing this practice on the basis of the current situation, are debatable issues. Onwu and Mosimege (2004:2) state that, what is now needed in the current science education reform agenda is a "mechanism for bringing IKS into our school science curriculum in a mutually supportive and inclusive way, so that both forms of knowledge systems can begin to provide the engaging tension among our learners."

## 1.8 TEACHING SCIENCE AND IKS

Strides are being made towards realising the goal of ensuring the utilization of indigenous knowledge systems by various academic institutions, individuals and Non-Governmental Organisations (NGOs) (South Africa, 1997:76; South Africa 1998: 27-28). In the present post-apartheid climate there is greater awareness and recognition for the inclusion of indigenous knowledge in higher education institutions. Although the Higher Education Quality Committee recognise the importance of IKS, its implementation and monitoring are vague (Odora, 2005). This raises the question, how can IKS be expected to be implemented at tertiary level if there is no foundation at school level? But according to Govender (2009) science teacher educators in tertiary institutions are "cognisant of these issues that impact on curriculum transformation negatively and are seeking informed ways to bring IKS, as valuable local knowledge, into the mainstream science curriculum."

Universities seeing the potential value of IKS are beginning to redesign course/modules to include IKS and in some universities in South Africa there is more focus on IK issues resulting in the establishment of IKS faculties. A Bachelor of IKS degree is to be introduced in 2009 by four historically disadvantaged universities, namely Universities of Venda, Limpopo, North West and Zululand. The Bachelor of Indigenous Knowledge Systems Qualification is comparable to similar international qualifications offered in Canada, Australia and New Zealand. These countries were chosen as a point of reference because they are regarded as leaders in terms of ensuring best practice in the field of IKS (Bachelor- Indigenous Knowledge Systems, Draft, 2008). The adoption of the National IKS policy has largely contributed to a period of growing awareness of indigenous knowledge in South Africa, alongside pressures on the school science curriculum to contribute strongly to national development. Schooling has begun to move to a new environment and concept of education.

It is ironic that schools in South Africa, once the site of cultural hegemony, are now called to become sites of language and cultural revitalization. Nyerere (1967) argues that if schools are established by any society to ensure the continued existence of the society then, education must be conceived as the transmission from one generation to the next of the "accumulated wisdom and knowledge of the society." In other words schools exist as agencies for the transfer of the culture of the society from one generation to the next. Therefore a good deal of what is taught in school science should be decided by reference to the culture of that society. According to Warren et al. (1996), schools in every nation should not ignore the responsibility of transmitting to the next generation; the "IK considered useful," and the skills and attitudes needed in order to maintain national culture.

IKS, which was introduced to schools in South Africa in 2001 and 2002 is mandated and strengthened through the Natural Sciences, Life Sciences and Physical Sciences curricula statements. Subjects, in South Africa, should be related more closely to learners' societal or cultural environment so as to minimise the conflicts that might arise from learners' views of the world and the views on which Subjects/Learning Areas being taught are based. Evidence that IKS is included in science education is observed in the South African National Curriculum Statement for the Life Sciences (Grades 10–12) which states:

> *"demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences, and the interrelationship of science, technology, indigenous knowledge, the environment and society."*

While the inclusion of indigenous knowledge into science education offers many advantages and while links have been established between science and IKS, important questions still remain. One needs to ask, how might one interpret these ideals into classroom practice? Whose knowledge is an indigenous knowledge system? How should it be practised and for what purposes? How does one create spaces in education for making meaning and achieving respect for IK? The emergence of IKS in the curriculum brings with it many debates and dilemmas. Raising these questions provides an opportunity to expose some of the arguments and debates, which will be captured in chapter two and three.

For Ntsoane, (2005), teachers in South Africa are confronted with new challenges, which are to a large extent political. He states that teachers would have to create new ways of knowing, different strategies for sharing knowledge and skills that they are unlikely to possess. Another question is raised by O'Donoghue and Neluvhalani (2002:24), which relates to indigenous knowledge, education and curriculum development:

> *"if much of the wisdom in indigenous ways of knowing has been, and can easily be overlooked, how might the necessary discontinuities and meaning-making challenges be mobilized to enhance (environmental) learning within the school curriculum?"*

Although, the responsibility lies on teachers to interpret the changes and to mobilise them into the education system so that they become meaningful, a number of challenges exist for teachers: What expectations are there for teachers who are diverse and differently oriented to IKS? For example, as a result of rising diversity in South African classrooms, it may well be that learners' worldviews are all not the same and may even differ from the teacher's worldview. How can science teachers enable all students to study western scientific ways of knowing and at the same time respect and access the ideas, beliefs and values of their IKS? Teachers may encounter difficulties with such complex situations in the classroom. It is these questions in problematising the inclusion of IKS that my study is seeking to address.

This National Curriculum Statement amongst others things, envisages teachers as researchers of indigenous knowledge and pedagogical practices. An understanding of both indigenous knowledge and indigenous educational practices is necessary for the insightful educator to integrate such curricular understanding into his or her teaching.

Malcolm (2002) argues that science educators are faced with the dilemma of how to sort out, from the available literature, the ideas and outcomes that may apply to their own schooling contexts. Such pedagogical abilities are intellectually demanding and will take time and detailed study for "everyone" involved (Semali and Kincheloe, 1999). This would further require that appropriate methods and methodologies for mobilising IKS in various learning contexts be identified and used.

The demands on teachers are further exacerbated by the freedom within the outcomes and standards – especially in the choice of specific content. While the Sciences Curricula Statements promote the inclusion of IKS in Learning Outcome three and assessment standards, it is lacking in providing IKS exemplars presumably leaving this to publishers and professional curriculum developers. Even so, teachers are expected to take major roles in curriculum design. Will teachers be able to interpret and implement IKS in their lessons from a policy that is open and non-prescriptive?

While the last few years have seen an "explosion of interest and activity" in IKS in various fields due to the African Reinaissance, not much that is tangible has emerged and as yet little has been translated in curriculum perspectives (O'Donoghue and Neluvhalani, 2002). A possible reason put forth by Naidoo (2002), is that although teachers believed that including IKS into the curriculum is essential and beneficial, at a practical level they did not translate this belief into action. One major barrier was that teachers didn't know how to do it.

Indigenous knowledge is not documented and it is not readily available to teachers. Although some recent South African textbooks have attempted to include IKS it has not been done with many cultural inclusions and activities (Naidoo, 2002). In other words textbooks designed for a national market do not accommodate the diversity of environments and students in the South African context, leaving teachers with very little material to support them. Teachers do not necessarily know the various indigenous knowledge systems that exist. The question arises: where will teachers go to for sources of IKS?

If IKS is to become a part of teaching and learning, then it is the teachers who are most important in taking this reformation in science education forward. There have been some studies in South Africa, which focused on "culturally relevant curriculum" and learners. This study is markedly different from other South African studies in that it centres on teachers in their classrooms.

In the long term I hope that this research will influence policy in South Africa, leading to examples of learning programmes that illustrate how indigenous knowledge might be included in the science curriculum. Research in this area could also contribute towards a framework for teacher education programmes. The significance of the study also lies in the possibility that the appropriate inclusion and recognition of IKS in South African school education can create new understandings of what it might mean for classroom practices.

## 1.9 RESEARCH QUESTIONS

During the apartheid era teacher education in South Africa emphasized the role of teachers as curriculum implementers. Curriculum 2005 is calling for major shifts and new skills from teachers. There has been substantial debate in recent years concerning the way school curricula in general and science curricula in particular should respond to cultural diverse learners. Implementing a science curriculum in which IKS is elaborated is not just desirable but a necessity in the present South African context. While there is a very large volume of literature about the nature of science with respect to culture (Aikenhead, 1998, Aikenhead, 2002, 2006, Taylor and Cobern, 1998) in the field of education, connecting IK to school science, little of it is based on studies done in schools. There is a need for substantial research on successful classroom approaches, which are inclusive of IKS.

These South African issues create interesting challenges for curriculum policy, teachers, design, materials and assessment. The critical statement in the RNCS states, that science curriculum development which takes account of world-views and indigenous knowledge systems is in its early stages and will be addressed with enthusiasm by many educators. "This National Curriculum Statement creates an invitation for such curriculum research and development, and in this way it is an enabling document rather than a prescriptive one" (DoE, 2002a: 12). In short, the

RNCS offers only broad advice on how to bring IKS into the curriculum: we don't know how to do it, or what it means. My study is a response to this "invitation" in the RNCS.

It is important to locate my position in this research. As a subject advisor for Natural Sciences and an educational practitioner, I was concerned about the way that IKS was implemented in the Natural Science curriculum. I was neither the subject advisor nor the lecturer to any of the participants in the study. My role in this study is purely one of researcher.

My study began with 23 science teachers who completed a university module "Issues in Science Education" which included an IKS component. Exploring teachers' thinking and their knowledge of IKS, the study investigated the first research question namely, what is currently informing teachers in the way they conceptualise IKS? The second research question is how teachers interpret and implement IKS in the science classroom? Three teachers who formed the case studies were followed into their classes to investigate how they implemented Learning Outcome Three (LO3) of Science Curricula Statements and what approaches pertinent to the inclusion of IKS were developed. Since no processes for enactment of the policy exists, I was especially interested in discovering how shifts were being made from the theoretical phase at the university to the actual phase of implementation in the classroom. Finally I attempt to explain why the teachers interpret and implement IKS in the way they do and theorise their thinking and actions.

I regard my research as representing a key study because while the new curriculum is being implemented in schools, the expectation is that it is imperative for science teachers to include IKS in their lessons.

## 1.10 THE PLAN OF THE DISSERTATION

In **Chapter one** I present a background for the research in terms of developments in the curriculum in South Africa especially during the post apartheid era. In particular, I described the new South African Curriculum 2005 (C2005) and related developments in reforms in science education with reference to institutionalising IKS. Having made a case for the importance of IKS, by referring to colonialism and apartheid, the performance of learners in science and inappropriate curricula, many debates, dilemmas and challenges still exist and my study is seeking to address some of these issues.

In **Chapter two** I trace the historical events that have reshaped science education from its early teaching to present day in an attempt to provide the context, which finally resulted in the Sciences Curricula Statements. In particular, I analyse the IKS component of the Natural Sciences, Life Sciences and Physical Sciences Curricula Statements. Different meanings of IKS and IK, a survey of some studies on IKS, and the effect that bringing IKS into education had on western science is presented. Finally the chapter examines teachers' knowledge of science to infer and raise questions on what the possible expectation might be for teachers' knowledge of IKS.

In **Chapter three** constructivism as a theory of learning, which also informs and influences teaching is elucidated. Those who argue for a constructivist framing use worldview theory, which emanates from anthropology and psychology, in science education to explain how teachers may manage and negotiate conflicting worldviews. Juxtaposing IKS with western science in the classroom brings with it issues of power and hierarchy which needs to be built into approaches that encourage such discussions in the classroom. IKS, which emerges from a postcolonial moment, provides grounds for science education to be located in such an analysis. Postcolonialism, which is not widely analysed in science education has been used as a critique of science education theories. Science educators have also attempted to develop models for "IKS in science" teaching, some of which are explored.

In **Chapter four** the research methodology describes in detail the reasoning behind the way this research was conducted, the design of the study and selection of the sample. The study uses multiple case studies supported by multiple sources of data. Data production was done in three phases, the first phase, which is the imagined/hypothetical, second phase or implemented/actual and the third phase, which is the reflective phase. Data collection employed surveys, telephone and face-to-face interviews in the imagined/hypothetical, classroom observation in the implemented/actual and reflective interviews in the reflective phase.

**Chapters five to seven** present analysis of data. The first level analysis, which is presented in **chapter five**, was done in distinct phases. The survey, telephone interviews and teacher education assignments address primarily the first and second critical questions: namely what teachers say informs the way in which they conceptualise IKS and how teachers interpret IKS and how they think they would implement IKS in the science classroom. In the first part of this chapter teachers' sources of IKS are examined by analysis of the survey. The survey data is supplemented by data from the telephone interviews to provide deeper insights into how teachers were thinking about IKS and to further illuminate their ideas and meanings. In the second section of this chapter the two assignment tasks they developed for the teacher education programme are analysed by using a re-interpreted framework of Snively's (1995) Five-Step Model to extend the analysis on how teachers were thinking about and planning for implementation of IKS.

The second level analysis presented in **chapter six** draws from the data obtained in the face-to-face interviews, classroom observation and reflective interviews. It deals with the construction of narratives from the data for the three teachers, Lizzie, Deva and Pindi who formed the three case studies. The analysis addresses the second critical question of how teachers implement IKS in the class and the third critical question of why teachers interpret and implement it in the way they do. By using empirical evidence from the narratives the three emerging approaches used by the teachers in implementing IKS in science lessons were illuminated in the concluding section of the chapter.

In **chapter seven a**nalytical categories were developed to categorise each teacher's approach for teaching of science in which IKS is elaborated. The three approaches gave rise to several themes in response to the research questions, which were influenced by the theoretical orientation made explicit in this study. In this chapter the themes further elaborated each of the three teachers' approaches, namely Lizzie's "incorporationist approach", Deva's "separatist approach" and Pindi's "integrationist approach". The themes were developed in response to the critical questions, through the three selected cases.

I attempt to synthesize the elements comprising the analysis in chapters five, six and seven into the final thesis in **chapter eight**, the final chapter in the dissertation. In this chapter what this would mean for each of the following is interrogated through the approaches developed as a new lens: policy, classroom practice, teachers, teacher education, "IKS in science" teaching and theory/research.

# CHAPTER 2

## SCIENCE EDUCATION REFORMS AND IKS IN SOUTH AFRICA

*Truth is never under the sole proprietorship of any single domain of knowledge—not even science.* (Cobern and Loving, 2001:65)

## 2.1 INTRODUCTION

Over the past 10 years curriculum change has become a major feature of teaching in South Africa. This process of change involved various role-players and interested parties, including science teachers who played a significant role. To situate the research in such a context a brief overview of science curriculum changes in South Africa will be discussed.

The purpose of this chapter is to locate science teachers within the context of transition from an apartheid political dispensation to a democratic one, particularly in reference to the introduction of IKS and its implementation. These considerations are central to this research. All teacher participants (in this study) were schooled in the apartheid system of education and while in the teaching profession they experienced curriculum change associated with apartheid and post-apartheid developments. In discussing the background to science curriculum reform processes in South Africa, some of the effects that these changes have had on the professional lives of science teachers and their engagement with IK are contextualized.

This chapter is presented in three parts: The first part engages with discussions on the early reforms in Euro-American science education, science education and curriculum reforms in South Africa that led to the inclusion of IKS. The policies central to this research, namely, Curriculum 2005 (C2005) and its revision, the Revised National Curriculum Statement (RNCS) for the Learning Area Natural Sciences and the

National Curriculum Statements (NCS) for Physical Sciences and Life Sciences are examined. While this period was characterized by turmoil, it was also a time of optimism for most South Africans. A part of this optimism was a deliberate attempt by the Department of Education to relate science education to society and environment, (such as the IKS of the local people) a long awaited development.

Part two of this chapter seeks to clarify the different meanings, foregrounding different aspects of IKS. It also provides some insights for the relations between IKS and western science and points out the challenges that these conflicts might bring to the multicultural and multiethnic classes of the new South African context. A survey of studies attempting to include IKS in western science is presented. This is in reference to the various approaches utilised to include IK into the curriculum.

In part three of the chapter I conclude by examining writings of science teachers' knowledge and practice globally and the changing identities of science teachers in South Africa as a result of the new demands made on the South African teachers through the introduction of the RNCS.

## 2.2 SCIENCE EDUCATION CURRICULUM REFORMS

The new South African curriculum, C2005, heralded the introduction of IKS into most of its' Learning Areas for example, Natural Sciences, Life Sciences, Physical Sciences, Technology, Mathematics and Arts and Culture. In this section I explore how IKS came to be in the national science curriculum statement.

Colonisation had a great influence on science education in Africa in general and in South Africa in particular (Hountondji, 2002). Therefore to understand the introduction of IKS in the science curriculum it is useful to examine how science evolved from its Euro-American roots. For this reason I chose to trace the development of science education from its early reforms in the 1950's to the present day of "science for all" agenda. The philosophy of "science for all" embraces a humanistic perspective of science through the inclusion of societal and environmental issues as articulated in one of the Learning Outcomes (LO3) of the Sciences Curricula Statements, which specifically allows for and accommodates IKS.

The historical analysis establishes a framework, which demonstrates how social events over the last three decades have reshaped school science curriculum from a “pure science” approach to a science-technology-society approach.

Although the history of science education spans from the Enlightenment period in the 1700’s (Tema, 2002) with one of the first formal school science curricula being written in 1867 in England (Abramson, 1998), I explore the historical events relevant to my study that have reshaped science education from the Sputnik Era with particular reference to “science for all” which promotes learning for diverse learners.

### 2.2.1 Early Science Curriculum Reforms

In most western countries before 1960, science education was dominated by the transmission mode of teaching, in which teachers saw their role as that of imparting an accepted body of knowledge to students (Tema, 2002). The Sputnik era was a distinctive period in the history of science education in the United States. The Soviet’s history marking the accomplishment of the launching of the Sputnik into orbit created a paranoia and concern that the Russians had beaten America in the space race (Bybee, 1998). That concern sparked a much-needed revolution in science education in the US. There was an overhaul in science education in the 1950s, which is sometimes referred to as the “Golden Age” of science and mathematics education (Bybee, 1998). In American classrooms, educational tools began to change. Textbooks were replaced with instructional materials that included laboratory kits and overhead projectors and films became part of the science curriculum (Abramson, 1998). No longer were schools’ science and mathematics programmes theory laden. Rather, students learned the structures and procedures true to the nature of science, namely modes of scientific inquiry, discovery and mathematical problem solving etc. Curriculum reform projects, for example, the Nuffield science teaching project, abandoned the content driven curriculum which encouraged rote learning in favour of the “processes” of science (Fensham, 2004a).

Process science was considered more valuable because this potentially allows for students an experience of science as is practiced by scientists and introduces them to the “scientific method”- a method that was thought to yield reliable knowledge

(Tema, 2002). However, over the years there was growing dissatisfaction about the efficacy of the "process method" as practiced in the schools. It was found to distort the nature of knowledge formation by the emphasis of the "out-thereness"[5] of knowledge rather than viewing it as a human construct. Formalisation of the scientific method in steps was also criticised by Paul and Binker (1990) in that scientific thinking was not a matter of running through an orderly set of steps. The problem-solving approach was subsequently advocated as a replacement of the "process-oriented" approach. Since problem solving involved the use of existing knowledge in the minds of individuals, a new form of research that attempted to apply the philosophy relating to the importance of prior knowledge (constructivism) to science education evolved in Britain.

Teachers, however, not given the necessary support had difficulty with the content and pedagogy of the new programmes that were developed. Lacking educational support within their system and experiencing political criticism from outside of education, they sought security by staying with or returning to the traditional programmes (Bybee, 1998). While many new science courses were developed in the 1960's in response to Sputnik, that period of reform halted shortly after the American astronauts landed on the moon in 1969 after which USA slid back to a more conventional approach to school science.

Western science influenced science in Africa and this is evident in Odora's (2002:129) statement "science education in Africa [South Africa] has by far and large not only copied curricula from western countries, but it also closely borrowed approaches to practice." This led to South African schools adopting the Nuffield science curricula. In South Africa the De Lange Report investigated amongst other things the learning of science and mathematics (Odora, 2002). It dismissed the idea that science-concepts can be related to concepts from traditional African culture (Odora, 2002). IKS and culture was not a feature of the early science reforms.

Whether teachers in South Africa would resort to a similar approach if not provided with adequate support for IKS teaching at this stage remains an open question. I began

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[5] False assumption that knowledge is situated out-there waiting to be discovered.

this study with the assumption that in the South African context science teachers may resort to a similar stance in respect of IKS if they fail to conceptualise it or implement it in the curriculum.

### 2.2.2 Science Education For All

Science and technology education in schools has traditionally served an academic elite group of students (Driver et al., 1996; Fensham, 2004b) for the purpose of supporting university science and engineering programmes. Those students who did not see themselves as future scientists and engineers were screened out.

These restricting initiatives to curriculum (science for the elite) for specific groups of students, that is, science and mathematically prone and college-bound students, led to most students disengaging with science (Fensham, 2004b). This resulted in criticisms of Sputnik-era reforms as inappropriate for students who were not “potential scientists” as the programmes catered only for those students who planned to study sciences at the universities (Bybee, 1998). Teachers in schools that implemented the new programmes, found that the materials were to a degree, inappropriate for some groups of students and too difficult for others. Restricting policies or targeting programmes opened the door to criticism on the grounds of equity. Proposing initiatives for all students also often resulted in criticism from both those who maintained that there was a need for a specific program for those inclined toward science and mathematics and those who argued that programmes for all discriminated against the disadvantaged (Bybee, 1998). This dilemma, “science for all” versus “science for an elite,” has plagued science education ever since the first formal school science curriculum was written in England in 1867 (Bybee, 1998).

In the early 1980s national reports in a number of countries recognised that school science was designed to serve the interests of that minority of students who would, in due course, become science-related professionals and, accordingly, issued the challenge that school science should rather serve many more students (Fensham, 2004). The rise in the demand was for “Science for All.” Science for all focuses on the cultural and human context of science, as well as promoting participation in science by all learners (Fensham, 2004a).

New curriculum projects were launched in Britain and USA and a curricula approach for "All" in science education moved to centre stage in some countries, such as England and Wales. In the USA, "Project 2061", which began in 1989 is a major long-term initiative of American Association for the Advancement of Science (AAAS) aimed at helping all Americans learn more about science, mathematics, and technology. By the latter part of the 1980's this social need gave rise to several initiatives in this direction - a movement referred to as Science/Technology/ Society (STS). This coincided with the demise of apartheid and apartheid education in South Africa. These new ideas were also emerging with respect to science education in South Africa.

The RNCS Natural Sciences makes "Science for All" clear in the following statement:

> *"It starts with the premise that all learners should have access to meaningful science education, and that arbitrary selection and rejection based on various kinds of biases should be avoided"* (DoE, 2002a: 5).

A major outcome of "Science for All" is the understanding that there are other ways of looking at the world. "Science for All" is important in the national vision (Department of Education, 2001; 2002a) but according to Malcolm (2001b) it is not clear what that means in practice, or how it will be achieved in the South African context.

"Science for All, Scientific literacy and Science, Technology and Society" in the international literature tend to view Science as an "object and singular" (Malcolm 2001b). Malcolm (2002) has argued that if it refers to one literacy for everyone in the world then "Science for All" has connotations of universalism. This universalistic position argues that western science is the paradigmatic science, has a universal essence, and provides knowledge, which is uniquely and epistemologically far more powerful than that of IK (Loving, 1995). Such a monopoly is impoverishing and denies people the pragmatic local indigenous knowledge that does not conform to the formal aspects of the "standard account" and science education then becomes a vehicle through which unequal access is maintained.

The question is that will the introduction of IKS, as local knowledge, in the science curriculum similarly promote a "culturally relevant" curriculum, thereby serving to "advantage" the disadvantaged majority in South Africa who represent the "other"[6] at the periphery? Inequalities in education in South Africa led to marginalisation and exclusion of majority of the people in education. By bringing them into the "focal point" it might be assumed that it would benefit their learning, thus breaking the inequality status into which they were "bound" during colonial and apartheid eras.

### 2.2.3 A Science, Technology and Society (STS) Approach

STS is an approach to science education based on the consideration of science and technology in societal (STS) issues and materials, a student-orientated approach whose roots spread rapidly in the 1980s (Solomon and Aikenhead, 1994, Semali and Kincheloe, 1999). Today there are a number of STS types of science curricula worldwide, for instance: "science-technology-citizenship" (Kolstø, 2001), "nature-technology-society" (Andersson, et al 2000), "science for public understanding" (Eijkelhof and Kapteijn, 2000), "citizen science" (Irwin, 1995; Jenkins, 2000), "functional scientific literacy" (Ryder, 2001), and "public awareness of science" (Solomon, 1994). These STS types of science programmes are often seen as vehicles for achieving such goals as "Science for All", "scientific literacy," and for improving the participation of marginalized students in school science.

In an STS science curriculum, canonical science content is related to the students' everyday worlds, and in a manner that mirrors students' natural efforts at making sense of those worlds. Thus, STS is student-centred, not science-centred (Aikenhead, 2001). South Africa has drawn on these worldwide developments in science curricula. C2005 acknowledges an STS approach in all Learning Areas by creating an awareness of human rights, social justice, a healthy environment and inclusivity (DoE, 2002a), which might be interpreted as other ways of cultural knowing.

Throughout the 140 years of science education's formal existence, (from 1867) there have been debates between two sets of visions for school science (Hurd, 1998). On

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[6] From a colonial perspective 'others" refer to that category of people who were colonised by the Europeans (Maurial, 1999).

the one hand, there is a vision that Aikenhead (2004) calls a "humanistic-cultural" approach to science education. This vision promotes practical utility, human values, and a connectedness with personal and societal issues to achieve both inclusiveness and a student-centred orientation. On the other hand, there is a traditional vision that promotes professional science associations (such as AAAS), the rigours of mental training and academic screening to achieve both exclusiveness and a scientist-centred orientation. Although the traditional vision of school science has been the status quo all these years, the humanistic-cultural vision has experienced a renaissance since World War II (Jenkins, 2000). The slogan STS was changed in some countries. For example, in Canada and Israel, the environment was emphasised by adding an "E" to STS, producing STSE or STES (Aikenhead, 2006b). Hence Canada inaugurated its first national framework for science education in 1997 by establishing a science-technology-society-environment (STSE) approach to achieving scientific literacy. At best, STSE education can be loosely defined as a movement that attempts to bring about an understanding of the interface between science, society, technology and the environment. A key goal of STSE is to help students realize the significance of scientific developments in their daily lives and foster a voice of active citizenship (Soloman,1994; Aikenhead, 1994).

In the 1980's due to the poor performance of indigenous students and the increasing diversity of students (Villegas, 2002), America saw the beginnings of what is now known as cross-cultural science. Science is now widely recognized in every aspect as a cultural practice, just as any other form of knowledge (Aikenhead, 2004). Science is treated as a subculture of Euro-American mainstream culture and according to researchers (Aikenhead, 2004; Barton, 2002; Reiss, 2000) most students (approximately 80 to 90%) find science to be a foreign culture to be avoided because it is either irrelevant to their cultural identities or "repugnant" to their social sensibilities. For them, a meaningful understanding of canonical science is usually beyond their grasp. It is inaccessible to them until they cross the cultural border between their everyday culture and the culture of school science. Hence science is seen as a cross-cultural event that involves border crossing, which I take up in chapter three.

Having detailed the evolution of science education in the Euro-American context, in the next section its impact on science education in Africa and in South Africa in particular is presented since IKS has arisen within and against this background.

### 2.2.4 Science Education in Africa

Before examining science education in South Africa some reforms that have taken place in science education in Africa over the last 50 years are discussed since reforms in most African countries were similar before political independence. At the end of the twentieth century, the genesis of science education in Africa could be traced back to Europe (Hountondji, 2002). This long history of theoretical and philosophical thinking about science teaching, primarily from Europe and America, has influenced its teaching throughout most of Africa. It can be argued that political independence in Africa was an important factor contributing to the development of science and technology education since countries no longer tied to the “apron strings” of the west, could break free and develop in an African context. Before 1960 most countries paid little attention to teaching these subjects (Yoloye and Emeritus, 1999). In the 1950’s, a few secondary schools taught the “pure sciences” of Physics, Chemistry and Biology and their facilities and equipment were limited and teaching was geared to overseas examinations such as Cambridge and London School certificates (Yoloye and Emeritus, 1999) and no cognisance was taken of cultural relevance.

In 1961 the Addis Ababa (Ethopia) Conference of African States on the Development of Education in Africa, organised by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the Economic Commission for Africa (ECA), recommended that:

> *“African educational authorities should revise and reform the context of education in the areas of curriculum, textbooks and methods, so as to take account of the African environment, child development, cultural heritage and demands of technological progress and economic development, especially industrialisation.”* (UNESCO, 1961).

In the last half of this century, in an effort to promote such changes called for by UNESCO and with the tremendous surge in science knowledge, science education and curricula have also undergone major reforms in Africa. These reforms occurred in two waves (Tema, 2002). The first reform in science education started in the 1960's with science curriculum projects from the United States and United Kingdom being based on Nuffield science programmes (Mulemwa, 1999). Mulemwa maintains that since these foreign science reforms were implemented without modifications they failed in Africa while George (1999a) and Ingle and Turner (1981) support the view that the continued use of foreign curricula denied learners to think scientifically in the context of their culture. The second wave of reform was the rubric of "Science for All" which was premised on the view that all societies and hence all individuals require some basic knowledge in science if they are to cope in today's technological world (Fensham, 1992; Fensham et al., 1989). Moving from Africa to South Africa similar reforms following the lead from western countries were taking place.

In the section that follows, apartheid and post apartheid science education in South Africa are examined to indicate the shifts in underlying principles and the transformation that occurred. These changes impacted on the professional lives of the science teacher and made new demands on teachers. A major influence was seen in curriculum, where teachers were now viewed as curriculum developers from their traditional roles of curriculum implementers.

### 2.2.5 Science Education in South Africa during the Apartheid Era (1948-1993)

The well-documented apartheid education system in South Africa has been described as, "racist, Eurocentred, sexist, authoritarian, prescriptive, unchanging, context blind and discriminatory" (Jansen 1999: 4). The apartheid system of education may be regarded as an extension of the colonial system of education because the inequities and discriminations practised during the colonial period were further entrenched through laws that were strenuously implemented. These inequities were carried into allocation of education resources, and indoctrination (in schools and teacher education) through Christian National Education and Fundamental Pedagogics (Kholofelo, 1998). Christian National Education required schools to educate their students about and in line with the spirit of Christian values. The principles of Christian National Education were used to divide and control, to protect White privilege and power and to ensure Afrikaner dominance (Pillay, 2006). This resulted in gross inequalities among schools that catered for different races in South Africa and its lack of sensitivity to religious and cultural diversity had negative implications for science teaching (Msila, 2007). For example, science syllabus restricted science teacher educators and science teachers to a creationist view of the origin of life on earth, as opposed to a scientific evolutionary view (Pillay, 2006). It selected science textbooks with a strongly Euro-centric focus, to the exclusion of local contexts and the contributions made to science by other race groups in the world through indigenous knowledge systems.

During apartheid, although teacher education was one of the readily accessible forms of tertiary education available to Africans (Pillay, 2006) science and mathematics subjects were still "inaccessible" because the government argued that Africans did not need science and mathematics (Rogan and Grayson, 2003). Two reasons could be advanced for this. Firstly, it was the intention of the apartheid government to reduce employment possibilities for Africans in more empowering and higher-powered positions in the work sector, which it reserved for other race groups, especially people classified as Whites. Secondly, the Government developed a firm bureaucratic control of education to suit its agenda based on race (Pendlebury, 1998).

Education policy decision making prior to 1994 was highly centralized and largely excluded teachers. During the early 1900s curriculum was spelt out in remarkable details, in order to render the curriculum "teacher proof" and was policed by "inspectors" (Barnett and Hodson, 2001). This way of defining the curriculum was also known as the content-centred or traditional approach derived from the objectives model. The section that follows explains how the traditional model for curriculum development was used during the apartheid era to support its agenda of disempowerment.

The science teacher was trained to keep the laboratory clean, become involved in stock-taking, preservation of plants and animals, preparation of chemicals, etc. Pillay (2006) described the approach as highly "technicist." Science teachers concentrated on the content of science, “correct explanation” and providing learners with a “firm foundation” for further studies in science. This approach was recognised as “science for the privileged” or “science for the elite” since most Africans[7] and females of all races did not pursue science. Science teaching ignored the underlying “processes” of science that represented the essence of science, but instead emphasised the “product” of science, which emphasised it’s theory laden nature.

The Research-Development-Dissemination-Adoption (RDDA) model[8], common across the world in the 1950s and 1960s, formed the dominant process of curriculum development. Samuel and Naidoo (1992) state that there was very little evidence to show that research and development in fact did occur. Teacher involvement in curriculum development in this approach focused largely on implementing the content in order to achieve the product. Involvement of teachers in the design or dissemination and evaluation phases was not an expectation due to the “top-down” approach. Teachers appeared to be severely de-skilled by such past education methods, and initiative appeared to be lacking. Barnett and Hodson (2001) refer to such curriculum dissemination as “highly controlled conditions” with administrators relying on their formal authority to get things done in the way that they wanted by “exerting influence over people, processes and the use of resources”- a superordinate model for the subordinate control of teachers.

According to Jansen (2003) the central requirement of teachers in the apartheid era was bureaucratic and political compliance with state education. Compliance was ensured through a complex system of instruments including school-wide and individual teacher inspection, a rigid syllabus outlining official content, objectives and methods of teaching, and a hierarchy of internal and external controls. Science teaching methods revolving around “telling” were typical, and learners were expected to be passive. Practical work under the guise of “discovery or inquiry learning” was characterised by overly prescriptive step-by-step instructions on worksheets that defied the principles embracing the nature of science (NOS). The school science

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[7] In this study Africans refer to “Black African” race group, forming the largest part of the population in South Africa and Blacks refer to all groups of Africans, Coloureds and Indians.

[8] The RDDA model used during apartheid South Africa excluded the teacher as a curriculum developer. So-called “experts” developed the curricula, disseminated it to teachers and teachers were to obediently implement it.

curriculum, its textbooks and teacher education were manipulated and used as instruments of propaganda and indoctrination (Pillay, 2006).

Science teachers taught the same content in the same way to different students. This "one-size-fits-all" curriculum did not acknowledge the diversity of learners, their different learning styles, their cultures, beliefs and languages etc. Researchers such as, Odora, (2002), Ogunnyi, (1988) and Naidoo, (1997) have criticised ways in which science education has been practised historically, especially the lack of equitable access to a culturally sensitive science education. In the context of South Africa, Naidoo, (1997) argues that, in the post-apartheid era, historical inequities in *Black Africans'* access to quality science education need to be addressed at both "societal level" (equitable resource distribution) and "school level" (equitable science curricula).

In such a context the cultures of the politically oppressed majority were severely marginalized and IKS stood no chance in the curriculum. The next section makes reference to the extent to which the new government has taken steps to address the imbalances in education especially in science education by including IKS in its educational agenda.

### 2.2.6 Science Education in Post Apartheid South Africa (1993-2008)

The first democratic elections held in 1994 brought new possibilities, opportunities and expectations for South Africa. Curriculum reform was seen as a major vehicle for change, driven by the vision of lifelong learning and credentials, one education system for all South Africans and one set of "outcomes" (Department of Education (DoE, 1995). In 1996 the South African government under the ideological guidance of the minister of education, Sibusiso Bengu decided to make the entire education system (from year 1 of school to postgraduate level at university) an outcomes-based system (Chisholm, 2003). Its frameworks were formally adopted in 1997 and the curriculum in 1998. OBE, the guiding philosophy of C2005 provides a broad framework for the development of an alternative to apartheid education that is open, non-prescriptive and reliant on teachers creating their own learning programmes and learning support materials (DoE, 1997a). OBE philosophy views that all students can learn, regardless of ability, race, ethnicity, socioeconomic status, and gender (DoE, 1997a).

OBE emphasizes learner-centred approaches and clear standards for observable, measurable outcomes. According to the policy documents Learning Outcomes are statements of what (knowledge, skills and values) the learner should know, demonstrate and be able to do and Assessment Standards describe the level at which learners should demonstrate their achievements of Learning Outcomes and the ways (depth and breadth) of demonstrating their achievement (DoE, 2002a). Assessment Standards break the three Learning Outcomes down into more detail and they describe the criteria by which to judge how well learners are able to achieve the outcomes (DoE, 2002a). In the Sciences Curricula Statements the three Learning Outcomes remains the same for all grades (GET and FET) while the assessment standards change from grade to grade. According to Pretorius (1998) outcomes-based education is recognized as an approach which provided a means to a single, unified education system (with one set of outcomes applicable across the nation), but with the outcomes defined as competencies, allowing variations in the details of teaching and learning in diverse settings. This allows for the OBE-oriented teacher to think about the individual needs of each learner and give opportunities for each learner to bring their diverse knowledge and cultural experiences to the classroom.

Since an outcome implies that knowledge is learnt in context this represents a shift not only in the conception of science, but also in how science should be learnt. There was a need to change methods of science teaching from science being taught as product (transmission of factual content) to a “process” (skills) true to the nature of science and for new science curricula to be embedded within students’ own (multi) cultural contexts (Pillay, 2006). In addition a major task of the new government in 1994 was to design a racially more equitable science education system in line with the trend of “Science for All’ which operates on the premise that all learners should have equal access to science education.

Numerous science teachers and researchers in South Africa (Ntuli, 2002; Odora, 2002; Malcolm, 2002; Onwu and Mosimege, 2004) and internationally (Aikenhead, 1996; Villegas, 2002; George, 1999b and Fensham, 1985) believed that science was not independent of culture. Hence as part of this reform, definitions of science in the curriculum were bound to change. In addition to acquiring basic scientific knowledge and the skills of scientific investigations, the new science curriculum expects learners to understand the complex relationship between science, society, technology and the environment (see Table 1: 38). Aikenhead (1994) argues that STSE types of science learning programmes promote goals as “Science for All” and “scientific literacy.” It would appear that the South African curriculum attempts to respond to these international imperatives by focusing amongst other things on the relationship between science, society, technology and the environment. For the teacher this would mean, how different contexts, and local realities, like the needs of the community, school and learners will be considered (DoE, 2002c). Accordingly indigenous knowledge generated by local people through their day-to-day experiences in facing challenges of nature and society became a part of the science terrain of the South African curriculum.

This added to the turmoil facing science teachers in developing contextualized curricula not only in terms of science processes but also in terms of the new component, IKS. During the early political transition period in South Africa, Brookes et al. (1993) claimed that in the context of post-apartheid political change, science teachers who were not trained as curriculum developers could serve as obstacles to change. The reality of such a claim was proved true when C2005 was introduced in South Africa in 1997, and there are more claims of the possibilities of implementation failure by its critics (Jansen, 1998).

Significant developments in research and policy are presented and critiqued here in an attempt to provide the context, which finally resulted in three fundamental curriculum changes that added yet more complexity to the lives of science teachers. According to Jansen (2001), the first change after democracy was the syllabus revision process of late 1994, which was an attempt to “cleanse” the curriculum of the racist, sexist and outdated contents of the apartheid syllabus. The second change involved OBE through C2005. As a result of confusion and flawed implementation processes at schools related to C2005 (Jansen, 1998; 1999), the government commissioned the third reform just three years into its implementation. The Review Committee established in 1999 affirmed the principles of OBE but called for "streamlining" of C2005, which resulted in the Revised National Curriculum Statement (RNCS) for General Education and Training phase (GET-Grades 1 to 9), which became policy in 2002 (Chisholm, 2003). The principles of C2005 for social and political redress, including the Critical Outcomes were retained in the RNCS, as was the expectation that teachers would design curriculum and assessment that would suit learners' local conditions. The committee recommended that for the Learning Area Natural Sciences, the Statement should include coverage of the nature of science, indigenous knowledge systems, the promotion of HIV/AIDS and the principles of sustainable development (DoE, 2000c). The NCS for Further Education and Training (FET-Grades 10-12) was published in 2003 and implemented at the Grade 10 level in 2006 and set for field integration for Grade12 in 2008 (DoE, 2002b).

In the FET band, the Physical Sciences and Life Sciences Learning outcomes are closely related to the Natural Sciences learning outcomes of the RNCS, drawing upon and building on the foundation laid by the Natural Sciences. This ensures continuity and further development of the skills, values and attitudes in the FET band. Physical Sciences and Life Sciences Learning Fields[9] have been included for learners to investigate the links between the IKS aspect in the GET and the FET bands. The next section proceeds to examine the Natural Sciences, Physical Sciences and Life Sciences National Curriculum Statements with a view of presenting details and analysis of only the IKS component as relevant to my study (see Appendix A).

### 2.2.7 Science National Curriculum Statements and IKS

South Africa's National Curriculum Statement for GET and FET is premised on the view that there are competing perspectives and worldviews from which to make sense of phenomena. Accordingly, elements of indigenous knowledges have been integrated into the discursive terrains of all subjects that form part of the National Curriculum Statement. This is explicit in the Natural Sciences Learning Area Statement:

[9] Since subject boundaries are blurred, dynamic and always responding to new and diverse knowledge the umbrella term Learning Field has been used to group "subjects" in the FET NCS.

> *"Through the teaching and learning of Natural Sciences we need to recognise that children and adults bring their own understandings of the world to the classroom. These "alternative conceptions" are widespread across age, gender and community, and are highly durable. Our teaching strategies need to recognise their existence and work with them"* (DoE, 2002a).

The three Learning Outcomes in the RNCS Natural Sciences are:

**Table 1: The Three Natural Sciences Outcomes of South Africa's C2005**

| | |
|---|---|
| **Learning Outcome 1 (LO1):** **Scientific investigations** | Learners act confidently on their curiosity about natural phenomena; they investigate relationships and solve problems in science, technology and environmental contexts. |
| **Learning Outcome 2 (LO2):** **Constructing knowledge** | Learners know, interpret and apply scientific, technological and environmental knowledge. |
| **Learning Outcome 3 (LO3):** **Science, society, technology and environment** | Learners are able to demonstrate an understanding of the inter-relationships between science and technology, society and the environment. |

In the Natural Sciences Learning Area processes and knowledge outcomes (Learning Outcome 1 and 2) are in parity with systems in other countries, for example UK and Australia (Pillay, 2006). The third outcome, "science, society, technology and environment" forges links between science education and technology education, embedded in social contexts relevant *for all students* (Fensham, 1985). LO3 gives the policy a South African flavour, by explicitly embracing the contribution of science to social justice, society, the environment and economic developments (DoE, 2002a; Ramsuran and Malcolm, 2004) and is important and relevant to this study. Whereas Learning Outcome 1 calls for problem solving of "closely-defined" problems, Learning Outcome 3 calls for the learner to become a "scientific problem solver in the context of South African society by thinking of ethical alternatives." Alternatives can come from completely new ideas, from adaptations of current ideas and practices in other societies, or by revisiting traditional practices and technologies (DoE, 2002a). In addition the National IKS Policy views transformation of a "content-driven" syllabus to a "problem-solving" one as creating impetus for the recognition of IKS systems (DST 2004:17). Often the focus of IKS is based on a range of activities that sustain a society and its environment, for example, meanings given to IKS by environmental educationists, O'Donoghue and van Rensberg (1999) are related to socio-ecological issues.

Although IKS is not spelt out in Learning Outcome Three, it is reasonable to assume that since notions of locality and science as a social construct are the central concepts of STSE programmes, IKS is embedded in LO3. However, indigenous knowledge and culture are clearly built into the assessment standards and illustrative examples and contexts under LO3. While the assessment standards are policy and teachers are required to cover all assessment standards during the year the supporting details and illustrative examples in the statements are not policy.

How teachers are expected to realise indigenous knowledge in the curriculum (Natural Sciences-senior phase) is made explicit through the following assessment standards of LO3 for the different grades (Department of Education, 2002a: 20-21):

> *"Understanding science as a human endeavour in cultural context* (Grade 7)."
> Achievement is evident when the learner, for example, compares differing interpretations of events (illustrative example).
>
> *"Learner identifies ways in which people build confidence in their knowledge systems* (Grade 8)."
> Achievement is evident when the learner, for example, describes ways in which traditional wisdom is accumulated and passed on (illustrative example).
>
> *"Learner recognises differences in explanations offered by the Natural Sciences Learning Area and other systems of explanation* (Grade 9)."
> Achievement is evident when the learner, for example, identifies sources and nature of authority of two differing explanations for an event, coming from two differing world-views (illustrative example).

The clearly defined assessment standards and illustrative examples serve as a form of leverage to ensure that teachers will embrace IKS. Progression is a key design principle of C2005 that enables the learner to gradually develop more complex, deeper and broader knowledge, skills and understanding in each grade (DoE, 2002a).

Progression is explicit in the above assessment standards, for example in Grade 7, learners have to evaluate different interpretations, in Grade 8 they are expected to analyse knowledge systems and in Grade 9 learners are required to identify, apply and reflect on different knowledge systems.

Similarly for FET Physical Sciences, it can be seen from table 2 that IKS is not spelt out in LO3, but is, in the assessments standards of Learning Outcome three which require teachers to embrace IKS in their teaching. However, the Learning programme guideline for Physical Sciences (2005) makes a note for teachers to recognise that indigenous knowledge systems (IKS) forms an integral part of Learning Outcome 3.

**Table 2: The Three Physical Sciences Outcomes of South Africa's C2005**

| | |
|---|---|
| **Learning Outcome 1 (LO1):** **Scientific inquiry and problem solving** | The learner is able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts. |
| **Learning Outcome 2 (LO2):** **Constructing and applying scientific knowledge** | The learner is able to state, explain interpret and evaluate scientific and technological knowledge and can apply it in everyday contexts. |
| **Learning Outcome 3 (LO3):** **Nature of Science and its relationship to Technology, society and the environment** | The learner is able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environment and human development. |

Regarding Learning Outcome 3, contexts have been suggested in the National Curriculum statement to support IKS learning. The Learning Programme Guidelines: Physical Sciences (2005) notes that since little appear in existing literature regarding IKS, teachers need to be innovative and design tasks that allow investigation of IKS.

The concept of indigenous knowledge to be implemented by teachers in the Physical Sciences Curriculum Statement is explored through the following assessment standards of LO3 (DoE, 2003a: 28-29). The Physical Sciences Curriculum Statement has examples of content and context, which provide opportunities to focus assessment on Learning Outcome 3:

> *"Recognise, discuss and compare the scientific value of knowledge claims in indigenous systems and explain the acceptance of different claim.* (Grade 10)."
> Learners are required to evaluate competing knowledge claims.

*"Discusses knowledge claims by indicating the link between indigenous knowledge systems and scientific knowledge* (Grade 11)."

Learners are required to evaluate competing knowledge claims.

*"Research, discuss, compare and evaluate scientific and indigenous knowledge system knowledge claims by indicating the correlation among them, and explain the acceptance of different claims* (Grade12)."

Learners are required to develop the skills to identify (from supplied data or a text or their own knowledge) the subject content they need to substantiate their arguments.

In the Physical Sciences Curriculum Statement progression is illustrated, for example, in Grade 10 learners are required to evaluate knowledge systems, in Grade 11 they are required to evaluate and synthesise knowledge claims and in Grade 12 in addition to the above they are expected to compare, connect and draw parallels between knowledge systems.

**Table 3: The Three Life Sciences Outcomes of South Africa's C2005**

| | |
|---|---|
| **Learning Outcome 1 (LO1):**<br>**Scientific inquiry and problem solving** | Learner is able to confidently explore and investigate phenomena relevant to Life sciences by using inquiry, problem solving, critical thinking and other skills. |
| **Learning Outcome 2 (LO2):**<br>**Construction and application of Life Sciences knowledge** | Learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences. |
| **Learning Outcome 3 (LO3):**<br>**Life Sciences, Technology, society and environment** | Learners are able to demonstrate an understanding of the nature of science, the influence of ethics and biases and the inter-relationship between science and technology, society, ***indigenous knowledge*** and the environment. |

It is only in the Life Sciences Curriculum Statement that IKS is obvious in the explanation of LO3 (Table3). In the section, "Sciences, Technology, Society and Environment" the statement makes clear reference to other science understandings, such as African indigenous knowledge systems, should also be considered by teachers (DoE, 2003b: 10).

LO3 addresses IKS in assessment standards 1 and 3 of LO3, raises awareness of the existence of different viewpoints of a multicultural society and encourages open-mindedness towards all viewpoints. The following assessment standards provide guidelines on the implementation of IKS in the curriculum (DoE, 2003b). Similar to the Natural Sciences Curriculum Statement illustrative examples are provided.

*“Exploring and evaluating scientific ideas of past and present cultures* (Grade 10, 11 and 12).”
Attainment is evident when the learner, for example: investigates various home remedies for nutritional disorders (G10).
Attainment is evident when the learner, for example: compares industrial production of fermented beer and/or food preservation in South Africa to the traditional method (G11).
Attainment is evident when the learner, for example: critically evaluates ideas on parental care during early childhood in various communities, eg. quarantine of mother and newborn baby immediately after birth (G12).

*“Comparing the influence of different beliefs, attitudes and values on scientific knowledge”* (Grade 10, 11 and 12).
Attainment is evident when the learner, for example: discusses the views of peers on cloning (G10).
Attainment is evident when the learner, for example: compares scientific ideas and indigenous knowledge of past and present cultures (G11).
Attainment is evident when the learner, for example: critically evaluates and takes a justifiable position on beliefs, attitudes and values that influence developed scientific and technological knowledge and their application in society (G12).

Similar to the Natural Sciences and Physical Sciences Curricula Statements, progression is evident in the assessment standards. For example in Grade 10 learners are required to investigate and discuss examples of IKS, in Grade11 they are required to make comparisons between systems while Grade 12 learners are required to justify and apply knowledge.

From the above tables (1, 2 and 3) it may be concluded that the assessment standards for the Physical Sciences and Life Sciences in the FET band ensures continuity by linking directly with Natural Sciences in the GET band. In the GET band assessments standards focus on describing, comparing and reflecting on different interpretations of events, while in the FET band they are required to build arguments and make judgements about competing knowledge claims, which allows for deepening and broadening of cognitive levels. Looking across all three Sciences Curricula Statements, Learning Outcome 3 explicitly allows for and accommodates the diversity emerging from the varied cultural experiences of the South African community.

The core knowledge statements in Chapter 5 of the Revised National Curriculum Statement for Natural Sciences represent a time allocation of 70%. Teachers are encouraged to view the remaining 30% of the time as available for extending the core and for curriculum development around contexts, which are significant to learners and the local community (see appendix A). There is a clear articulation of relating science knowledge with the context of learners' lives, and of thematic links within the science discipline throughout the document. Thus spaces are created for "inclusiveness" of, for example, African knowledge, African rural experience and indigenous knowledge. According to Karikan and Ramsuran (2006) IKS has to be legitimated as "high knowledge, high skills" before it can claim a rightful place in the school curriculum. Questions raised may be: What is "high knowledge, high skills" and to whom? How might teachers achieve this?

LO3 is a demanding outcome for teachers with the potential to broaden the curriculum and make it distinctively South African. This can only happen if teachers have knowledge to implement IKS. In no way am I implying that IKS is a system of cultural knowledge that can simply be acquired and implemented in the curriculum. Naidoo (2002) argues that indigenous knowledge emerges from the interactions between people (the knower) and their environment (the known) and that indigenous knowledge cannot be handed over ready-made, but has to be appropriated by the knower. This argument is further explored in Chapter two under section 2.3.2 "Meanings and Kinds of Indigenous Knowledge"

Teachers who attempt to implement IKS may encounter difficulties, for example, IKS has been introduced for the first time in the curriculum; the fact that teachers have been schooled in western science and hence are more familiar with that worldview and may not have knowledge of IKS and they may follow traditions and customs that are not shared by their learners. Although the curriculum documents provide clear guidelines in the form of assessments standards there seem to be some gaps, especially in terms of practical implementation. The policy discusses the need to include IKS into the science curricula, but does not propose how an "IKS in science"[10] curriculum could be implemented. Therefore the task of creating alternative more culturally sensitive routes and redefining content might not be obvious or taken for granted.

The RNCS Natural Sciences makes reference to alternate forms of knowing:

> *"science cannot necessarily be seen as the only way of making sense of the world around us. Other cultural means of clarifying the world, such as through language, and religion or art, should be seen as a validity and benefit, just as science has (DoE, 2002a:5)."*

There is an explicit demand that the presence of multiple worldviews, contained in indigenous knowledge systems (IKS) of South Africa's "rainbow nation"[11] be recognized and valued (see Appendix A). Although the Curriculum Statements as well as the Teachers' Guides acknowledge "Other" ways of knowing, there is no guidance on how to accommodate the notion of "alternative ways of knowing." Addressing alternative explanations of scientific phenomena and worldviews might result in conflict. Does this absence presuppose a lack of conflict when alternative forms of knowing are presented in the classroom? Or is the method of dealing with conflicting knowledge systems left to the classroom teachers? However, the usage of "This is a challenging Learning Outcome" in the Natural Sciences document does

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[10] Writers use a range of concepts such as multicultural science, multisciences, cross-cultural sciences, and science-IKS. However, this research will use the concept "IKS in science" when referring to the inclusion of IKS in the science curriculum.

[11] The term was intended to encapsulate the diversity of South Africa's cultural, ethnic or racial groups after apartheid.

give an indication that including worldviews in the classroom is not a straightforward task (DoE, 2002a: 10).

This policy amongst other things envisages teachers as researchers of indigenous knowledge. This places tremendous demands on teachers both in terms of their philosophical orientations and the conceptual demands of indigenous knowledge. How would teachers explore the underlying structures of these knowledge systems considering that science teachers in South Africa are of diverse origins, cultures, races, different genders and teaching in different (urban and rural) contexts? It is the question of how teachers would deal with these concerns in the classroom that is of interest to this study.

Robbins (1990) states that schools which, in response, alter their curricula in order to be able to recognise the merit of students who have been differently socialised, will find that they become marginalised as institutions because they are perceived as having "poor standard." This is a worry that is also indirectly identified in the Natural Sciences Curriculum Statement (DoE, 2002a: 12):

> *"Is it (to include both world views in the curriculum) a hindrance to teaching or is it an opportunity for more meaningful learning and a curriculum, which tries to understand both the culture of science and the cultures at home?"*

The preceding analyses of the Natural Sciences, Physical Sciences and Life Sciences Curricula Statements clearly indicate that IKS is now expected to be part of the *content* of the sciences. This recognisation of IKS has profound implications for assessments. Analysis of the exemplar of the National Senior Certificate (DoE, 2008) examination papers has revealed that there were only two questions on IK in Life Sciences paper 2 while the Life Sciences paper 1 did not have a question on IK. 3.3% of the marks in paper 2 were allocated to aspects of IK. The first question on creation required explanations on different ways of knowing. The second question was based on the usage of leaves of the Neem plant as a natural pesticide by Tanzanian farmers. However, this question unlike the question on "creation" did not include alternate ways of knowing or competing perspective, for example a question on artifical pesticides. In the 2008 exemplars for Physical Sciences, that` is, paper1 (Physics) and paper 2 (Chemistry), IK did not feature probably because examiners did not think it important or did not know how to assess IK.

Attempts to include IKS within the science curriculum is not unique to South Africa and similar attempts have been made in many other African countries (Tanzania, Kenya, and Botswana) Canada, USA, Australia, as well as Central and South American countries (Aikenhead, 1997; Corsiglia and Snively, 2001; Michie and Linkson, 2005). The outcome of some these studies will be discussed later on in this chapter.

In South Africa there exists profound enthusiasm and deliberate propositions to include indigenous knowledge systems in education (South Africa, 1996; National workshop on indigenous knowledge, 1998:1; Higgs and Van Niekerk, 2002; Odora, 2002). However, policy and enthusiasm alone are insufficient to bring about this change. How will teachers enact this government mandate against the challenges discussed above? My study attempts to explore this issue.

Having shown IKS expressed in curriculum reforms it is necessary to interrogate IKS itself, its emergence and the challenges that emerges from its recognisation in national curriculum reforms.

## 2.3 (DIS)CONNECTIONS BETWEEN WESTERN SCIENCE AND IKS

Bringing IKS into a national science curriculum introduces some major foundational conflicts between western science and IKS.

### 2.3.1 <u>Redefinition of Science</u>

To some of the earliest philosophers such as Mach and Popper western science was the only knowledge and any system of knowledge that was not compatible with the former was considered a myth (Cobern and Loving, 2001). Colonisers had a similar view and denied IKS the status of knowledge (Maurial, 1999) because those that were colonised, the “others” were regarded as devoid of knowledge. In recent years this view has been countered by Cobern (1993) who argues that there is “no people or culture without science.” Kyle (1999) supports Cobern’s view in that a foundation principle of post-modern theories is that there is no universal knowledge; rather there are multiple knowledges. In light of the above argument this means that, “IK is knowledge.”

Horsthemke (2004) argues that for something to be referred to as knowledge it must be valid, legitimate and warranted. The implications of Horsthemke’s definition, is that if something is referred to as “indigenous knowledge” it must meet the requisite criteria: belief, justification and truth and if it does, it is on par with non-indigenous knowledge (western).

A major point of debate with respect to IKS is whether modern science should be the starting point for legitimatising IKS or whether it should exist in it own right without trying to justify itself in terms of other knowledge systems. Some researchers (Onwu and Mosimege, 2004; Ntsoane, 2005 and Odora, 2005) argue that what renders IKS logically and epistemologically dubious is the fact that IKS possesses a “cultural logic of its own” that is often ignored. The science-centred approach poses a fundamental threat to indigenous knowledge. When screened on the sole basis of value to science, knowledge judged useful is selected and the remains are discarded as superstition and belief. When IK is codified and translated for classroom science the concealed aspects of certain practices that are wrapped around in myths and spirituality remains invisible and is often ignored. For teachers to treat IK as such trivialises it and shows disrespect to those who hold such knowledge. Such a process also dismembers, demeans and undermines the knowledge system, jeopardizing its continued existence. By “mining” these systems for short-term intellectual gain, the social and cultural foundations are undermined thereby threatening the traditional societies that embrace them.

From the literature it is evident that there are various ways in which IKS is accepted as legitimate knowledge. Different criteria exist for accepting any knowledge as valid knowledge, which lead to questions like: Valid by whom? For whom? And for what purpose? Firstly, scientific validation is done by science experts and scientific literature to determine the scientific rationality and comparability of IKS with the principles of science (Sidhu, et al 2007). Secondly, the meaning given to social validation by Sidhu, et al (2007) is that validation is done by local experts, and key informants from the community. Thirdly, a concern raised by the Science and Technology Portfolio Committee (2004) is that validation of indigenous knowledge should be viewed as a two-way process. Indigenous knowledge could validate other knowledge systems, as much as it could be validated by such other systems. Fourthly, while some proponents of IKS argue that IKS is different from western science and should be validated on its own terms, the World Bank is calling for the development of innovative protocols for the validation of IK (http.www.Worldbank.org/afr/if/what/htm). The preceding discussions demonstrate that validation of IKS is becoming an extremely difficult and daunting affair. Therefore the dilemmas for establishing indigenous knowledge as part of school curriculum provides a forum for "on-going debate about the production of knowledge, what knowledge is of most worth, whose knowledge is of most worth and what constitutes official knowledge" (Apple, 1993).

Since a challenge of bringing IKS into the curriculum is foundational, it is necessary for this research to examine different meanings and kinds of IKS, meanings of science, nature of science and the relationship between science and IKS.

### 2.3.2 Meanings and Kinds of Indigenous Knowledge Systems

Indigenous knowledge develops from the associations between people and their environment (Naidoo, 2002). Shava (2004) who borrows and builds from Horsthemke (2004) describes three kinds of IK:

(a) propositional knowledge - this is factual knowledge accumulated by local people such as knowledge that a plant is poisonous, can cure a certain ailment, or is edible (it is this aspect of indigenous knowledge that is usually underplayed in its representation);

(b) practical knowledge (know-how) - this is process knowledge or capabilities (skills) such as how to make arrow poison, a mat or basket, a hoe handle, beer or food; and

(c) knowledge of the context (knowledge about) - this comes from familiarisation/naturalisation over time such as knowledge of where certain plants and animals occur in the geographic terrain, what season certain fruits and vegetables occur, or where to find water.

The following section attempts to clarify the concept of indigenous knowledge systems with reference to the literature.

A number of critical questions have been raised about indigenous knowledge, namely what is understood by “indigenous”? What type of “knowledge” is presupposed in the expression “Indigenous Knowledge Systems”? How must one understand the concept “system”? (Maurial, 1999; Odora, 2002 and Wallner, 2005. In international contexts “indigenous” is often taken to be similar to “traditional”, “vernacular”, “aboriginal”, “native American” or merely “African” or “Black”. The term “indigenous” is often explicitly understood as the opposite of “European” (Loubser, 2004).

From its origin, the word “indigenous” has been loaded with ideological connotations. Its coinage is inextricably linked with colonialism. Colonial history has taught us that all the non-conquering people (non-Europeans) are indigenous (Maurial, 1999). Viewed through the eyes of the colonisers, indigenous people are the “losers,” those who lack power and power defines knowledge. Therefore the colonisers denied recognising the beliefs and values of indigenous people to the status of “knowledge.” The terminology, “indigenous or traditional” entails something of the past, something static, not creative and innovative (Maurial, 1999). According to Semali and Kincheloe (1999) such a return is impossible, as all cultures are perpetually in a state of change. There is therefore a constantly global culture in creation. This universal cultural heritage is literally shared as common property by all people (Prah, 1999). Any study of indigenous knowledge in education must therefore allow for its evolution and ever changing relationship to Eurocentric scientific practice.

The word *system,* gives rise to images of separate individual components acting in concert together. When used in conjunction with the words *indigenous knowledge* as reflected in literature, the same connotative image is induced (Reynar, 1999). Reynar further argues that it is commonly misunderstood that indigenous knowledge can be *“dissociated from the people, beneficially altered, called indigenous knowledge once again, and then re-taught to the same people”* (p300). For him this does not recognize the intertwined and symbiotic relationship between the knowledge and community in which it resides.

Despite the increasing attention that indigenous knowledge is receiving it has not yet led to a unanimous meaning of the concept. Although many researchers and educationists have a very good understanding of IKS, some are still asking the question: “But what is IKS?” The greatest challenge to answering the question is to present IKS alongside western science without devaluing one system over the other. For this reason different approaches of exploring the meanings to IKS are presented. According to Battiste (2002), Eurocentric scholars have taken three main approaches to IKS. In all of these approaches IKS has been understood as a binary opposition to scientific, modern or Eurocentric knowledge.

According to her classification, in the first approach, western scholars have tried to reduce it to taxonomic categories that are static over time, handed from one generation to the next, unchanged. The approach focuses on identifying knowledge, practices and techniques used as well as recording their local names, and cataloguing their reported uses. The approach underscores the superiority of Eurocentric knowledge and its classification and the apparent inferiority of IKS. For her, the second approach to IKS is the commercial value of IKS to scientists and its empirical content. To treat IKS as only empirical knowledge trivialises its significance to the custodians of this knowledge. She further argues that the third approach has gone in the opposite direction, abandoning any concern for empirical validity and treating IKS as purely normative or spiritual and superstitious. The preceding discussion illustrates the challenges defining IKS within a Eurocentric framework.

After a survey of the major works in the field the political scientist Agrawal (1995) criticised attempts to separate IK and scientific knowledge. He argues that there are three sorts of grounds that have been used to effect this demarcation focusing on the differences between scientific and indigenous knowledge:

> *“substantive grounds: because of differences in the subject matter and characteristics of indigenous and western knowledge;*

> *methodological and epistemological grounds: because the two forms of knowledge employ different methods to investigate reality and*
>
> *contextual grounds: because traditional/indigenous knowledge is more deeply rooted in its environment"* (Agrawal, 1995: 415).

Agrawal (1995) questions both the possibility and desirability of drawing a sharp distinction between science and indigenous knowledge on the above grounds. According to Agrawal, science cannot be separated from "traditional" knowledge on substantive, methodological, epistemological or contextual grounds. Moreover, he stresses, for the sake of keeping a fruitful "dialogue" open, there should not be a fixed demarcation between indigenous knowledge and modern science.

Giving meaning to indigenous knowledge is therefore enormously difficult, partly because, of the very fact that the category is an invention of colonial history and continues to be affected by the ongoing de-colonization processes. Despite these difficulties some of the meanings of indigenous knowledge in the South African literature are presented as part of a larger agenda of "reclaiming knowledge systems" denied, suppressed or distorted during colonial and apartheid education.

However, Giddens (1991) uses the ramifications of modernity to explain the loss of knowledge (IKS) and identity. He argues that in modern societies reappropriation and self-identity becomes an inescapable issue, indicative of social phenomena or trends towards development. Changes, he maintains, stem from social influences, that is, the demand for the change comes from everyday life and that major transitions occur in everyday life in the character of social organizations and in the structuring of global systems.

He uses the example that while earlier societies with a social order firmly based on traditions would provide individuals with clearly defined roles, in post-traditional societies we have to work out our roles for ourselves. Changes stem from a mesh of both individual (micro) and global forces (macro). Globalisation has to be understood as a dialectic phenomenon. Events at one pole often produce divergent or contrary effects on another. No one can opt out of the transformations brought out by modernity.

### 2.3.3 IK in South Africa

The White Paper on The Conservation and Sustainable Use of South Africa's Biological Diversity (1997: appendix 2) defines indigenous knowledge of biological diversity as:

> *"A body of knowledge built up by a group of people (from different **communities and places**) through generations (**time**) of living in close contact with nature. It is both cumulative and **dynamic,** building upon the experience of earlier generations and **adapting** to the new technological and socio-economic changes of the present."*

This understanding of traditional environmental knowledge as "cumulative and dynamic" is key, for it encompasses both the intense and long-term relationship that people have had with their environment and allows that knowledge to become "updated" in a rapidly changing world as new information is acquired.

This non-racial description, in accordance with the opening statement of the Freedom Charter[12] that South Africa belongs to all its peoples emphasizes the creative and dynamic nature of IK.

Odora (2005:2) describes IK as, "*knowledge that is held and used by a people who identify themselves as indigenous of a place on a combination of cultural distinctiveness and prior territorial occupancy relative to a more recently arrived population with its own distinct and subsequently dominant culture*." This meaning of IK places it in descriptors of western cultures (dominant) and such meanings of IK, are not desirable for the rationale for the inclusion of IK in the science curriculum.

[12] Freedom Charter declares that *South Africa belongs to all who live in it, black and white* and amongst others address equality, social justice and human rights.

The meanings of IK in the three curriculum policy documents, central to this research are examined. The NCS Physical Science (Grades10-12) refers to indigenous knowledge systems in the glossary to "a *body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years*" (see appendix A). The NCS Life Sciences Grades 10-12 refers to indigenous knowledge in the glossary as "*knowledge that has been produced by groups of people living in an area for a long period of time"* (DoE, 2003b: 64).

The Revised National Curriculum Statement for Natural Sciences makes the following reference to IK: *"Indigenous or traditional technologies and practice in South Africa are not just ways of working; they are ways of knowing and thinking. Traditional technologies and practices often reflect the wisdom of people who lived a long time in one place and have a great deal of knowledge about their environment"* (DoE, 2002a: 10).

These definitions in National Curriculum Statements are rooted in time and space. The meanings are written in the past tense and reference is made to 'evolved" and "produced" and "wisdom of people who lived a long time" implying that IK has no relevance for the present. It is important to realize that there is more to IK than the repetition, from generation to generation, of a relatively "fixed" body of data.

The meanings given to IK in the three documents do not account for the dynamism and creativity when different cultures mix, an issue that is pertinent in the present, post-apartheid South African context. Therefore for this study the most appropriate meaning of IK is that of the White Paper on The Conservation and Sustainable Use of South Africa's Biological Diversity (1997) since it is a non-racial description, recognizes fluidity and adaptability, time and place as the main defining characteristics of IK.

LO3, in the sciences curricula statements besides including science, society and technology encompasses the environment. According to the National IKS policy (DST, 2004: 5) IKS's focus on "environmental knowledge" is significant since *"IK has always been and continues to be the primary factor in the survival and welfare of the majority of South Africans."* Therefore it is relevant that I present some meanings of indigenous knowledge in environmental settings: Chavunduka (1995) in O'Donoghue and van Rensburg (1999: 92) suggests that IKS:

> "*refers to African history, African cultural heritage and African customs as developed in direct response to the physical and social realities in this part of the world.*"

In the same document, O'Donoghue and van Rensberg (1999: 94), add:

> *"Indigenous knowledge processes are seen as any responsive and sustaining symbolic capital, historically grounded and characterising a common-sense life-world amidst local people in particular socio-ecological settings around the world."*

Clearly, from the usages of "developed in direct response" and "responsive" IK is seen as changing and open to change, in response to changing circumstances within different social settings.

There is an array of components in IK and in summarizing the most important elements of IK from the above discussions it may be concluded that:
IK is the product of a dynamic system; it is the context of the knowledge that determines its value or bias; it is a part of the physical and social environments; it emphasizes locality and is of value to the community.

These definitions raise the issue of whether indeed all knowledge belongs to one or another indigenous system. Kyle (1999) argues that western science itself is an indigenous system, rooted in western philosophies and culture. From the above argument it follows that the relationship between IKS and science in the classroom are not between a particular "local knowledge" and a "universal knowledge", but between alternative forms of indigenous knowledge developed in different cultural traditions.

The next section examines the implications that the emergence of IKS in the curriculum had on the meanings and nature of science and on the complex relationship between the two knowledge systems.

### 2.3.4 Meanings of Science

Learning science, according to Lemke (1990:1) means learning to *"communicate, reason and problem solve, in the language of science and to act as a member of the specific practice."* Ogawa (1995: 588) directs science educators towards a broadly inclusive conceptualisation of what science is by defining science simply as "a rational perceiving of reality", where *"perceiving means both the action constructing reality and the construct of reality."* The word "perceiving" gives science a dynamic nature and acknowledges that science can experience gradual change at any time. Ogawa's (1995) claim that people have different ways of perceiving reality implies that there is not just one science but also "many sciences."

Snively and Corsiglia (2001:10) view is closely aligned to that of Ogawa and argue that, "every culture has its own science" something like its own way of thinking and or its own worldview. Cobern (1996) supports this view by claiming that, "if science is taken to mean the casual study of nature, then of course all cultures at all times have their own science." When western modern science (WMS) is defined as universal (Corsiglia and Snively, 2000) it displaces revelation-based knowledge (i.e., creation science) and it also displaces pragmatic local indigenous knowledge that does not conform to formal aspects of the "standard account." Therefore it may be argued that western or modern science is just one of many sciences that need to be addressed in the science classroom.

The Natural Sciences RNCS (2002a: 4) define what is today known as science from the nature of science viewpoint as:

> *"to understand the natural world through observation, codifying and testing ideas, and has evolved to become part of the cultural heritage of all nations. It is usually characterised by the possibility of making precise statements, which are susceptible to some sort of check or proof. They promote reproductibility, attempts at objectivity and a systematic approach to scientific inquiry. Repeated investigations are carried out."*

The Physical Sciences NCS focuses "*on investigating physical and chemical phenomena through scientific inquiry and by applying scientific models, theories and laws it seeks to explain and predict events"* (DoE, 2003a: 9).

The above definitions and close examination of learning outcomes and assessment standards prescribed by the RNCS and NCS reveals a definition that is heavily "positivist, mechanistic and behavioural" and centred on the "basics" from the Physics, Chemistry, Biology and Geology. Overlays of Science, Technology and Society are added, but with science continuing to be a definable entity (Malcolm, 2001b). The RNCS Natural Sciences and the Physical Sciences NCS discuss how empiricism has been remarkably effective in generating accurate and reliable knowledge about the natural world. It is challenged by those who argue that empiricism is too limited a way of understanding the world. Therefore the inclusion of IKS in the science curricula requires a redefinition of western science true to the claims of Ogawa (1995), Cobern (1996) and Corsiglia and Snively (2000).

How then should school science be labeled? Many writers (Cobern and Loving, 2001; Ogawa, 1995; Snively and Corsiglia, 2001; Stanley and Brickhouse, 1994) use the term Western Modern Science or Western Science (in uppercase) to refer to the version of science found in standard science textbooks. The adjective Western is used to denote two things. The Standard Account of science called "Western" highlights the view that modern science had its historic origins in Ancient Greek and European Culture. Needham (1969), however, argues that although modern science was born in Europe, people of Asian cultures helped to lay the foundations of mathematics and science and set the stage for decisive breakthroughs that came about in a favourable social and economic milieu of the European Renaissance. Second, and more contentiously, the use of the word "Western" signifies the author's contention that there are other, alternative sciences besides "Western" science. Using the term "modern science" to refer to the "standard textbook science" seems to be more appropriate because it denotes that people from non-western cultures have made significant contributions to a modern understanding of the natural world and is also broad enough to encompass the claim that there is no unified science. However, for the purpose of this study the terminology western science (in lower case) is used to avoid confusion and since this term is used by most of the international scientific community.

Meanings of science are often evident from a nature of science viewpoint and therefore it is important to examine the nature of science.

### 2.3.5 Nature of Science

Esteemed science authorities have been wrong many times in history in claiming science as the complete and absolute truth. Changes in science are inevitable because new observations may challenge prevailing theories leading to amendments and improvements.

Wang and Schmidt (2001) claim that there is no fixed set of steps that scientists always follow, no one path that leads them unerringly to scientific knowledge. There are, however, certain features of science that give it a distinctive character as a mode of inquiry. There is a heavy reliance on evidence, the use of hypothesis and theories to draw conclusions. In fact, the process of formulating and testing hypotheses is one of the core activities of scientists.

Science cannot provide complete answers to all questions. However, accurate approximations can be made to account for the world and how it works There are, also beliefs that by their very nature cannot be proved or disproved, such as the existence of supernatural powers and beings, or the true purposes of life (Naidoo, 2002). In other cases, a scientific approach that may be valid is likely to be rejected as irrelevant by people who hold to certain beliefs (such as miracles, fortune-telling, astrology and superstition). Blades (1996) offers lessons on the handling of issues that seem to be deeply rooted in religion. This provides teachers with an opportunity to open up discussions on the limits of science and the value of religious responses to such profound questions.

### 2.3.6 Relationship Between Science and IKS

The relationship between science and IKS is a much-contested subject in the literature. Debates abound as to whether or not non-western systems of knowledge about nature (IKS) could be considered science. Some proponents of IKS (Leeuw, 2004; Kraak, 1999) claim that the rationality of IKS is similar to that of western science and that it may therefore be equated with science while Visvanathan (1997) and Horsthemke (2004) argue that all forms of knowledge are valid and should co-exist in a dialogic relationship. For Feyerabend (1984), IK is science because it functions. If science is understood in the most generic sense of the term, as suggested by Goonatilake (1984:1) when she defines science "as the search for valid explanations of physical reality," then, perhaps IK can be understood as science. However, she makes a distinction between this "science" and science as originally conceived by Francis Bacon and the science at sites of higher learning. It seems that she makes this distinction because she perceives IKS as a "kind of science" but not equivalent in status to western science.

Corsiglia and Snively (2000) are of the belief that IKS offers important science knowledge that western modern science has not yet learned to produce. Also, like Stanley and Brickhouse (1994) their interest in IKS goes much deeper and they assert that the inclusion of traditional ecological knowledge and IK in the science curriculum will better serve the needs of all students, both western and non-western students, who must solve problems during times of environmental crisis.

Silva's (2003) view is that western science has become a "universal science" not due to its superiority over the other sciences but because of the sponsorship of western colonialism. He further argues that in order to hide this fact an entirely new discipline, called the "philosophy of science" has been created in the academia whose purpose is to show that western science (universal and omnipresent) has a philosophy and a methodology (scientific method) of its own that is not found in other systems of knowledge. The existence of a sub-system of knowledge called the philosophy of science, dealing with western science and not any other sciences shows the value attached to the status of western science.

Willams (1999), a strong proponent of the modernist view proposes an opposite view, that to include cultural and ethnic beliefs and experience under the rubric of science would in fact do violence to science. Cobern and Loving, (2001) have a more moderate view and feel that knowledge gained outside of western modern science should not be included in the school science curriculum because too often science dominates all other discourses. Cobern and Loving, (2001:50) further argue that indigenous knowledge is better off on its own so that it can be "valued for its own merits and it would make much more sense to talk about multiple domains and types of knowledge, with differing logics and epistemologies," while other philosophers of science such as Carnap, Grunbaum and Lakatos have long abandoned the hope of a satisfactory methodology for distinguishing science from non-science (Agrawal, 1995).

The Natural Sciences, Physical Sciences and Life Sciences Curriculum Statements do not resolve the issue of whether IKS is science. In fact it is silent on the nature of IKS. This silence might be interpreted in two ways. Is the policy suggesting that IKS is science because the science learning area has been chosen as one of the homes of IKS or could it be that the normally lower status accorded to IKS is raised if it is couched in the context of high-status science? If western scientists can acknowledge that IKS has made genuine contributions to ecology and other practical sciences then, it satisfies the characteristics of what counts as "science knowledge."

To refer to the relationship between science and IKS in the classroom the term "IKS in science lessons/curricula" are used which necessitates providing clarity of its' meaning. For Ogunniyi (email 29/11/08) science-IKS lessons/curricula or IKS-science lessons/curricula denotes the same thing. Using these terms interchangeably may have implications because it can be argued that a science-IKS lesson means something different from IKS-science lesson. In science-IKS lessons/curricula science is dominant while in IKS-science lessons/curricula IKS is dominant. If IKS was a Learning Area, which featured in the school curriculum then using IKS-science would be justified. But science is the Learning Area in C2005, which mandates that science teachers include IKS with science. This suggests elaborating the latter *(IKS)* with the former (*science*) hence the preference for "IKS in science" lessons/curricula.

### 2.3.7 Studies including IKS and Western Science

Returning to a review of literature reveals that research on the topic of IK and pedagogy is limited in depth and scope in the South African context, but attempts have been made internationally to include indigenous knowledge and understandings in the science curriculum. Studies including IKS as part of the science curriculum focus on learners in some studies (Jegede, 1999), on teachers in others and on the curriculum in a few of the studies (Jegede and Aikenhead, 1999).

Examples of a studies that focus on curricula, are the curricula designed for the North American Indians, the Aboriginals of Australia and the Maori of New Zealand. These curricula have not fully succeeded and the main reason for the failure was that the programmes tended to treat learners who come from indigenous cultures as tabula rasa[14] (Bishop, 1990; Van Wyk, 2002; Ogunniyi, 2005; May and Aikman, 2003).

Studies that concentrated on teachers focused on why non-indigenous teachers do not include IKS in the science curriculum (Silva, 2003). It was found that there are various reasons for this, one of which is that teachers feel they should not include IKS since they are not Aboriginal (indigenous). The second reason provided is that many science teachers do not feel that IKS is science. Silva (2003) argues that the dominance of western science has contributed to such an attitude. In addition, many do not know how to get started or how to go about bringing indigenous knowledge into science (Thompson, 2004). Teachers in South Africa may experience similar obstacles since neither the NCS policy documents nor the Teachers' Guides provide this information and teachers have not observed "IKS in science" lessons being implemented.

The main advances in introducing IKS in its education for minority indigenous people in the western world, is for example, the Maori Education System. Jones and Hunter (2004) reported that schools in the Maori Education System use a learning model to include indigenous education, which seeks to foster the recognition that all people are bound to be dependent upon local ecosystems. The implementation of this learning

[14] tabula rasa – treatment of learners like empty vessels with nothing to offer.

model depends on enlisting local experts, and elders as collaborating educators who utilise traditional Maori methods of knowledge transmission, visual and oral, with liberal use of metaphors. Since the Natural Sciences Learning Area Statement recognises that the people of South Africa operate in a variety of learning styles such indigenous educational approaches may be of significance in South Africa where resources for teaching IKS are scarce or unknown.

Research focusing on curriculum in the Arctic Region has shown that minority pupils suffer in primary schools that are designed to suit the majority (Todal, 2003). The researchers in the Arctic approached this question with the assumption that the school system (curriculum) was at fault, not the students. Based on this assumption, they raised questions regarding the content of the curriculum and questioned the traditional school definition of the concept of “knowledge” itself. In order to rectify the situation, researchers proposed the creation of a separate school system for indigenous peoples. Such infrastructures were built in Alaska, Canada, Greenland and in the Sami area in Scandinavia (Todal, 2003). In order to accomplish this separate system, educational institutions were set up to produce textbooks, establish and develop curriculum, conduct research and provide teacher education for indigenous students. According to Todal (2003) although the number of indigenous students enrolled at Canadian universities has increased significantly over the past two decades, student retention and completion rates still remain fairly low. This approach of creating separate schools for indigenous students characterized apartheid education in South Africa where separate schools were established for different race groups. However, in South Africa the curriculum was designed on dominant western cultures to suit the minority, making the majority “victims” in the system.

Although Saskatchewan has initiated a curriculum review for public schools, the priorities that the province has articulated have largely been add-on processes, not affecting core learning (Aikenhead, 1997). Science teachers respected Aboriginal knowledge, yet only a token amount was added to school science and the fact that it is still an elective and that it is not mandatory to include IKS leaves this curriculum as such, an add-on option, instead of a fully integrated one.  In South Africa IKS is part of the National Curriculum, and expected to be taught to all learners.

An innovation in including IKS into curriculum and pedagogical practices is provided by “Alaskan Standards for Culturally Responsive Schools” and “Guidelines for Respecting Cultural Knowledge.” The Alaskan Standards (Barnhardt and Kawagley, 2005) are curricula guidelines that are democratic, inclusive, and comprehensive and clarifies ways in which indigenous knowledge may be adapted to local needs. Each school, community, and related organization is required to review these standards, determine their appropriate application and devise new standards to fit local circumstances. Barnhardt and Kawagley (2005) argue that the newly devised standards are not an attempt to standardize or homogenize heritages, but a means to nurture and build upon “rich and varied” cultural traditions. In South Africa too, there are many ethnic groups, so to impose the IKS of one ethnic group on another can be just as oppressive as imposing Eurocentric knowledge on African learners. For the curriculum to be relevant it must speak to the unique culture of the group.

One well-known example of a national effort to indigenize the curriculum in Africa was Education for Self-Reliance (ESR) in Tanzania (Semali, 1999). Though not completely successful, this initiative aimed to localize the curriculum in Tanzania by emphasizing practical rural-oriented education (Semali, 1999). The program of ESR was more ideological than pedagogical for the political view at the time of its formulation was that western forms of education had caused much “damage” to African traditional ways of learning and teaching, and therefore needed to be de-emphasised (Semali, 1999). Although the re-introduction of indigenous education in formal schooling were undertaken in Botswana, Kenya, Guinea, Uganda, Zaire, Zambia and Zimbabwe, nowhere has the “traditional” African education component become as apparent in policy documents as it was in ESR (Fafunwa and Aisiku, 1982).

In introducing IKS in the science curriculum it becomes necessary to examine the knowledge and practice of science teachers since these determine to a large extent how they respond to educational reform (Duffee and Aikenhead, 1992). The underlying assumption is that science teachers’ knowledge and beliefs are critical determinants of how they teach and respond to educational innovations, for example, teaching of science in which IKS is elaborated.

## 2.4 TEACHERS' SCIENCE KNOWLEDGE, PRACTICE AND IKS

There is little literature on teachers' knowledge of IKS for the science classroom. Some general findings from studies where IKS is presented as part of the science curriculum in the UK, USA, Australia and South Africa have shown that science teachers generally do not hold valid understandings of the nature of science and IKS or possess adequate knowledge or instructional skills to implement "IKS in science curricula" (Aikenhead, 1997; Aikenhead and Jegede, 1999; Harlen and Holroyd, 1997; Dekkers and Mnisi, 2003). By interrogating the extensive literature on teachers' knowledge of science we might begin to anticipate some of the challenges that teachers have when they have to teach a curriculum that is not readily available to them.

The concept of teacher knowledge is examined as it forms the backbone of teaching and learning. The domains of *science teachers' knowledge* (knowledge of the science subject-matter to be taught) together with some aspects of *pedagogical knowledge* (knowledge of how to teach) are then reviewed.

Various labels have been used for teacher knowledge in literature, each indicating a relevant aspect of this knowledge for example, *personal knowledge* (Connelly and Clandinin, 1985) *tacit knowledge* (Eraut, 1994) and *professional craft knowledge* (Shimara, 1998). Teacher knowledge may have a range of origins, including school experiences in the past, initial teacher education, practical knowledge of day-to-day experiences and continued professional development. Wallace (2003:8) argues that the development of teacher knowledge is a gradual process of *"tinkering and experimenting with new classroom strategi*es*, trying out new ideas, refining old ideas, problem setting and problem solving. The new experiences can disturb old experiences, hence, new structures arise and teachers' knowledge change over time."*

The following section examines subject content knowledge, which according to Shulman (1987) is the understanding of subject matter *per se* on science teaching.

### 2.4.1 Science teachers' subject-content knowledge

It is common for teachers in the UK, elsewhere in Europe and in South Africa to teach subjects that did not feature strongly in their own education. Researchers, such Golby et al (1995) and Parker (1985) argue that it does not matter if teachers do not have an extensive knowledge of science because they would acquire the knowledge when they prepare their lessons. If we accept this argument then, on the one hand it is reasonable to assume that science teachers in South Africa with weak or no knowledge of IKS might make it good in preparation for lessons. On the other hand teachers' lack of science knowledge might impact on their inclusion of IKS in the curriculum.

On the other end of the continuum, Shulman (1986) and Hollon et al (1991) maintain that subject content knowledge is a crucial part of a teacher's repertoire, that guides "planning, shapes the content and presentation and increases a teacher's confidence and fluency" in responding effectively to comments, questions, discussions and explanations. Darling-Hammond (2000) agrees that although content knowledge is important to effective teaching, it is pedagogical knowledge that exerts a greater influence on the overall teaching performance, guiding questioning techniques ideas and critical reflections. An important aspect that I see emanating from Darling-Hammond's (2000) argument is that it does seem reasonable to assume that science content knowledge can facilitate or enable content-related discourse. However, content knowledge must be seen as a means to an end, and not an end in itself, as teachers may have sufficient content knowledge but lack science pedagogical knowledge.

Researchers such as Newton and Newton (2001); Hickey (1999); Hogan et al (2003) and Smith and Neale (1989) found that amongst other things science teachers with less content knowledge had limited confidence, which resulted in narrow lesson objectives and an undue emphasis on the transmission of factual information. Would South African teachers resort to similar tactics if they do not have the content knowledge to teach "IKS in science" lessons? Or would they be able to transform "western science" content by drawing on their pedagogical knowledge into forms that are more accessible to cater for the needs of their diverse learners?

Reports on studies that have introduced new content in curriculum and teacher responses are few and far between. One such study conducted in the UK looks at teachers' responses to the new Earth science component of the science curriculum. This study is examined to see whether it has any relevance for the introduction of IKS in the science curriculum. Studies (Jenkins, 2000; King et al, 1998, 1999) conducted on Earth Science, an area of the curriculum that was new for most teachers in the Science National Curriculum in England, found that teachers' lack of background knowledge had a very detrimental effect on effective teaching. It limited their coverage of higher levels of the curriculum and teachers had difficulty in adapting their teaching strategies. With the range and scale of difficulties noted in these studies, it may be anticipated that the introduction of an IKS component in science education in South Africa would pose similar problems. Whether these findings would hold in South Africa is an open question, bearing in mind that the background and context in South Africa is different.

In South Africa to successfully implement the RNCS and NCS it is essential to have teachers who are knowledgeable in science, science-learning theories, confident in their ability to conduct science investigations and with the necessary pedagogical skills and resources to facilitate inquiry-based learning through an outcomes-based education teaching approach (OBE). According to Cameron et al (2005) South African teachers are battling to understand content and have no understanding of theories, such as the worldview theory. This raises the question of how will teachers value and take cognizance of the presence of multiple worldviews that is made explicit in the RNCS and NCS?

In addition to knowledge of science, some authors (Abd-el-Khalick and Akerson; 2004; Schwartz and Lederman, 2002) have also noted other prior conditions for pedagogical knowledge content, which include the interest, intentions, and beliefs of the teachers. In other words, they must be convinced of the importance of the inclusion of certain content (for example IKS) in their daily work, in order for them to take an interest in acquiring this knowledge. Teachers' beliefs according to Cameron et al (2005) may be part of a broad definition of "culture and worldview" and these backgrounds are carried into the classroom.

Jita (2004) adds another dimension by arguing that the construction of teachers' classroom practice is contingent on more than just what they know or believe about teaching and learning. It is shaped by their identities. He uses the term *identity* to refer to a person's sense of self, as socially constructed within social settings. Such an identity includes a person's knowledge and beliefs, dispositions, interests and orientation toward work (Drake et al, 2001). It also includes notions of how a teacher feels about himself/herself professionally, emotionally and politically (Jansen, 2001). Spillane and Zeuli (1999) argue that teachers are expected to assume identities of being learners themselves and not the bearers of all the science knowledge students are required to learn. It seems that Spillane's and Zeuli's (1999) suggestion would be appropriate for teachers who do not have the knowledge for teaching IK in science curricula. This agenda, that is, from one of teacher to one of learner represents a fundamental shift in the science teachers' identities of many teachers across the country trained in the apartheid era.

Jansen (2003) and Rogan and Grayson (2003) argue that the availability of teaching and learning resources and the teaching experiences of teachers influence the presentation of science lessons in the class. From informal discussions with science teachers, Naidoo (2002) found that resources for teaching IKS were not available or were unknown to them. Further very few teachers had real teaching experience of IKS and those who had not, lacked the content knowledge. How would teachers embark on this innovation since IK resources and IK content knowledge are necessary for an insightful educator to interpret such curricular understanding into his teaching? Will teachers be able to acquire this knowledge by preparing and teaching the lessons? Will its realisation in the class be as great a challenge as implementing OBE for educators in South Africa? My research attempts to explore how science educators have addressed some of these issues.

### 2.4.2 New Demands on South African Science Teachers

Unlike its traditional predecessors, the RNCS Natural Sciences, NCS Physical Sciences and Life Sciences make demands on teachers in a number of ways. First, in its approach to science as a discipline that promotes scientific literacy which involves the development of a range of process skills that may be used in everyday life, in the community and in the workplace (DoE, 2003a: 4); second, in its view of science as a human activity (DoE, 2002a: 5) and finally, in its emphasis on scientific problem solving in the context of South African society (DoE, 2002a: 10). This new focus on reasoning, problem solving, human engagement and discourse, and other process skills in science represents a radical departure from the traditional curriculum in South Africa which focused more on science content knowledge for its own sake.

The RNCS and NCS demand that teachers reconceptualise their own relationship to the subject matter and to their learners in order to foster the new agenda. Ideally, teachers of science are expected to be facilitators of a deeper discourse about science knowledge, how it is produced and the contextual environmental and global issues.

Kahn (1995), Jansen (2003) and Chisholm, et al (2000) argue that this reform agenda represents a tall order for the majority of South African teachers who are ill or under-qualified to teach science especially at the senior secondary level. This would also be very demanding on classroom teachers whose experiences of science and science identities did not consider cultural differences in classrooms as part of their training. It is ironical that whilst science teachers may not have experienced a culturally based education themselves, they are required to use such approaches in their teaching. In addition the many and varying roles of the teacher made explicit in the Norms and Standards document (DoE, 2000) add to the complexity of the curriculum change process and place new demands and expectations upon teachers work. Critics of Curriculum 2005 have suggested that its complexity assumes a level of teacher competence, which does not exist in the current South African system (Jansen, 1998).

In achieving Learning Outcome 3, Govender (2009) reported that science teacher educators in tertiary institutions are cognisant that science teachers are constrained by having limited content knowledge and pedagogical training for the successful implementation of the "IKS in science" curricula and are seeking informed ways to bring IKS, as valuable local knowledge, into the mainstream science curriculum. Some teacher education programmes have embraced this goal, one such example being the module "Issues in Science Education" at the University of Kwa-Zulu Natal, which forms the basis of this study

At present, South African teachers are working in a context of "prolonged, complex and controversial attempts to transform our education system" (Jansen, 1999a and Moletsane, 2004:323). In all this the most important levers, the teachers of successful policy implementation, seem to have been forgotten. Instead, increasingly complex demands are piled on teachers and the teaching profession. In addition, in the era of globalisation, teachers are expected to develop the capacities for innovation, flexibility and commitment to change (Hargreaves, 1994). The concern of my research is the extent to which such changes, difficulties and innovations impact on the professional lives of science teachers.

The key elements in this chapter will be used as a lens to provide some insights into teachers' knowledge and understandings of IKS and science, the relationship between IKS and science and the approaches they deploy in implementing LO3 of the Sciences Curricula Statements.

## 2.5 CONCLUSION

Curriculum development will always be at the centre of any education system that is vibrant, growing and adapting to changing circumstances. For the past ten years the South African science education system has been undergoing the most radical changes that are meant to bring it into line with the new political, social and economic phase that the country has moved into since 1994.

I have explained the reforms in science education leading to a science, society, and environment outcome (LO3), which makes explicit reference to IKS in the Natural Sciences, Physical Sciences and Life Sciences Curriculum Statements. There is little research on what science teachers think and do when a curriculum imperative to include IKS exists, that is, when diverse teaching in diverse classrooms is required to engage IKS, culture and contexts meaningfully. Therefore what this means for classroom practice and for teachers we do not really know.

In the next Chapter I detail the theoretical framework, which informs my study.

# CHAPTER 3

## SCIENCE EDUCATION AND IKS:
## FROM CONSTRUCTIVISM TO POSTCOLONIALISM

## 3.1 INTRODUCTION

The previous chapter traced the evolution of science from its early Euro-American reforms to its science, society, technology and environment form, as present in most science curricula globally. It dealt with how culture and IKS have been introduced into the South African science curricula, leading to Learning Outcomes of the Natural Sciences, Physical Sciences and Life Sciences Curricula Statements that include IKS. Different meanings of IK and IKS were explored and finally teachers' knowledge of science was examined to raise questions and make inferences on what might be the expectation of teachers' knowledge of IKS.

The purpose of this chapter is to establish the theoretical framework that underpins this research by developing the theoretical tools, which will be used to inform the methodology and analysis. The first part of the theoretical framework explores the theories of constructivism (from social to critical) in terms of its relevance for teachers' practice. Constructivism theories have dominated science education research and practice. Postcolonialism has been included because the inclusion of the IKS component in the South African Curriculum allows for understanding the relationship between different knowledge systems in a particular socio-historical period of post-colonial and post apartheid South Africa. The second part of the theoretical framework seeks to explore the processes of teaching that occur within and at the intersection of diverse worldviews and knowledge systems. Worldview theory which has been used in science education, as part of the theoretical framework has been included to provide some perspective into the relations between indigenous and western ways of knowing, and to point out some of the challenges these bring to the educational system. The third part sets out to examine possible models for science teaching that engage with IKS.

## 3.2 CONSTRUCTIVISM

Constructivism is undoubtedly a major theoretical influence in contemporary science and mathematics education (Fensham, 2000b; Driver and Oldham, 1986 and Matthews, 1998). There are many types of constructivism, such as, radical, pragmatic, radical, realist, social, sociocultural and critical, sharing the same epistemology and ontology (Kyle, 1996). This section examines radical, social and critical constructivism.

Since my study examines how science teachers transform their classrooms from more traditional and teacher-centred towards ones that reflect learner-centred notions of science teaching, I examine constructivism as a theoretical framework to analyse teaching. I use constructivism to understand how teachers' construct knowledge of IKS and to consider issues and challenges, that surface when implementing IKS approaches.

Although constructivism began as a theory of learning, it has progressively expanded its dominion, becoming a theory of teaching, a theory of education, a theory of the origin of ideas, and a theory of both personal knowledge and scientific knowledge (Matthews, 1998). Translating a theory of learning to practice is both difficult and imprecise. However, education literature documents, large and small scale, have made significant efforts to do so (Kaufman, 1996; Richardson, 1997, Fischetti, et al (1996) thus providing guiding principles and possible indicators of constructivist teaching. Amongst some of these, which inform and influence teaching are, the teacher as facilitator, learner-centred approaches and multiple representations of reality, with IKS being one such representation.

### 3.2.1 <u>Radical Constructivism</u>

Radical constructivism starts from the assumption that knowledge, no matter how it is defined, is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience (Wheatley, 1991). What we make of experience constitutes the only world we consciously live in, that is, all kinds of experiences are essentially subjective.

Glasersfeld (1989: 162) offers two main claims of the epistemological core of radical constructivism:

> *(a) " knowledge is not passively received but actively built up by the cognising subject;*
>
> *(b) the function of cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality. Thus we do not find truth but construct viable explanations of our experiences."*

The new curriculum appears to fulfil the expectations of constructivism as a philosophy by assuming that knowledge is not neutral (Asmal, 2003) but constructed by people. Although none of the South African policy documents make direct references to this theory as its driving force, the principles of constructivism, such as, facilitation, learner-centred approaches, knowledge construction in authentic embedded learning situations and multiple representations of reality, are supported by C2005.

Constructivist teaching and learning environments provide multiple representations of reality, which are in harmony with Ogawa's (1989) assertion that western science is only one form of science among the sciences (multisciences) of the world. A complex task for science educators will then be to develop curricula that value knowledge in its many forms and from its many sources thereby allowing IKS a place in the science classroom. For the constructivist, each person's subjective construction of knowledge is just as valid as anyone else's, and no one has an epistemologically privileged viewpoint, but this is not sustained in science education, for example ethnoscience is relegated to a lesser science (Bishop, 1990 and Gerdes, 1994). If constructivists accept Poerksen's (2004) claim that there are no objective criteria for what constitutes knowledge, then there is no argument why IKS cannot be accepted as legitimate and authentic knowledge.

Contrary to criticisms by some scholars, constructivism does not dismiss the active role of the teacher or the value of expert knowledge (Hoover, 1996). Constructivism modifies that role, so that teachers help learners construct knowledge rather than reproduce a series of facts. Science teachers need to use learner-centred strategies to elicit learners' alternative knowledge base (for example IKS) and bring such knowledge into the science classroom.

For teaching, and in the case of science and technology, all knowledge must be understood as partial to the social position of the knower (van Wyk, 2002). The next section examines social constructivism, as social interactions cannot be ignored since it serves as and exerts a dynamic force on science and IKS issues related to teaching and learning.

### 3.2.2 Social Constructivism

Social constructivism differs from radical constructivism in that it has a conspicuously public element in that "truth" or "reality" will be accorded only to those constructions on which most people of a social group agree" (Murphy, 1997: 5). A criterion to judge knowledge would therefore emphasise consensus between different people. Berger and Luckmann (1967) argue that all knowledge, including the most basic, taken-for-granted common sense knowledge of everyday reality is derived from and maintained by social interactions. Since this common sense knowledge is negotiated by people, it can be said that reality is socially constructed. For McMillan and Schumacher ( 2001:396) a social constructivist philosophy, in addition to recognising the shared social experience interpreted by individuals, includes "understanding the social phenomena from the participant's perspective (and showing) context sensitivity."

Contemporary literature has shown that recognising the social aspect of learning, as well as the effect of the learner's socio-cultural background in the teaching and learning of science, is of primary importance if a strong basic foundation is to be established for successful pupil achievement and affect outcomes (Cobern, 1993; Jegede, 1995; Ogawa, 1995; Ogunniyi, 1988; Solomon, 1994). According to Jegede and Aikenhead (1999) social constructivism emphasises that all learning is mediated by culture and takes place in a social context and that prior or indigenous knowledge is of significance in accomplishing the construction of meaning in a new situation. For teachers working with a social constructivist viewpoint, it is important to take into account the background and culture of the learner throughout the learning process, as this background and embedded worlview helps to shape the knowledge and truth that the learner creates, discovers and attains in the learning process (Govender, 2009). In terms of the South African context, in one classroom there may be learners from different cultural backgrounds and teachers will have to acknowledge these differences and accept the learners' perspectives of reality and accept that multiple realities exist. While it is possible for a teacher to become familiar with cultures other than one's own, to become familiar with twenty or thirty cultures is no easy task and close to impossible. In such contexts will teachers be able to adjust science content to meet and reflect the IKS and the history of every group?

Given that the purpose of my study is to understand how teachers interpret and implement IKS in the science class within the context of a changing South African society, my concern is related to what informs teachers' conceptualization of IKS. While my study is interpretivist, it attempts to understand how teachers make meaning of "IKS in science" curricula in the classroom. Therefore one needs to consider the social cultural factors that have influenced the teacher's concept of IKS.

According to Fensham (1992) science research globally has increasingly been dominated by social constructivism and South Africa is no exception in this regard (Patel, 2006). Currently, there is a tendency towards an "inclusive" view of science research (Atwater, 1996; Aikenhead, 2006a; Cobern, 1996; Costa, 1995 and Jegede 1999), which brings together approaches of different theoretical orientations. In bringing such an analysis to the South African context, Patel (2006) examines science education from a critical perspective.

In South Africa critical constructivism may have particular relevance for teachers working with IKS that values context and empowering approaches to teaching science. It is therefore necessary for critical constructivism to be elucidated in the context of this research.

### 3.2.3 Critical Constructivism

This particular stance on constructivism assumes that the methods and issues of education are always political, so that the constructivist teacher must be both socially and politically contextualised (Taylor 1996). The justification for introducing a new curriculum in any country is often based on historical, political, or socio-economic reasons. The main reason for introducing IKS in Curriculum 2005 (DoE, 2002a: 10), is:

"*IKS reflects the wisdom about the environment developed over the centuries by the inhabitants of South Africa, and much of this valuable wisdom believed to have been lost in the past 300 years of colonization now needs to be rediscovered and utilized to improve the quality of life of all South Africans"* (see appendix A).

According to Ntuli (2002), retrieving and repossessing IK that may have been suppressed (but never lost) in an emancipatory act both in politics and pedagogy. Critical constructivism would provide teachers with the opportunity to contextualise their thinking and teaching in a broader personal, social and political context, sensitive to the needs of the large majority of disadvantaged learners in South Africa. According to Kincheloe (2002), by understanding these dynamics, educators are better equipped to formulate policies and develop actions that cultivate the intellect while operating in a more socially just and inclusive manner.

Learning Outcome 3 of the RNCS and NCS provide scope for teachers to critically engage with different knowledge, however constructed. In an effort towards addressing this outcome a challenge for teachers would be to move beyond social constructivism and to encompass a critical approach in their teaching. For example, revolutionary science teachers with emanicapatory intent would engage learners in situations that challenge the Eurocentric values and beliefs underlying western science. Critical constructivism therefore serves as a position for cultural reform in science education by foregrounding the normally invisible socio-cultural context of knowledge construction (Hoover, 1996).

For Taylor and Cobern (1998:207) critical science education offers the empowering prospect that students will learn to "adapt their local cultures to scientific ways of knowing, believing and valuing and learn to adapt science to their own cultural ways of knowing, believing and valuing." This critical enterprise in school science would be achieved if science education were related to the lives of the learners by providing for the possibility of these meaningful engagements.

Critical constructivism leads to professional problem solving (Watts et al, 2006) and empowerment, which entails the devolution of responsibility for learning to the learner. In short, critical constructivism enacted through the teacher's actions is seen to be an attempt to handle human purposes, paying attention to human dignity, freedom, authority and social responsibility (Kincheloe and Steinberg, 1998). Through this approach, the learner-teacher relationship becomes more open, with the interpersonal distances diminishing but the respect continuing. In the science classroom, the teacher encourages learners to test their own ideas (IKS), compare these with accepted scientific knowledge and look for some movement in their thinking from one to the other. Efforts to address meaningful critical engagements in science education would require teachers committed to emancipatory and social justice practices.

A major limitation against constructivism in relation to IKS and science is that it does not raise issues of power and hierarchy. IKS fundamentally challenges the power relations of science and since interpretative approaches by themselves do not accommodate the analysis of the relationship of power between knowledge systems, I have included reference to postcolonialism. A postcolonial analysis captures IKS itself emerging out of a postcolonial challenge to knowledge and in South Africa postcolonialism includes and overlaps with post-apartheid. A postcolonialism gaze may not be seen as particularly relevant in science education research, which makes it necessary to comment about its relation to this study.

## 3.3 BREAKING FROM CONSTRUCTIVISM: TOWARDS POSTCOLONIALISM

One of the main principles of our transformative education policy, C2005, is about "human rights, social justice, inclusivity and a healthy environment" (DoE, 2002a: 2; 2003a and 2003b). There may be several interpretations of "inclusivity," for example, inclusion of mentally challenged learners, inclusion of "different ways of knowing" which are promoted in the Sciences Curricula Statements. If inclusion refers to "different ways of knowing" then one such way would be to include IKS.

The inclusion of IKS in the South African science curriculum provides grounds for postcolonial discourses as a way of understanding relationships of power, social justice and equity among different ways of knowing.

Before beginning this section on post-colonial theory, it is important for me to place the term into some historical and intellectual contexts. As the term implies, one of the central features of postcolonial theory is an examination of the impact and continuing legacy of the European conquest, colonization and domination of non-European lands, peoples and cultures (Odora, 2002). Central to this critical examination is an analysis of the inherent ideas of European superiority over non-European peoples and cultures that such imperial colonisation implies. IKS falls into this analysis.

Postcolonialism today functions in the academy as a political analysis of what to do about the problem of colonization as a structure of historical power (Mansour, 2008). Mansour (2008) further argues that postcolonialism is an engagement with and contestation of "colonialism's discourses, power structures, and social hierarchies" with an emphasis on the inclusion of other voices and knowledges, for example, IKS. Bringing a postcolonial analysis to science education makes it possible to challenge dominant approaches to learning and definitions of knowledge by those who were previously silenced or excluded from such discourses. For classroom practice this would mean a space for participatory democracy with both teachers and students engaging in this dialogical experience to challenge structures of oppression, repression and inequality.

Fanon (1986) argues that colonised populations must be aware that their education is based on the ideologies and beliefs of the colonisers and they must take care not to reproduce the concepts and beliefs of the colonisers in the period of postcolonial rebuilding. A way proposed by Martin (2007) is by employing an inclusive culturally relevant pedagogy. To derive culturally relevant and socially just pedagogy and practice Martin (2007) and Vadeboncoeur (1997) urge teachers to deconstruct and scrutinize cultural assumptions that underlie various interpretations. Without such scrutiny, societal inequities and historical forms of oppression may be perpetuated in classrooms, and the very constraints that teachers seek to remove or ameliorate will be reinforced. Critics (Freire, 1994; Semali and Kincheloe, 1999) argue that a western view of science is linked to the centralization of power and control, as well as oppression.

In South Africa, Ntoane (2005: 92) maintains that both science education and cultural diversity will have little meaning if science is taught at the expense of indigenous knowledge, as this will elicit charges of “epistemological hegemony and cultural imperialism.” If IKS is juxtaposed with western science in the classroom it brings with it issues of power, knowledge (which knowledge has more worth?) and imperialism.

Postcolonial theory, as applied to education in colonised countries, in addition to seeking to disrupt western science’s Eurocentric and neocolonial remnants, should work towards “new models of education that embrace multiculturalism,” engage diverse ways of knowing, and ensure that curriculum and pedagogy are relevant and appropriate to specific cultural and community settings (Martin, 2007). What is needed is a coherent strategy to put an end to colonial ideologies and the inclusion of IKS into the South African curriculum may be viewed as one such strategy.

By bringing postcolonialism into a constructivist framework there are epistemological and ontological contradictions. These contradictions are evident and play themselves out in the relationship between western science and IKS. Teachers have to negotiate how children learn and the power relations between the knowledge systems. These are indeed contradictory tasks for teachers. The question is, how are teachers to develop approaches that counter hegemonic discourses and still teach science?

## 3.4 WORLDVIEW THEORY

Having detailed a postcolonial analysis for science education, there are in fact theories, such as worldview theory, which emerged in anthropology and psychology that attempt to deal with knowledge systems of different groups of people. Even though worldview theory has been developed and underpinned by social constructivism (Cobern, 1996) I would like to underpin worldview theory by including a critical constructivist and postcolonial theorising, which recognises relations of power between knowledge systems.

Science educators are often at a loss to understand why some students fail to develop orthodox scientific conceptions even after the best of instruction. The argument from worldview is that in some cases, it is not that the students fail to understand what is being taught (comprehension), they simply do not believe what is being taught (apprehension). There are, therefore occasions when the careful epistemological explication of a concept is not sufficient to bring about learning. I will attempt to explain this from a worldview perspective in our current context.

The driving force behind the development of a worldview is a need to relate to the outside world. Beginning in childhood, each person interacts with his or her physical and social environment, and through this myriad of environmental interactions**,** worldview presuppositions are "consciously or unconsciously" constructed (Kearney, 1984). Through the years of schooling, formal education also contributes to worldview development, and in turn, a worldview provides a foundation upon which cognitive frameworks are built during the learning process (Cobern, 1996).

Since most classrooms in South Africa are made up of learners who come from amongst others, different socio-economic, political, geographic, cultural, language and educational backgrounds, this means that they bring with them different experiences and worldviews into the classroom. Roth (1994) concluded that to get to know each other's worlds, learners and teachers would have to begin to interact with each other; they would have to enter each other's life worlds by participating in a common discourse. A teacher, teaching in post-apartheid South Africa should therefore not see the "typical" learner but individual learners with a wide range of backgrounds and needs (Genishi, 1997).

A view on the existence of worldviews is expressed in the RNCS Natural Sciences:

> *"One difference between the modern science and technology on one hand, and traditional and IKS on the other hand, is the existence of worldviews………one can assume that learners [to this I add teachers] think in more than one worldview"* (DoE 2002a: 11-12).

There are many worldviews that communities and individuals may draw on according to context. For example, according to Malcolm (2001b) science teachers might teach Evolution at school, but subscribe to Creation Science in the context of their church. However, a worldview is not entirely individualistic: an individual's worldview is shaped by culture and history as well as experience (Wallace, 1970). Accordingly, for Wallace (1970) worldview is never part of a "closed" system; its power lies in the correlation and interaction with other worldviews.

Worldview theory is underpinned by constructivist model as is most curriculum theories in science education, which recognises that learners construct knowledge from their own background and for indigenous students, this can be from another worldview. Jegede (1996) and Ogunnyi (2003) have argued that learners' understanding of any new meaning is strongly influenced and determined by prior knowledge, that in turn, is determined by cultural beliefs, traditions and customs governed by a world-view. These fundamental beliefs about the world then exert a powerful influence on how sense is made of events in the world.

Since individuals have many ways of perceiving nature, science, the surrounding world and their place in it, understanding science and scientific concepts depends on their worldview and whether the science seems to be meaningful and important for their lives (Odegaard, 1999). Three issues emerge: whether teachers perceive the differences in worldviews as important in their science learning, how they negotiate the difference, and how they design science curricula to accommodate the differences.

A science curriculum that includes aspects of relevant indigenous knowledge that recognises students' preconceptions and worldviews and affords a platform for discussion of "different ways of knowing" and encourages critical thinking is bound to attract and sustain more students in science (Govender, 2009). He further maintains, as Bryan and Atwater (2002) and Chinn (2007) that engaging teachers' beliefs and practices that can lead to deeper insights into contributions to science, lead to culturally sensitive teachers and provide science educators with a knowledge base that could guide "equitable and culturally-relevant transformation" in science instruction.

However, justifications based on constructivism and worldview is not without problems. Firstly, Gough (1998: 515) points out that *"science education informed by constructivism does not necessarily problematize the cultural construction of scientific knowledge; rather it attempts to use knowledge of learners' personal constructs to generate more effective strategies for persuading learners to adopt western worldviews."* This questions the purpose of IK in the curriculum. For teachers who think that it is not necessary for learners to abandon their worldview understandings, a useful approach might be to uncover both the IK and western science without any biases and prejudices.

Secondly, IKS and science worldviews may be regarded as competing worldviews (Ogunniyi, 2002) and bringing together such worldviews has potential for conflicts. Worldview theory underpinned by social constructivism does not consider such issues that come into play when worldviews meet, which means that worldview theories might need to be underpinned by critical theories in order to better explain how learners and teachers would manage the relationship between the two.

Debates abound in the literature about whether traditional worldview and western worldviews are indeed in conflict or complementary. The next section attempts to uncover some of the critical elements of when traditional worldview and western worldviews are brought together.

### 3.4.1 Traditional and Western Worldviews

Since many of the present South African classrooms are now complex spaces with learners from different races, gender, various cultural, ethnic and linguistic contexts, in addition to knowing about the worldview that learners bring into the classroom, teachers need to know what to do when different worldviews meet.

As noted, the science curricula statements call for education to foster a scientific worldview, or in other words, to bring about change so that students see the worlds scientifically. This is evident in concepts such as "to investigate and solve problems in scientific contexts, "interpret and apply scientific, technological knowledge, which are in keeping with western curricula (DoE, 2002a: 89). The RNCS Natural Sciences acknowledges the tremendous contribution that has been made by empirical science to human progress over the centuries, but also contends that, there are other worldviews present in classrooms. For example, in South Africa many people hold a strong world-view, which says:

> *"That people are not separate from the earth and its living things; they believe that all things have come from God or a creative spirit and therefore have a spiritual meaning; events happen for spiritual as well as physical reasons . . . People tend to use different ways of thinking for different situations, and even scientists in their private lives may have religious frameworks or other ways of giving value to life and making choices"* (See Appendix A).

Indigenous knowledge systems and western science are based on different explanatory models: the traditional worldview is based on an anthropomorphic model while the scientific worldview is based on a mechanistic model (Ogunniyi, 2002). Jegede (1999) and Jegede and Okebukola (1990) describe the anthropomorphic model of IKS as ecologic, holistic, relational, pluralistic, experiential, timeless, infinite, communal, oral and narrative-based and the mechanistic model of western science as reductionist, linear, objective, hierarchical, empirical, static, temporal, singular, specialized, and written.  It becomes clear from the above descriptors that IKS and western science represent competing worldviews and belief systems. Can there be an interface between two theoretical models namely, IKS and western science, that seem, at first glance, to be diametrically opposed?

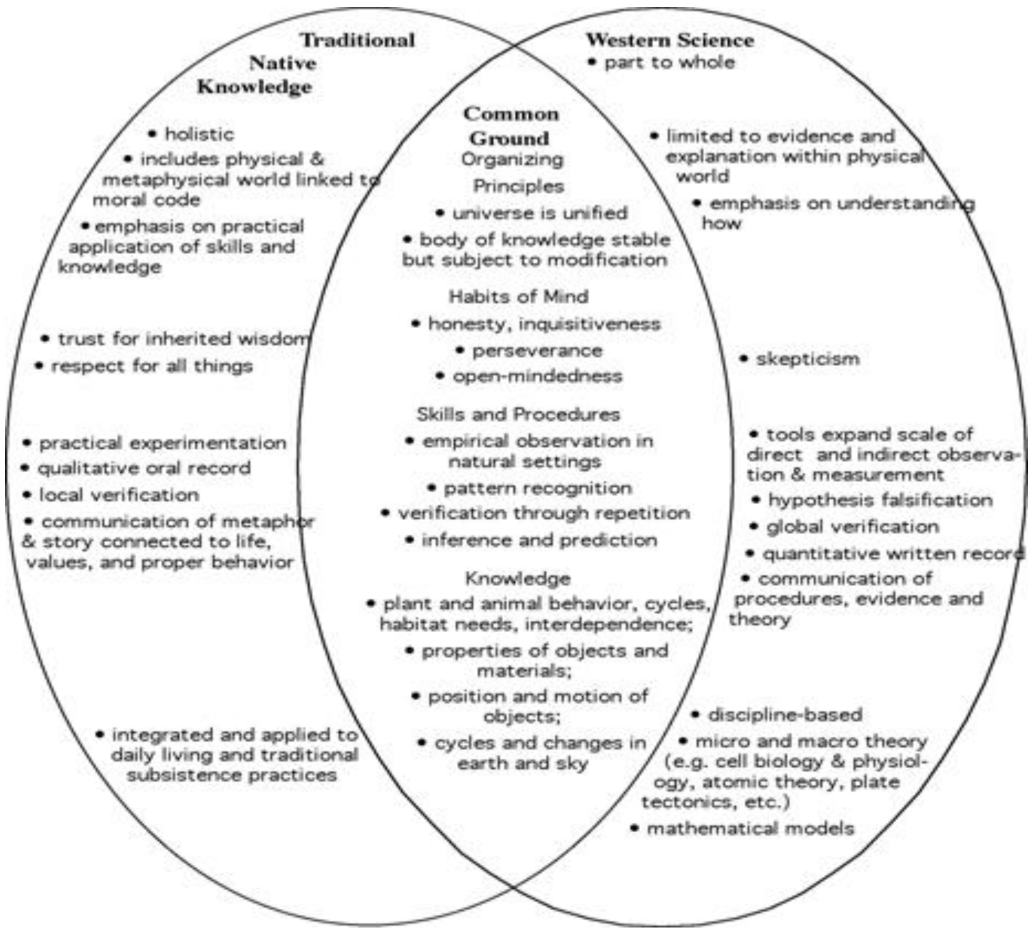
There is no doubt that the cultural and epistemological issues are complex and if simplistic binary oppositions are embraced then we have to choose one and dismiss the other. This dichotomous mode leaves little room for dialogue.

Agrawal (2002) argues that the attempt to create distinctions in terms of indigenous and western worldviews is potentially ridiculous keeping in mind the above limitations of a dichotomous framework. According to Agrawal (2002) it makes much more sense to talk about multiple domains and types of knowledge, with differing logics and epistemologies.

Pickett and Fatnowna (2002: 258) call for a "partnership that relinquishes dominance and control, and moves towards collaboration and negotiation - the coming together of world-views that is not just one of pluralistic tolerance, respect and co-existence, but one that goes beyond transformation and the emergence of a new synthesis that incorporates the diversity of worldviews."

This difference in worldview between western and non-western cultures affects science teaching and learning. The complexities that come into play when two fundamentally different worldviews converge, present formidable challenges to science teachers. The teacher therefore needs to understand the worldview(s) existing in the community from where the learners come and the IK used in their communities. Mosimege (2005) argues that focusing on the similarities between the two systems of knowledge rather than on their differences may be a more useful place to start when considering how best to introduce IK in science lessons.

Using worldview theory Stephens (2000) captures some of the critical elements that come into play when indigenous knowledge systems and western science traditions are brought together in an effort to develop more "culturally sensitive" science curricula.




(Stephens, 2000)

**Figure 1: Traditional and Western Worldviews**

Characteristics of the anthropomorphic model depicting IKS, as local, holistic and oral and the mechanistic model base of western science as objective, fragmented and written are clearly evident in the above figure 1. The model's illustration of the nature of IKS and the nature of science is central to this research.

It can be seen from figure 1 that there is an overlap between traditional and western worldviews and hence are not mutually exclusive. The model attempts to bring traditional and western worldviews together in a manner that promotes a synergistic relationship such that the two "previously disparate systems join to form a more comprehensive holistic system" (Stephens, 2000). The interdependence in this model allows for worldviews to intersect and make links at places and to considerably overlap in some areas. Because every culture's way of viewing the world is different it seems probable that every culture may have developed unique strategies for doing science and that some of these may just possibly fill in the gaps in others. Therefore by seeking to include western and traditional worldviews in a complementary way it might better serve the needs of all learners. The above model has implications for curriculum design. Teachers would have to re-design educational programmes, which will be more formative and holistic in content and pedagogical methods.

The implications for the teaching and learning processes embedded in the three domains of knowledge represented in the overlapping circles above are numerous and of considerable significance. Although educators obviously differ in their perspective, there is no doubt that the creation of a "culturally sensitive" science curriculum has powerful implications for learners for at least three of the following reasons according to Stephens (2000:10-11), "The first is that a learner might conceivably develop all of the common ground skills and understandings while working from and enhancing a traditional knowledge base. The second is that acquisition of the common ground, regardless of route, is a significant accomplishment. And the third is that exploration of a topic through multiple knowledge systems can only enrich perspective and create thoughtful dialogue." This line of thinking resonates with McGregor's (2000) "co-existence" model, which promotes the functioning of both systems (western science and IKS) side by side and encourages equality, mutual respect, support and cooperation. This model proposed by Stephen might be regarded as such a model.

Linking the two knowledge systems is not without challenge. A criticism levelled by Dekkers and Mnisi (2003) against comparing the two knowledge systems is that if fair comparison between IKS and western science fails, it is likely that one or both knowledge systems will lose credibility. Gaskell (2003) who has another view argues that if other knowledge (IKS) is compared with western science then western science will always be seen to be superior in any such comparisons.

If according to Chauraya (2008), multiple domains and types of knowledge systems especially IKS and African indigenous worldviews need to be introduced explicitly in the curriculum for acknowledgement, debate and research in multiple epistemological issues in science education, then clearly this would require teachers to interrogate multiple knowledges. A worldview theory underpinned by a critical and postcolonial perspective would therefore provide for such possibilities.

## 3.4.2 Language and worldview

Language represents a specific worldview and ontology and nothing reflects indigenous worldviews and ways of being more than indigenous languages (Ntuli, 2002). On this, the United Nations website http.www.un.org (Jan., 2008) for cultural diversity says, "Language not only communicates, it defines culture, nature, history, humanity and ancestry"… "And to learn culture is to learn language" Language therefore is the main medium for the representation and transmission of indigenous knowledge. The challenge according to Shava (2008) is to recognize and accurately interpret these many cultural phenomena in order to act and interact appropriately and effectively.

Language may also result in an increased power imbalance for example the use of terms such as "mainstream," and "dominant" in reference to western society and the use of "alternative" in reference to indigenous society. These English terms are strongly bound to the western worldview where hierarchies and power, as usually defined by materialistic standards, are the norm.

### *3.4.2.1 Translation of IK by a Non-indigenous person*

An often-encountered problem in understanding indigenous perspectives is that translation occurs in the paradigm of the translator, not in that of the translated. Words are translated, but often the loss of cultural context obscures meaning. According to Agrawal (1995) changing language, as usually happens in interpreting indigenous knowledge in English and other internationally dominant languages, and/or writing down indigenous knowledge usually results in "modifications, accommodations and loss of its fundamental features" to fit the new language, that is misrepresentation or loss through transmission and translation occurs.

The translator who translates from his or her indigenous language has a more natural and practical knowledge of the various linguistic elements of his or her language, such as semantics, syntax, morphology and lexicology than the translator who translates from a foreign language. In some languages, one word can be used to refer to more than one thing and only those who translate from their indigenous language are aware of such a semantic feature. Therefore when a non-indigenous person does translation it often causes confusion or translation loss.

Coates (2005), in his consideration of comparative history, discusses the problems involved in the translation of indigenous histories by non-indigenous academics. Coates emphasizes the need to advance beyond a Eurocentric interpretation of differing cultural systems so as to accurately represent indigenous knowledge. He argues that the translation of indigenous language must include the entirety of the worldview and not just the words. Further he claims that the inability to represent differing worldviews, properly translated in complete ontological and epistemological complexity, would seem no more than the disability of the translator. This in turn serves to further limit discussions into areas of subjugation and oppression. Not only does the silencing of cultures represent a loss of knowledge in general, but it also represents a continued advancement of post-colonial oppression.

#### *3.4.2.2 Intergenerational Translation of IK*

Language enables the transmission of cultural knowledge between generations not only in the present, but also from past to future generations. Indigenous knowledge is immersed in the whole culture and is recreated through generations and takes place daily, orally (through narratives, stories/folklore, songs and poetry), visually (through arts such as ‘bushmen’ paintings, writings, craft, cultural rituals and dance) and practically (through doing and the artifacts associated with practice).

Knowledge changes as it is passed from one person to the next and from one generation to the next. Sometimes the change is dramatic. As Kunnie (1995) observes, “language constitutes the vehicle by which essential cultural and cosmological idioms are transmitted and removing a person’s language is tantamount to destroying their culture.”

#### *3.4.2.3 Translation of IK for science*

The challenge for educators is to develop curricula that value knowledge in its many forms and from its many sources therefore bringing IK into the science classroom. IK has to be re-structured, codified and re-organised and translated into scientific discourse, that is, translation from the mother tongue or vernacular language to the national language or to the language of teaching and learning. Words and phrases to express concepts may not easily be translated into another language. English for example, may not have equivalents for Isizulu words, such as, the inadequacy of English to express Isizulu ideas about the metaphysical world. As a result, there is a tendency during translation to make generalised and thus decontextualised representations. If students do not understand a word or give it a slightly different meaning to that intended, their performance may not accurately represent their scientific knowledge and skills, for example, the Isizulu word "amandla" which translates into English as "power", "force" or "strength". Clearly, as indicated above, the structure, form and language of the curriculum materials are crucial determinants in what happens in the science teaching and learning situation.

### 3.4.3 Border-Crossing

The current development towards "science for all" globally, necessitates that teachers need to consider how learners move between their everyday life-world (part of IKS) and the world of school science (western science), and what would this mean for effective teaching of science. This process is described in Giroux's (1992) work as "cultural border-crossing." "Border crossings" for learners can only happen if teachers feel confident that they can cross such borders themselves. How do teachers themselves traverse between their own worldviews in their thinking and in their classrooms? The next section focuses on how teachers may facilitate this transition between learners' everyday worlds and school.

The Natural Science Learning Area Statement explicitly refers to border crossing by claiming that, "several times a week they cross from the culture of the home, over the border into the culture of science, and then back again" (see Appendix A). The above statement highlights the significance of the phenomenon of border crossing in the

African continent. Border crossing occurs, for example, when learners from indigenous communities respond to western science culture promoted by school science curricula. In the South African context border crossing may occur when learners cross the rural-urban divide or move from rural traditions to modern everyday tradition, etc.

In the classroom the teacher is the person who would facilitate this border crossing and for Aikenhead and Jegede (1999) successful "border crossing" will depend on the assistance pupils receive from teachers who can identify the cultural borders to be crossed and guide students back and forth across those borders. They argue that effective cultural border crossing is a complex event. The metaphor "teacher as culture broker" was used to analyse a teacher's role in resolving cultural conflicts that arise in "cross-cultural" education. One of the ingredients of a successful culture broker effective teacher demands making links and flexibility in moving between the learner's worldview and the worldview of science (Lugones, 1987).

The cognitive explanation of border crossing is captured by a theory called collateral learning, that is, learning of something in a western "setting" that conflicts with indigenous knowledge embedded in a different cultural setting (Jegede 1995; Aikenhead 1996). Collateral learning generally involves two or more conflicting schemata held simultaneously in long-term memory. Jegede (1995, 1996, 1999) recognised variations in the degree to which the conflicting ideas interact with each other and the degree to which conflicts are resolved. At one extreme of collateral learning, the conflicting schemata do not interact at all. This is parallel collateral learning, the compartmentalization technique. At the opposite extreme of collateral learning, conflicting schemata interact and the conflict is resolved. This is secured collateral learning.

While this explains how learners manage and negotiate different conflicting worldviews, science education has also attempted to develop models for "IKS in science" teaching.

## 3.5 POSSIBLE MODELS FOR "IKS IN SCIENCE" TEACHING

Various models for "IKS in science" teaching exist in literature. Snively (1995) has proposed a "Five-Step Model", a "Learner-Centred Model" is described by Malcolm (2002), and Aikenhead (2002b) has proposed a "Research and Development Model." These models, besides having the potential for teaching western science and IKS, retain a high degree of the culture of learners.

Snively's (1995) "Five-Step Model" is discussed in greater detail because it is more comprehensive and incorporates elements from the other two models, namely "Learner-Centred Model" and "Research and Development Model". Snively's (1995) Five-Step Model was found to be particularly relevant and an adapted version is used later in the analysis of the science teacher's work on interpreting IK for the classroom.

Snively (1995: 27), outlines a five-step process for producing what he calls a Traditional Ecological Knowledge (TEK) unit, which is a subset of IKS in "cross-cultural" science teaching. The model provides a general framework for exploring the two perspectives, that is, western science and IKS while teaching any one concept or topic of interest. The process is outlined as follows and details of how each step of the model will be used in the analysis is further discussed in chapter five:

Step 1 Choose a science concept or topic of interest (e.g. Agriculture, animal migration, sustainability).

Step 2 Identify personal knowledge (may be cultural, social or environmental).

- Discuss the importance of respecting the belief of others.
- Brainstorm what we know about the concept or topic.
- Brainstorm questions about the concept or topic.
- Identify personal ideas, beliefs or opinions.

Step 3 Research the various perspectives.

- Research the western /modern science perspective.
- Research the various indigenous perspectives.
- Organise/process the information.
- Identify similarities and differences between the two perspectives.
- Ensure that authentic explanations from the perspectives are presented.

Step 4 Reflect

- Consider the consequences of each perspective.
- Consider the concept or the issues from a synthesis of perspectives.
- Consider the consequences of a synthesis.
- Consider the concept or issue in view of values, ethics and wisdom.
- If appropriate, consider the concept or issue from a historical perspective.
- Consider the possibility of allowing for the existence of differing viewpoints.
- Consider the possibility of a shared vision.
- Ensure that students compare their previous perspective with their present perspective
- Build consensus.

Step 5 Evaluate the process.

- Evaluate the decision-making process.
- Evaluate the effects of personal or group actions.
- Evaluate possibilities in terms of future inquiries.
- Evaluate how the process made each person feel?

This model builds on a constructivist view of learning, which is evident in the recognition it gives to personal knowledge, and brainstorming of concepts (Step 2). For Eraut (1994) personal knowledge is what a person brings into new situation that enables him/her to think and act in those situations. In the classroom there are different personal knowledges, those that learners bring and those that teachers bring. This view is extended by Jegede's (1996) statement that prior knowledge is determined by cultural beliefs, traditions and customs governed by a worldview. For Steinberg and Kincheloe (1998:13) Step 3, that is, "the idea of students as researchers who explore their own lives and connect academic information with their own lived experience is alien to many schools." This step may therefore be a challenge for many teachers to accomplish.

Snively and Corsiglia (2001) maintain that using such a model is not to establish whether one form of science is more relevant than another, but to develop scientific thinking and to ground the study of science within students every day world. Odora (2002:16) from her argument "it cannot be said enough that rural peoples' knowledge and modern scientific knowledge are complementary, combined they would achieve what neither would," might be interpreted to support such a model.

Although the Snively's (1995) Five Step Model is framed on constructivist thinking it might be argued that the notion of comparison as reflected in step 3 seeks to bring perspectives and experiences from different contexts into critical reflective dialogue and step 4, which allows for the existence of different viewpoints which might help confront ignorance, prejudice and stereotyping in the teaching of "IKS in science."

A second possible model for teaching "IKS in science" is the "Learner-Centred Model" proposed by Malcolm (2002) who claims that "learner-centred science" is explicitly multicultural, and avoids the notion of "one science". For him the model can make lessons more culturally relevant by focussing on the knowledge (IKS) that the learner brings to the learning situation. It also draws from constructivist approaches since it foregrounds IK held by learners from their cultural environments. An implication for teachers would require them to select examples and contexts that relate to students' interests, helping them to extend and reconstruct their knowledge in ways that engage diversity. This feature that IK is located in the learner is incorporated in step 2 of Snively's (1995) Five Step Model.

A third possible model for "IKS in science" teaching is Aikenhead's (2002b) "Research and Development Model." A common pattern of including IK is to develop an Aboriginal (indigenous group) framework at the beginning of each unit. Learners are involved in gaining local knowledge from elders and other knowledgeable people in the community. Learners are taught protocols for approaching these "experts". The students record the knowledge in an appropriate way and it is shared and synthesized in the class. Western science is introduced to learn more about learners' indigenous world. For Aikenhead, this approach celebrates the co-existence of both worlds. The model emphasises the recognition that IK is held in the community, a feature that is also incorporated in step 3 of Snively's (1995) Five Step Model.

While Snively's (1995) Five Step Model makes "IKS in science" teaching practical, it still remains to be seen how teachers in South Africa actually negotiate "IKS in science" teaching. In this respect it offers a useful framework for analysing teachers engagement with IK.

## 3.6 CONCLUSION

The theoretical framework established serves to contribute to the data analysis in the analysis chapters that follow.

In this chapter constructivism as a theory of learning, which also informs and influences teaching was elucidated. Those who argue for a constructivist framing use worldview theory, which emanates from anthropology and psychology, in science education to explain how teachers may manage and negotiate conflicting worldviews. Juxtaposing IKS with western science in the classroom brings with it issues of power hierarchy which needs to be built into approaches that encourage such discussions in the classroom. IKS, which emerges from a postcolonial moment, provide grounds for science education to be located in such an analysis. Postcolonialism, which does not come from science education has been used as a critique of science education theories. Postcolonialism has been used in the analysis because it allows for understanding the relationship of power, social justice and equity between different knowledge systems, that is, science and IKS.

Since teachers facilitate border crossing, the ease or difficulty of moving between the learner's worldview and the worldview of science depends on approaches that teachers take.

Science educators have also attempted to develop models for "IKS in science" teaching, some of which were explored. The five-step analytic framework suggested by Snively (1995) for “IKS in science” teaching was adapted and used in the analysis of the science teachers’ assignments which provided information on how they interpreted IK for the classroom.

I analysed each assignment against this framework and captured the steps that fitted in with the model while also noting steps that were neglected in the tasks. The framework draws on the constructivist approach in that it draws on the learners’ prior knowledge. It also draws strongly on the overlap of worldviews, and may be interpreted to have some critical elements as discussed in the theoretical framework.

The theoretical frame established in this chapter will be used to develop the research design in Chapter Four.

# CHAPTER 4

## RESEARCH METHODOLOGY

### 4.1 INTRODUCTION

In the previous chapter the theoretical framework that guides this research was examined. In this chapter the research methodology is described. It is framed by the theoretical orientation together with justification for the research design from literature.

In locating the methodology for my research questions, Ritchie and Lewis's (2003) argument that the use of methodology is heavily influenced by the aims of the research and the specific questions that need to be answered were kept at the forefront. Focusing on the research questions namely, what currently informs science teachers about how they conceptualise IK, how teachers interpret and implement IK in the science classroom and why they implement it in the way they do, I found the interpretive paradigm with case study, as the main organizing perspective, to be most appropriate in serving the needs of this research.

This chapter is divided into four sections. The first part provides explanations and justification from the literature and theory to support the research design. The second section describes the phases of data production, namely the first phase, the imagined/hypothetical, the second phase or implemented/actual and the third phase, the reflective phase and the research instruments employed in each phase. The next sections examine the approaches to analysis of data, with reference to what was done in each chapter and the limitations of the study.

## 4.2 THEORY AND RESEARCH DESIGN

As indicated earlier my study is located in the interpretive paradigm. It uses case study, which is supported by qualitative and quantitative methodologies. Narrative is the dominant type of analysis employed. This section begins by examining why the interpretive paradigm is most appropriate for my study.

### 4.2.1 Interpretive Research as an Approach to the Study

Denzin and Lincoln (2003) claim that from an interpretive point of view, human action has meaning and that meaning is in principle determinable or decidable by the interpreter. Trowler (1995) maintains that interpretive research involves investigations that view reality in action or as it happens, with the researcher interpreting what is going on in different ways. Ernest (1994) sums up the above understandings by maintaining that the interpretive research paradigm is primarily concerned with human understanding, interpretation, inter-subjectivity and lived truth (that is, truth in human terms). Thus to understand a social action, for example, the teaching of "IKS in science" the researcher must grasp the meanings that constitute the actions.

Cohen et al (2001) add that to understand human action requires grasping the subjective consciousness or the intent of the actor from the inside. The implication is that there is a need to examine situations through the eyes of participants rather than the researcher. In other words it may be seen as an act of psychological re-enactment-getting inside the head of the teacher participant to understand what he or she is up to in terms of motives, beliefs, desires, etc. The concept of acquiring an inside understanding is a powerful, central concept for understanding the purpose of qualitative research. To obtain the "intent" of the teacher participants from the inside, the study pays particular attention to reflections as a stage in the research.

My decision to analyze the data from an interpretive perspective is supported by Denzin and Lincoln's (2003) view, to examine situations from the "inside and through the eyes" of the respondents. Reflection as a category of analysis was therefore purposefully built into the design. The data collection methods and the analysis employed were based on Schon’s (1987), view of reflection as reflection-in-action and reflection-on-action. An important aspect of Snively’s Five Step Model that was used in the analysis focussed on reflection. Reflection-on-action was considered by the use of reflective interviews. Although the Snively’s (1995) Five Step Model is framed on constructivist thinking it might be argued that the model in seeking to bring perspectives and experiences from different contexts into critical reflective dialogue embraces a critical perspective.

As indicated in chapter three, social-constructivism, critical constructivism and postcolonialism that guide this study do not complement each other. In bringing postcolonialism into a constructivist framework there are epistemological and ontological contradictions. Social-constructivism stresses the social construction of the nature of reality, critical constructivism deals with the notions of emancipation and empowerment in the changing climate in South Africa and postcolonialism addresses issues of power and social justice that arise when knowledge systems come together. Teachers of science should aim at teaching for critical consciousness, teaching for social justice, leveling power relations, social change and empowerment. The process of knowledge creation, the manner in which it is produced and validated and its status need to be questioned. The postcolonial theory therefore plays an important role in informing the analysis. The framework created enabled me to understand how social factors and teachers’ experiences, have influenced their teaching of IK and how they have been able to negotiate “IKS in science” curriculum.

### 4.2.2 <u>Case study</u>

Yin (1989) defines the case study research approach as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. He further maintains that in general, case study is an approach when how and why questions are posed, when the investigator has little control of events and when the focus is on some contemporary phenomenon in a real-life context (Yin, 2003). In the present study the phenomenon refers to *how* science teachers interpret and implement IK in the classroom and *why* they implement it in the way they do. Feagin, et al (1991) state that the case study approach is ideal when a holistic, in-depth investigation is needed. According to Tellis (1997) the unit used in a case study could include an individual, a social institution or a cultural group. In this study the unit is the science teacher. Three cases studies are developed and although each case study is treated as a single case the information from each case study have been combined as information contributing to the whole study.

In identifying the type of case studies, I examined Stake's (2000) classification of case studies, which is based on the intentions, and purposes of the study. Stake, (2000) who has written widely on case studies, identified the following specific types of case studies:

- **Intrinsic Case Study:** is when the researcher has an interest in the case. It is undertaken because the primary and only purpose is for the researcher to obtain a better understanding of this particular case. The purpose is not to come to understand some abstract construct or generic phenomenon, for example, literacy or what a principal (teacher) does (Stake, 2000).
- **Instrumental case study:** describes a situation when a particular case is examined mainly to provide insight into an issue or to redraw a generalisation. The case is of secondary interest, playing a supportive role and facilitates our understanding of something else. The case is looked at in its depth, its context scrutinised, its ordinary activities detailed, but all this helps the researcher pursue the external interest.
- **Collective case studies:** is when a researcher may jointly study a number of cases in order to investigate a phenomenon. This method is chosen because it is believed that it will lead to a better understanding, perhaps better theorising of the phenomenon.

Since case studies often do not fit neatly into categories (Stake, 2000), and with the above classification in mind, I identified my study as instrumental in its purpose since the study attempts to provide insights to a new and unfamiliar phenomenon, that is "IKS in science" curricula and extended to several cases studies (three), which could be regarded as an "instrumental-collective" type. This study is in part a comparative case study because it sought to compare whether there are differences or commonalities in the way culturally different science teachers interpret and implement IK.

Often case study is mistaken as appropriate for qualitative research only. Erickson (1986) clarifies this by stating that in fact, the case study approach can involve both qualitative and quantitative methods to support research. The research takes seriously claims made by Rubaie (2002) that each of these two methodologies provides a distinctive kind of evidence and when used together they can offer a powerful resource to inform and illuminate the practice of teachers. It must be emphasised that the “rich descriptions” of the interviews and observations, were strengthened by quantitative analysis of the surveys to obtain a more comprehensive picture of the “IKS in science” teaching. Both methods were brought together to study the same phenomenon of teachers’ interpretation and implementation of IK, but divided according to research questions based on what was to be explored and what data needed to be collected. However, this research leaned largely towards qualitative research since I was interested in capturing the exact words used by the participants as they discussed the sources of their concepts of IKS and experiences of IKS.

Since the research employed largely qualitative methods there was a need to examine the main criticism levelled against qualitative methods, which is the question of validity and reliability. Agar (1985) argues that in qualitative data collection, “the intense personal involvement and in-depth responses of individuals secure a sufficient level of validity and reliability. However, contrary to this, researchers such as Pontin (2000) and Silvermen (2000) maintain that these grounds are insufficient for ensuring validity and trustworthiness. It can be argued that multiple cases studies strengthened the results because they can be more robust than a single case study hence strengthening external validity. To further ensure validity and reliability not only quantitative and qualitative methodologies were employed in my study but also multiple sources of data were produced, which included surveys, interviews, that is, telephone, face-to-face and reflective interviews and classroom observations at different phases of the research

Interviews may be seen as a way of teachers telling their stories. The data that emerged was used to construct narratives for each one of the three teachers.

### 4.2.3 <u>Triangulation</u>

Guba and Lincoln and (1994) established that the trustworthiness, reliability and transferability of naturalistic research design are important because it reflects on the quality of the inquiry. This section discusses attempts at making data for the case studies as "rich" and "trustworthy" as possible.

Cresswell and Miller (2000: 126) define triangulation as a "validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study." Denzin (1989) outlines four types of triangulation, including different methods, diverse sources of data, different investigators and different perspectives to the same data.

The discussion, which follows indicates attempts made during my research to increase the trustworthiness of results. In keeping with Denzin's (1989) list of triangulation my study involved collecting data in different ways and from diverse sources so that the multiplicity of perspectives, present in the social situations, could be discerned.

As mentioned earlier the study employed diverse sources of evidence, namely survey instruments, (quantitative) interviews, assignments, classroom observations, reflective interviews (qualitative) to "corroborate one set of findings with another; in the hope that two or more sets of findings will converge on a single proposition" (Massey 2004:2). Triangulation also helped "home in" on the teachers' correct understandings of IK by approaching it from several methods.

While the results of the research are applicable to the sample of Bachelor of Education Honours teachers they might be more credible because they are representative of teachers from culturally diverse backgrounds and from three of the four historically different types of schools in South Africa. Another concern for the study is the numerous debates and questions about the status of IKS some of which have been discussed. This issue together with the fact that there seems to be no unanimous definition (or as many as there are researchers in the field) puts IKS in a controversial position.

### 4.2.4 Narratives

Within the case studies narratives were developed to explore more closely teachers' thinking and actions with IK in their science classrooms.

Storytelling is an ancient tradition used in indigenous communities to pass on information, which preserves customs, beliefs and events of significance. Storytelling as cultural representation and sociological text emerges from many traditions, but nowhere more strongly than in oral history and folklore and is becoming more disciplined in a line of work called narrative inquiry (Clandinin and Connelly, 1994). Representation of data in narratives enhanced the humanistic and subjective elements of science being promoted by Learning Outcome 3, of the RNCS and NCS, which emphasises the Science, and Society aspects. It is in Learning Outcome 3 that IKS can be addressed. Eisner (1981:9) aptly indicated the value of narratives in research,

> *"It is the artistic to which we must turn, not as a rejection of the scientific, but because with both we can achieve binocular vision. Looking through one eye never did provide much depth of field."*

According to Connelly and Clandinin (1994: 7):

> *"Humans are storytelling organisms, who, individually and socially, lead storied lives. The study of narrative, therefore, is the study of the ways humans experience the world."*

Narratives in the study were a way of representing how teachers told their stories. However, narrative inquiry as a valid methodology for research is not without debate. One the one hand researchers, for example, Malcolm et al (1999) and Stears et al (2003), who refer to the context of poor, marginalized and indigenous and have used narratives argue that it encourages imaginative thinking (there is no 'correct' place to start), a sense of audience, attention to developing plot and interest which can be used as analytic tools to produce explanatory stories. On the other hand Kaplan (1964) asserts that if you can't measure it then it isn't worthwhile doing. He shows little confidence in a form of research that does not deal directly with measurable data.

Although narrative inquiry is subject to the essential fallibility of human beings this study values narrative as representations because it is believed that it might still allow theorization about how science teachers interpret and implement “IKS in science” lessons and why they do it in the way they do.

There have been increasing calls, to move away from western positivistic methods to indigenous methods in research. One such example was from Maori scholar Linda Tuhiwai Smith who, published *Decolonizing Methodologies: Research and Indigenous Peoples* in 1999, which articulated the importance of indigenous people devising and using indigenous research methodologies and addressing issues from frames of references that are derived from within their own communities and cultural traditions. Working within the interpretive paradigm of western research I see the shortcoming, but I have deployed some methods that share similarities with indigenous methodologies, for example the primary qualitative method employed in my study was representation by way of narratives, which is a conceptualisation of teaching that resonates with the traditions of story telling in indigenous communities (Maurial, 1999). Barnhardt and Kawagley (2005) argue that bringing indigenous methods from the periphery to the centre will ensure that scholars are in a position to enlarge the scope of research paradigms in ways that will benefit both western and indigenous research traditions. They further argue that interaction between indigenous epistemologies and western epistemologies may lead to finding new methods to produce knowledge

### 4.2.5 Sample

The sample comprised of a cohort of 23 Bachelor of Education Honours students who had specialisation in sciences and are also resident secondary school educators. The 23 teachers came from 23 secondary schools across a wide cross-section of Kwa-Zulu Natal. These schools ranged from urban (4) and peri-urban (6) to rural (13). All teachers in the sample taught Natural Sciences, Life Sciences or Physical Sciences. Through exposure to the Honours science education module these teachers were introduced to indigenous knowledge and its implication for classroom teaching and learning. I believed that this exposure would have made these teachers possibly more knowledgeable and informative about the phenomena being investigated. I used the technique of purposive sampling.

With purposive sampling the sample is “hand-picked” for the research and they are seen as instances that are likely to produce the most valuable data (Denscombe, 2005). Through purposive sampling educators from schools representing each of the historically demarcated Departments of Education, namely[15], House of Delegates (HOD), House of Representatives (HOR), House of Assembly (HOA) and Department of Education and training (DET) were to be included to allow for diversity. The sample would be representative of cultural diversity as well. In the cohort of 23 teachers there was one White female teacher (ex-HOA), one Indian male, (ex-HOD) one Coloured female (ex-HOR) and the rest were African males and females (ex-DET).

During the first stage of the research all twenty-three teachers were given a ten-item survey, requiring about ten minutes to complete (Appendix C). Of the 23 in the cohort, 11 indicated that they would not be willing to further engage as participants in the research.  This was not because of their lack of IK or their lack of interest in including IK in lessons but because of an overload due to school responsibilities. I continued the study with the teachers who had indicated that they wished to be participants. Of the eleven teachers eight were interviewed by telephone. The others were unreachable.

From the initial cohort, the number of teachers who finally continued as participants in the research was reduced to three, that is, Lizzie, Deva and Pindi. These teachers were in fact self-selected on the basis of their willingness to continue as participants. This also suited the needs of the research since they were from diverse cultural backgrounds, race and gender and came from the three historically types of schools; Lizzie, a Coloured female from an ex-HOR school, Deva an Indian male from an ex-HOD school and Pindi an African female from an ex-DET school.

[15] During apartheid South Africa, schools were segregated along racial lines. The three different departments of education were represented in parliament, House of Assembly for Whites, House of Representatives for Coloureds and House of Delegates for Indians. The Department of Education and Training for Africans was not included in parliament.

These diversities were useful to explore, whether or not they in fact had an influence on what teacher participants say and think about "IKS in science" teaching. In the South African context race is relevant because it is known that different races have different IK. Learners' races were included in order to contextualise schools and to observe whether learners' races have a bearing on how teachers interpret and implement teaching of "IKS in science" lessons.

Undertaking race analysis brought with it difficulties and challenges of "labeling". Racial labeling has always been a sensitive and contentious issue in South Africa but especially so after democracy since it encourages stereotypes. My dilemma was then what label should I use "Black, African or South African?"

In addition at the end of apartheid there has been a growing sense of nationhood in this race-conscious country, with most of all the diverse people seeing themselves as primarily South African - not as members of a specific racial or ethnic group.

The Freedom Charter (footnote 12) declares that South Africa belongs to all who live in it, black and white. Hence the label "Black" includes other races, that are not White that is, Africans, Coloureds or Indians. In this research I want to differentiate between the three different "Black" participant teachers. Also since both the Physical Sciences and the Life Sciences Curricula Policies refer to African Indigenous Knowledge (Appendix A) I therefore find the term African most appropriate for this study.

To ensure that other ethical considerations were accommodated throughout my research, I have undertaken to maintain the anonymity of the schools and the individuals involved through using pseudonyms.

The following considerations were taken into account to address ethical concerns in this research (Cohen, Manion and Morrison, 2001).

- seeking prior informed consent;
- obtaining access and acceptance;
- avoiding possibility of emotional harm to respondents;

- avoiding violation of privacy, ensuring anonymity of respondents, their schools and confidentiality of information; and
- avoiding deception of respondents through misrepresentation.

### 4.2.6 Methods of Data Production

Qualitative research involves the use and collection of a variety of empirical materials that describe routine and problematic moments and meanings in individuals' lives (Denzin and Lincoln, 2003). Accordingly, I deployed more than one interpretive data-gathering method to get a better understanding of the subject matter at hand, that is, the sources of teachers' IK and their approaches to "IKS in science" teaching.

During this phase I followed Miles and Huberman's (1994) suggestion that careful data display is an important element of the data reduction and selection, by displaying all the data collected for each participant, side-by-side to create a grid (see Table 5 below). Five of the six sources of data collected have been coded for easy reference in the analysis. For example, assignment is given the code A, telephone interview the code TI, face-to-face interview the code FI, classroom observation the code CO and reflective interview the code RI. These codes would be used to indicate the source of excerpts and vignettes used in discussions.

## Table 4: Sampling Details of Teacher Participants

| Teacher Participants | Race | Gender | Learning Areas being taught by teacher participants | Type of Schools and Location of Schools | Race of Learners |
|---|---|---|---|---|---|
| **1. Lizzie*** | **Coloured** | **Female** | **Natural Physical Sciences** | **Urban - Wentworth** | **Mostly Coloured, few African** |
| **2.Deva*** | **Indian** | **Male** | **Physical Sciences** | **Urban - Chatsworth** | **Indian and African** |
| **3.Pindi*** | **African** | **Female** | **Life Sciences** | **Periurban - Inanda** | **All African** |
| 4.Toko | African | Female | Mathematics Natural Sciences | Rural -Empangeni | All African |
| 5.Bongi | African | Female | Natural Sciences | Rural – Washbank | All African |
| 6.Hlona | African | Female | Natural Sciences | Periurban - Mandeni | Mostly African and few Indian |
| 7.Mkiza | African | Male | Life Sciences | Rural - Umbumbulu | All African |
| 8.Nomsa | African | Female | Physical Natural Sciences | Rural -Obenjoni | All African |
| 9.Pindi | African | Female | Mathematics Physical Sciences | Rural - Ndlinde | All African |
| 10.Sindi | African | Female | Mathematics Physical Sciences | Rural - Maphumalo | All African |
| 11.Fika | African | Male | Mathematics Natural Sciences | Periurban- Ladysmith | All African |
| 12.Sithemba | African | Male | Life Sciences | Rural- Pongola | All African |
| 13.Jane | White | Female | Mathematics Life Sciences | Urban - Ballito | African, Indian and White |
| 14.Bonga | African | Male | Physical Sciences | Periurban – Kwa-Mashu | All African |
| 15.Nomagugu | African | Female | Mathematics Natural Sciences | Rural – Glencoe | All African |
| 16.Thuliswe | African | Female | Natural Sciences | Rural – Kokstad | All African |
| 17.Zama | African | Female | Natural and Life Sciences | Rural - Kokstad | All African |
| 18.Zondi | African | Male | Mathematics Natural Sciences | Rural - Ndwedwe | All African |
| 19.Pretty | African | Female | Natural Sciences | Rural - Umvoti | All African |
| 21.Siza | African | Male | Physical Natural Sciences | Rural -Kranskop | All African |
| 22.Tokosizwe | African | Male | Mathematics Natural Sciences | Periurban –Kwa-Dugusa | All African |
| 23.Langa | African | Male | Life Sciences | Urban - Umlazi | All African |

* Teachers who participated in the indepth case studies.

**Table 5: <u>Methods of Data Production</u>**

| | P H A S E 1 | | | | Phase 2 | Phase 3 |
|---|---|---|---|---|---|---|
| **TEACHER PARTICIPANTS** | **Survey** | **Assignment (A)** | **Telephone Interviews (TI)** | **Face to Face Interviews (F I)** | **Class Observation (C O)** | **Reflective Interviews (R I)** |
| **1. Lizzie** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **2. Deva** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **3. Pindi.** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4. Toko | ✓ | ✓ | ✓ | | | |
| 5. Bongi | ✓ | ✓ | ✓ | | | |
| 6. Hlona | ✓ | ✓ | ✓ | | | |
| 7. Mkiza | ✓ | ✓ | ✓ | | | |
| 8. Nomsa | ✓ | | ✓ | | | |
| 9. Pindi | ✓ | | | | | |
| 10. Sindi | ✓ | | | | | |
| 11. Fika | ✓ | | | | | |
| 12. Sithema | ✓ | ✓ | | | | |
| 13. Jane | ✓ | | | | | |
| 14. Bonga | ✓ | | | | | |
| 15. Nomagugu | ✓ | | | | | |
| 16. Thuliswe | ✓ | | | | | |
| 17. Zama | ✓ | ✓ | | | | |
| 18. Zondi | ✓ | ✓ | | | | |
| 19. Pretty | ✓ | | | | | |
| 20. Dave | ✓ | | | | | |
| 21. Siza | ✓ | | | | | |
| 22. Tokosizwe | ✓ | | | | | |
| 23. Langa | ✓ | | | | | |
| **TOTAL** | **23** | **10** | **8** | **3** | **3** | **3** |

## 4.3 PHASES OF DATA PRODUCTION

Drawing inspiration from the methodologies presented in Vithal's (2000) study for researching mathematics education theory and practice from a critical perspective, I re-interpreted the methodology in a different context. She discusses the methodology as the "imagined/hypothetical", "actual" and "arranged situations". For her the imagined/ hypothetical situation, exists only as a conception established by different theories, hypotheses and information, the actual situation is the "situation that actually exists in the class, the school, a teacher education institution or even the educational system as a whole, the arranged situations is a re-organised actual situation, which is created by and constituted by the researcher and research participants" (Vithal, 2000: 61).

For this study the "imagined/hypothetical", "implemented/actual" and "reflective" an appropriate way of organising the data production according to the phases in which it was collected. The imagined/hypothetical phase was a phase prior to the actual implementation in the classroom, a state that only existed as conceptualisations outside the classroom. The imagined /theoretical phase relates to what teachers learn, think and say about IK use in the classroom; the implemented/actual phase refers to the "concrete teaching and learning" situation in the classroom and deals with what teachers do with IK in the classroom; the reflective phase occurred after the "concrete teaching and learning" phase in the classroom and speaks to what they think about what they have done and learnt after IK teaching in the classroom.

### 4.3.1 Imagined/Hypothetical Phase

In this initial phase teachers were enrolled for the module "Issues in Science Education" as part of the Bachelor of Education Honours (B.Ed.Honours) degree at the university. During this phase the teacher's knowledge is cluttered with theories and assumptions of what should happen in the classroom. It may represent an ideal situation being held by either the lecturer of the module or by the teachers or by both lecturer and teachers because it can be related to their expectations and hopes and visions. Once the teacher is engaged in the actual phase, in the real classroom situation he/she is challenged to use such theories obtained from the imagined/hypothetical phase (Vithal, 2000).

Although many science teachers find new ideas during pre-service and in-service training to be very interesting, back in the classrooms they resist application of what they have learnt due to feelings of insecurity in innovating with new methodologies and content in the classroom especially since they were comfortable with the ones they already use, for example the teaching practices associated with OBE. Therefore theories (knowledge) that enable teachers to feel comfortable in the class and to enhance their sense of self is embraced, while knowledge that increases anxiety or makes teachers feel inadequate will be resisted or rejected. In addition most of the South African schools are limited by different kinds of constraints such as lack of adequate human and learning material resources. These concerns raise questions about teachers' responses to "IKS in science" teaching. What will teachers do with IKS? Will they embrace IKS or will they resist or reject it?

In this phase of the study the Bachelor of Education Honours module was examined (Appendix B). In the B.Ed science module teachers were introduced to the principles underpinning the RNCS and NCS curriculum statements, that is, human rights, inclusivity, social justice and the environment with IKS being identified as an area embracing all the principles. Various definitions of IKS were discussed. Readings included the importance of IKS and comparison of IKS with western science. An assignment made up of two tasks was set in the module (Appendix E). Task one as part of the assignment required teachers to develop lesson plans to include indigenous technologies that would be used to demonstrate scientific concepts in the science curriculum. Task two required teachers to choose a scientific concept, which was in conflict with learners' indigenous beliefs and to attempt to resolve the conflicts that may arise.

#### *4.3.1.1. Introducing the Research to the Participants*

I made prior arrangements with the lecturer of the Bachelor of Education Honours module, to introduce my study to the teachers who were enrolled for the course. This was done so that I could secure participants for the study. I explained the nature of the project to the teachers and clarified the research agenda and its purpose. I also discussed the reason for collecting the data and how it will be used. The survey forms were then handed to all the teachers. Unlike a postal questionnaire that is received “cold” without prior notification this method (Denscombe, 2005) ensured that there was personal contact between myself, as the researcher, and the respondents. This initial meeting with participants assisted in establishing rapport which according to Creswell (2002) are essential steps in obtaining relevant data to answer the research questions posed for the study. This rapport was maintained throughout the research process.

#### *4.3.1.2 Survey*

The survey, which was conducted during the imagined/hypothetical phase, served two purposes. Firstly, the survey was designed to indicate the sources that informed the teachers in the way they conceptualised IKS for the classroom and secondly to identify teachers who had more knowledge than others in IK as participants for the study. This would be determined by analysis of the survey documents. However, as pointed out earlier, many teachers who were more knowledgeable were not willing to participate in the research due to other commitments. The survey document had ten different sources of IKS (see Appendix C). The survey was developed as a Likert scale with three categories labelled “greatly”, “somewhat” and “little”. By ticking in the appropriate category teachers rated how much each source informed their concept of IKS.

Having determined the sources of their IK from the surveys, I used the teachers’ assignments to determine whether in fact teachers were drawing on these sources for their interpretations and planning for “IKS in science” lessons.

#### *4.3.1.3 Analysis of Assignments*

Since I felt that by simply asking teachers "how do you interpret IK in the RNCS and NCS" might not yield substantial data, I decided to use tasks one and two of the assignments for this information. The assignments required teachers to understand and interpret IK in the curriculum. Therefore a document analysis of the assignments would be a valuable route to take because it would provide me with significant information about the teachers' sources of IK, their interpretations and understandings of IKS. My decision is supported by Tellis's (1997) opinion that documents are also useful in making inferences about events (interpretation of IK for the classroom).

The assignments developed during the initial imagined/hypothetical phase fitted my study since teachers developed lesson plans to include IK in science lessons. Assignments included both indigenous technologies and indigenous myths and beliefs. Teachers were requested to design two lessons in which they integrated IK, one lesson using an indigenous technology and the second lesson using a belief or myth. Teachers were expected to select a topic from any one of the Life Sciences, Natural Sciences or Physical Sciences curricula. In the first task they had to explain how they would use examples of indigenous technologies in the lesson.

In the second task teachers were asked to select a cultural belief or myth that conflicts with the western view of science and explain how they would attempt to reduce conflict between the belief that learners hold and the scientific explanation for the particular phenomenon (see Appendix E). The lecturer provided a framework for the lesson plan. Analyses of these assignments would provide data on how teachers interpreted and planned to teach IK in the classroom.

#### *4.3.1.4 Telephonic interviews*

Telephone interviews were conducted during the imagined/hypothetical phase of data production. Initially I had doubts about the reliability of factual information obtained over the telephone since it forfeits the visual contact of face-to face interviews and hence its comparability with information obtained from face-to face interviews. However, I subsequently realised that it would not seriously hamper data collection since participants had personal contact with me when I introduced the research to them.

This was also discounted by Descombe's (2005) argument that there is no general reason to think that information obtained by telephone is less valid and in fact has been claimed to be more valid in some situations. To support this viewpoint, Dinham (1994) found there was strong evidence that the settings of the interviews in each respondent's house surroundings with an "anonymous" researcher at the end of the line aided greatly in promoting relaxation and reflection. Initially I visited the first participant at her home to collect data. The interview was audio-taped. After that I ran into difficulties meeting with participants. Numerous meetings were arranged, but participants did not turn up.

The interview schedule was designed to produce data in terms of the following issues that are represented with greater detail in Appendix D and were derived from the theoretical frame.

- Teachers' conceptualisation of IKS
- Teachers' interpretation of IKS and
- Teachers' implementation of IKS

I found telephone interviews particularly useful because they were conducted at a time most suitable for the respondent, after the respondents had taken care of all school and out-of-school responsibilities. The telephone interview was usually at about 20 h 00-20 h 45.

This method was also an advantage because I did not have to travel across a wide geographical extent of Kwa-Zulu Natal in order to gain access to respondents. Access would have been extremely difficult, not to mention costly, if face-to-face interviews had been utilised at this stage of the research. All interviews were audio-taped and transcribed. Eventually only seven of the eleven teachers were telephonically interviewed because I could not reach the other four teachers.

#### *4.3.1.5 Face-to-Face Semi-Structured Interviews*

From the above sample, three teachers (self-selected) continued as participants because they agreed to continue with the research. These teachers, Deva, from an ex-HOD school; Pindi from an ex-DET school and Lizzie from an ex-HOR school were then interviewed face-to-face during the imagined/hypothetical phase of the research. Qualitative semi-structured interview questions and a protocol were developed in a manner that allowed for maximum flexibility. This I found was a good technique for exploration. I used lead off interview questions and from these questions used other, more probing questions as the interviews progressed.

The three educators became the respondents for the three case studies. The main purpose of this interview was to solicit the views, experiences and practices of the teachers regarding IKS. A further purpose was to gather in-depth responses to the issues raised in the telephone interviews. Each interview with the participant lasted for approximately 45 minutes. I have related the theoretical underpinning for the content of the interview to issues in science education in post-apartheid South Africa, with particular reference to the Sciences Curricula Statements. The theory of constructivism as a key rationale for C2005 also features in the interview process wherein I attempted to determine whether science teacher had adopted it in informing their teaching practice. The semi-structured interview schedule was designed to provide data on the following aspects:

- RNCS and NCS Sciences Curricula Statements
- IK experiences
- Professional development regarding IKS
- Thoughts/feelings/experiences about IK teaching (Appendix F)

Interviews were audio taped and transcribed and clarification and further explanations were sought at subsequent meetings with the teachers. The interviews supplemented data obtained from the surveys to address critical question one, namely, what currently informs teachers' concepts of IK. The interview was in the main used to address critical question two, namely how teachers interpret the policy on IKS in the sciences curricula statements.

### 4.3.2 Implemented/Actual Phase

The implemented/actual phase is the "real, concrete" situation where the teacher is engaged in the real classroom. This phase is usually developed from concepts, ideas and planning obtained during the imagined/hypothetical phase (Vithal, 2000). The knowledge gained during the imagined/hypothetical phase is usually exposed and challenged by the real classroom encounters (Ndlalane, 2006). Some aspects of the actual situation are the science teachers, the learners, the curriculum, the pedagogy, lesson plans etc. However, it is not as simple as it seems because in the actual classroom situation, teachers are very often required to 'think on their feet" and to constantly adjust their approach to ensure learning progress for their students. There is often a failure to recognise and acknowledge these day-to-day realities of the classroom and Barnett and Hodson (2001) argue that it is therefore not surprising that so many attempts at curriculum innovations have failed. Keeping in mind that teaching is such a complex and uncertain enterprise what would this mean for "IKS in science" teaching?

In this phase of the research my concern was to observe how the interpretation and implementation of the RNCS and NCS policies pertaining to IKS played out in the science classroom. In the interest of collecting as "objective" data as possible brings forward the idea that the researcher should be inconspicuous in the classroom, just making observations and not interfering with classroom proceedings. Observations can be distorted or fuzzy but a careful design of data-collection procedures can reduce disturbances or fuzziness. Therefore I chose to video record the actual "IKS in science" lessons that I observed.

In this study I want to understand the educational ideas and theories of IKS as expressed in the imagined/hypothetical phase as well as theorise about the actual phase of teaching of "IKS in science" lessons. In this way the imagined/hypothetical phase turns into "a window through which I might be better able to grasp and qualify the actual phase" (Vithal, 2000: 61).

#### *4.3.2.1 Classroom Observation*

Classroom observations characterised the "implemented/actual" phase. Arrangements were made with participants to inform me when indigenous knowledge was to be included in their science lessons, which were observed and video-recorded. I sat as unobtrusively as possible at the back of the class, while the lesson was video-recorded. To be less obtrusive a technician who remained stationary at the back of the classroom or laboratory did the video recording and to overcome the distance the video recorder had a wide range of view in the zoom lens.

Through lesson observations I was able to address critical questions two and three namely, how teachers interpret and implement IK in the classroom and why they interpret and implement in the way they do. Both participants Lizzie and Deva were observed twice. However, with Pindi only one lesson was observed, as there were numerous disruptions at her school. In addition the school was involved with Integrated Quality Management Systems (IQMS) and learners' testing programmes. I chose one lesson of each of the participants for detailed analysis. Since Lizzie and Deva taught two lessons each I chose the one most related to IK.

Although only one lesson was chosen for the analysis, each lesson was probed deeply and analysed intensively through "play-back" of the video-recording of the lesson with the teacher. The purpose of the stimuli-recall was to seek deeper insights into the teachers' perceptions and practices and to explain why they did what they did. The idea of using prepared material also evolved from Merton's (1987) study, which exposed the respondents to concrete experiences such as films or radio programmes to solicit responses. Using the video of the classroom observation afforded the teachers the advantage of hindsight and allowed them to share their thoughts and feelings that occurred during the lessons. This reflective phase allowed for teachers "thinking about events, knowledge and methods" of the actual phase (DoE, 2002a: 48) in order to analyse them.

### 4.3.3 Reflective Phase

Constructivist assumptions are implicit in the notion of learning through reflection in professional practice (Atherton, 2005). Schon (1987) an influential writer on reflection, described reflections in two ways: reflection-in-action and reflection-on-action. Reflection-on-action is looking back after the event whilst reflection-in-action occurs during the event. Both aspects of reflection had a place in my research with reflection-on-action playing a more prominent role in providing better insights into the knowledge, understanding and skills that teachers deploy in “IKS in science” teaching.

For Fitzgerald, (1994:67), reflection-on-action is “the retrospective contemplation of practice undertaken in order to uncover the knowledge used in practical situations, by analysing and interpreting the information recalled.” Alternatively for Boyd and Fales (1983:101) reflection-on-action is “the process of creating and clarifying the meanings of experiences in terms of self in relation to both self and the world. From the above meanings it may be deduced that in essence reflection-on-action in the classroom might mean conducting a post-mortem on lesson plans, teaching strategies, approaches etc.

This form of reflection involves the teachers in careful thought followed by speaking about the details of their classroom practices (Rosenberg, 2004). Teachers were required to reflect on all instruments and processes used in the imagined phase (surveys and assignments) and the actual phase (vide-recording of the lesson). This type of introspection afforded the teachers the advantage of hindsight and allowed them to share their thoughts and feelings that occurred during all the stages, but especially the actual phase of the lesson. In the South African context this enquiry into one’s practice in order to analyse them is in line with Dewey’s (1993) conception of reflection, and the Assessment Guidelines (DoE, 2007). The Norms and Standards for Educators or NSE (DOE, 2000) also endorse such an expectation since one of its propositions is for teachers to develop reflective competence.

#### *4.3.3.1 Reflective Interview (Post Observation)*

Looking at all the data and initial analysis I realised that it was not “thick” and “rich” enough for the research that I had aspired for. In addition, the next phase of the data production was informed by Wiersma’s (1986) view that, most things cannot be entirely apparent during observation. I decided to revisit the teachers to get them to reflect on aspects that emerged from the imagined phase, namely, the surveys and tasks one and two and in the actual phase of classroom observation.

Although a video may be limited because it can capture only what is observable while unspoken thoughts and feelings of a participant cannot be captured its advantage is that it can be played back to the participants (Erickson, 1986) in order to attempt to get them to recall and describe their thoughts, feelings and reactions at different points in time during a given event, thus giving us information about the unobservable.

Making use of this advantage of “play-back” the video-recordings of the lessons were viewed together with teachers at their homes for the purposes of a “reflective interview.” This was done by teachers reflecting mainly on the video-recording of the classroom observation. Teachers were asked to also reflect on the survey forms, the assignments and interviews. The reflective interview schedule (Appendix G) was designed to provide answers to all three critical questions of the research. The questions posed in the interview encouraged teacher participants to discuss some of their observations in “IKS in science” teaching and to address their views, aspirations and concerns on a range of issues relating to teaching indigenous knowledge. In addition the process of reflection served for the emancipation and empowerment of the teachers. Critical constructivism was therefore an important perspective that underpinned the reflective interview. The “reflective interview” was taped and transcribed. The transcripts were sent back to the interviewees to maximize the validity of interviews as a data collection tools by ensuring that the interview was not misunderstood or included my bias of interpretation as an interviewer. This process is known as respondent validation and has been proposed by Silverman (2000) as a means to improve the validity of data.

Thus the information from the reflective interviews helped complement data that was obtained from classroom observations. There were three interviews, which contributed greatly to the data collection process and this necessitated a good relationship between the teachers and me. This relationship was set up at the first meeting and sustained throughout the study.

The data collected from the three schools took place from April 2006 to January 2007. The table below summarises the three phases of the research and the instruments used for data collection during each stage. Although the data production was categorised in phases, these categories are not exclusive and there is some degree of overlap. For example, in the reflective phase teachers also commented on data produced in the imagined/hypothetical and implemented/actual phases.

**Table 6: Summary of Phases of Data Production**

| **Imagined/hypothetical**<br>**First Phase** | **Implemented/Actual**<br>**Second Phase** | **Reflective**<br>**Third Phase** |
|---|---|---|
| As a university student | As a teacher | As a teacher |
| ▪ Survey | ▪ Class Observation | ▪ Survey |
| ▪ Assignment | | ▪ Assignment |
| ▪ Telephone interview | | ▪ Face-to-Face interview |
| ▪ Face-to-Face interview | | ▪ Video recording of class observation |

## 4.4 APPROACH TO DATA ANALYSIS

### 4.4.1 Chapter Five

The first level analysis, which is presented in this chapter, was done in distinct phases. The first phase involved the quantification of the survey data. Analysis of the draft survey was done using computer software programme SPSS and Table 7 was generated. This was followed by a qualitative analysis of the telephone and face-to-face-interview. Each interview was transcribed verbatim and the transcripts were read and re-read to gain a holistic picture of the experiences of the participants. In order to be as close to the data as possible I did all the transcriptions personally. I highlighted words, phrases and actual quotes that reflected possible themes and issues.

In some cases the actual words of the informants were used to construct vignettes and interpretive commentary to provide explanations and connections with the surveys. In other cases excerpts were used to support ideas in the text. Participants' responses were reported verbatim to provide a true reflection. Relevant quotes from the interviews were presented on the basis of Rudduck's (1993) suggestion that "some statements carry a remarkably rich density of meaning in a few words."

The five-step analytic framework suggested by Snively (1995) for "IKS in science" teaching, which was discussed in detail in the previous chapter, was adapted and used to analyse the assignments. I analysed each assignment against this framework and captured the steps that fitted in with the model while also noting steps that were neglected in the tasks. The framework draws on the constructivist approach in that it draws on the learners' prior knowledge. It also draws strongly on the overlap of worldviews, and may be interpreted to have some critical elements as discussed in the theoretical framework.

It should be emphasized that the quantitative results of the survey which were used largely to supplement the qualitative data became more meaningful when interpreted in relation to the qualitative information obtained through interviews and tasks one and two of the assignments.

### 4.4.2 Chapter Six

The second level of analysis represents the construction of narratives written in the form of vignettes and excerpts. I wished to produce storied accounts from the data collected from teachers rather than collect storied accounts from them. Polkinghorne (1995) refers to this approach as narrative analysis, where synthesised information obtained from the data is compiled into a story. This type of analysis moves from elements to stories, as opposed to analysis of narratives, which move from stories to common elements. By being largely consistent with indigenous methodologies my choice of narratives in this study is strengthened as being the most appropriate to address the research questions.

A reflective hermeneutic cycle of writing, thinking and discussion resulted in the presentation of a narrative from the data obtained from the various sources for each teacher participant. The science teacher's narrative is a composite of their experiences as learners and teachers of science and includes the following sources of data namely, surveys, telephone interviews, face-to-face interviews, assignments, classroom observations and reflective interviews.

Since a personal narrative is a subjective process depending on many factors such as the narrator's social construction of themselves and their worldview, which may change, I constantly verified the data with the participants. The clarifications provided me with a further opportunity to make comments and changes, which were minimal. Hence three rich descriptive narratives were constructed to fully depict their background and experiences of IK, their underlying attitudes and their approaches to "IKS in science" teaching.

### 4.4.3 Chapter Seven

Analytical categories were used to deepen understandings of each teacher's approach for teaching IK in science lessons. The approaches used by the teachers have given rise to several themes in response to the research questions. In this chapter each of the approaches is developed and interrogated through the emergent themes and subsequent theorisatising is presented. Postcolonialism has been used in the analysis because it allows for understanding the relationship between different knowledge systems, that is, science and IKS.

Having detailed how analysis was completed and while every effort was made to ensure that data obtained was as valid and as reliable as possible, the following factors may have placed some limitations on interpretations of results.

## 4.5 LIMITATIONS OF THE RESEARCH

### 4.5.1 Methodological Limitations

A frequent criticism against the case study approach is that its dependence on a few cases renders it incapable of providing a generalizing conclusion. Yin (1989) presented Gidden's view that case methodology was "microscopic" because it "lacked a sufficient number" of cases. However later, in Yin (2003), he pointed out that generalization of results, from either single or multiple designs, is made to theory and not to populations. While a few case studies therefore may widely be assumed to hold little promise for generalisability, I would like to argue that it might be too simplistic to concede that this study is entirely lacking in wider applicability, and that, ideally speaking, other science teachers with similar teaching/learning conditions and experiences might well achieve similar outcomes.

A methodological issue arising out of this research is one of sample selection. Initially the sample selection was planned to be purposive so that the sample could be representative of both cultural diversity and teachers who came from different ex-departments of education. Unfortunately, it became apparent during the initial phase of data collection through the survey that this would not occur. I had to rethink the sampling strategy to accept only the teachers who indicated that they wished to continue with the study. I did not view this as a serious setback because the study eventually included participants from the three historically demarcated departments of education while at the same time accounting for cultural diversity.

A second methodological limitation is that a short time was spent on classroom observations. Two lessons were observed for both Deva and Lizzie while one lesson was observed for Pindi. However, in trying to overcome this limitation the lesson that most related to an IKS lesson was chosen for further analysis.

The language barrier is another limitation, which was not considered. The lecturer of the module as well as the researcher did not understand indigenous languages. They were neither able to read nor write indigenous languages and these barriers could have results in limited access to IK and unequal representation (and application) of IK (Hountondji, 1997; Shava, 2008).

Another limitation related to the survey, which was used to determine teachers' sources of IK. The survey had ten categories (see appendix C) and no allowance was made for teachers to include a category other than the ten, which teachers may have deemed to be an important source of IK for them.

### 4.5.2 **Personal Bias**

One of the greatest threats to credibility might have been that I, as the researcher was the only one who conducted the interviews. Expectations or biases not recognized by myself may have influenced the teachers' responses. For example, teachers giving responses that were politically correct. However, this was minimised, as the nature of the study required me to make detailed observations of the teaching-learning process in the classroom, which followed on from the interviews. This was based on Eisner's (1991) claim that what people actually do and say be compared with their account of what they did and said; two methods of collecting data must be employed in such inquiries; interviewing and observing.

Another issue that could have influenced the study was my own position as a subject advisor in the Department of Education. Generally teachers view subject advisors as "inspectors". This could have had a positive or negative influence on the teachers' lesson preparations and classroom teaching. Therefore the lesson observed could have been "unusual" examples of exemplary or weak "IKS in science" lessons. Since I was aware that this position could influence results, teachers were reminded on numerous occasions that I was there as a researcher and not in my capacity as subject advisor.

## 4.6 CONCLUSIONS

In this chapter I have explained the theory used to support the research design of this study. Various dimensions of the encountered during the study influenced the methodologies, for example, during the course of the research, as explained above, the sampling technique was amended. In addition after initial analysis of the data I recognised a need to go back into the field for further data collection. This had to be done at the beginning of 2007 because the participants were involved in school examinations in October and November 2006. This could have resulted in some loss of continuity on the part of teachers. Reflective interviews were therefore used to prompt recall. Chapter Five focuses on comparisons and relationships that may or may not exist in data collected from surveys, telephone interviews and tasks one and two of the teachers' assignments.

# CHAPTER 5

## WHAT TEACHERS THINK AND SAY ABOUT IKS

### 5.1 INTRODUCTION

In the previous chapter I presented the methodology, which was informed by the research questions. The six sources of data collected for the study was divided into three phases. The analysis presented in this chapter deals with data produced in the first phase or the imagined/hypothetical phase, namely, the survey, telephone interviews and teacher education assignments. The data produced in this phase addresses primarily the first and second critical questions: namely what teachers say informs the way in which they conceptualise IK, how teachers interpret IK and how they think they would implement IK in the science classroom.

In the first part of this chapter teachers' sources of IKS are examined by analysis of the survey. The survey data is supplemented by data from the telephone interviews to provide deeper insights into how teachers were thinking about IK and to further illuminate their ideas and meanings. In the second section of this chapter the two assignment tasks developed for the teacher education programme are analysed by using a re-interpreted framework of Snively's (1995) Five-Step Model. This extends the analysis of how teachers were thinking about and planning for the implementation of "IKS in science" lessons.

The next section provides a justification for the choice of the ten categories of IKS that was included in the survey (see Appendix C).

## 5.2 SOURCES OF THE SURVEY

In constructing the survey the first category considered, as an obvious source for teaching IK was the National Curriculum Statement, which provides the basis for this study. The RNCS Natural Sciences and NCS Life Sciences and Physical Sciences are especially relevant because it is through the new curriculum that IKS has been introduced into South African classrooms. Therefore it might be expected that a large number of teachers would choose the RNCS and NCS policy documents as a primary source of IK.

The second category in the survey was the university B.Ed Honours module. It is also an obvious source to be included in the survey because teacher participants were formally introduced to IKS through this module. Therefore it is likely that these teachers would rate the module highly as their source of IK.

Three categories in the survey, that is parents/grandparents; elders in the community and stories and legends were constructed on the basis of literature reviewed. For example Maurial (1999) and Semali (1999) value the mother, the father, grandparents and the authority of elders as the first educators of children in indigenous communities. This is further qualified by the often-cited adage: *"It takes a village to raise a child"* (Semali, 1999:108). This is done mostly through stories and legends.

Further a common presumption within IKS research is that the "knowledge system" is one that has been developed over generations of experiences and observations (Warren, et al 1996). In addition, the richness associated with the knowledge system presumes accumulated experiences. As a result, this knowledge is commonly associated with persons of advanced years and deep experiences, i.e., elders within the local social community (Davis and Wagner, 2003).

Media and books were considered as it is an important resources used by teacher to gain information. Herbal remedies may be one such example.

Herbal remedy in the survey refers to the use of plants for medicinal purposes. According to Hountondji (2002), the World Health Organization (WHO) of the

United Nations estimates that as much as 80% of the world population relies on the use of various forms of herbal medicine for its primary healthcare. In addition Hountondji (2002) argues that in rural areas where there are few medical doctors there is a heavy reliance on treatments based on herbs, plants and oils for primary health care. Herbal remedies are undergoing a renaissance and are increasingly beginning to be accepted as, at least, complementary to conventional medicine and are obtainable at pharmacies. This supported the inclusion of the category, regular practice of herbal remedies. It must be pointed out that one does not necessarily have to consult a sangoma or a traditional healer to practice herbal remedies.

Sangoma is the term for a “diviner-priest” in the tradition of the Nguni-speaking peoples (Zulu, Xhosa, Ndebele, Swazi) of Southern Africa and are said to access the wisdom of the ancestors to cure ills and divine knowledge (Masuku, conversation 7/11/08). They do this through the use of traditional medicines (*muti*), dream interpretation, bone throwing and channelling. There are medicines for everything from physical and mental illness, social disharmony and spiritual difficulties to potions for love and luck (Cumes, 2004). They have specific coloured cloths to wear to please each ancestor, and often wear the gallbladder of the goat sacrificed at their graduation ceremony in their hair (Masuku, conversation 7/11/08). They summon the ancestors by burning a plant called “imphepo”, dancing, chanting, and most importantly playing drums. Sangomas far outnumber western-style doctors in Southern Africa and according to Binsbergen (2005) more than two thirds of people in rural Africa consult sangomas before they go to a clinic that is, if at all, they consult a clinic. The province of Kwa-Zulu Natal where this study was conducted is inhabited predominantly by the Nguni people and therefore this was listed as a source of IK.

Other African ethnic groups, in South Africa mostly consult traditional healers also known as “eingaka,” or diviners. Traditional healers are able to access advice and guidance from the ancestors through divining. A traditional healer does not wear traditional uniforms or robes. He silently communicates with the spiritual world, (Masuku, 2008 conversation) without singing and dancing. Traditional healers, like sangomas are respected by the community partly because of their acquired knowledge, their age, their ability to provide answers and treatment that are meaningful to the community and their position as the moral core of the community (Masuku, conversation 7/11/08).

Studies that explored sources of IKS were considered for the survey. For example, sangomas were used as a source of IK (Khumalo, 2001) and elders in the community were a source of IK (Manzini, 2000). Sangomas and elders were listed as sources of IK.

Hence the following ten sources of IK emerged and were included in the survey to provide an indication of what sources teachers referred to for their teaching:

- RNCS/NCS
- University Module
- Elders in the community
- Media/books
- Stories and legends
- Regular practice of herbal remedies
- Traditional healers
- Sangomas
- Priests
- Parents/grandparents

In the survey (see Appendix C) the ten sources of IK were presented and a likert scale with three categories, labelled “greatly, somewhat and little” according to which the teacher participants were asked to rate each source of IK information. This indicated the extent each source of IK informed the way in which teachers conceptualized IK for implementation in the science classroom.

## 5.3 SOURCES OF TEACHERS' INDIGENOUS KNOWLEDGE

Establishing the sources of teachers' indigenous knowledge was important for two reasons. Firstly teachers' sources would inform them in the way they were conceptualising IK for the classroom and secondly different sources of IK might have a bearing on how teachers were thinking and planning to implement IK in the classroom.

It appeared from teachers' responses that the sources for the survey were well chosen since for most of the sources of IK listed in the survey, the majority of the teachers ticked "greatly". Therefore the category "greatly" was given more attention in the analysis. The sources of IK that was rated "greatly" by the participants were listed in rank order in table 7 below.

**Table 7: Science Teachers' Sources of IK**

| SOURCES OF IK | GREATLY | | SOMEWHAT | | LITTLE | | BLANK | |
|---|---|---|---|---|---|---|---|---|
| | COUNT | % | COUNT | % | COUNT | % | COUNT | % |
| University B.Ed Science Module | **19** | **82.6** | 2 | 8.7 | 2 | 8.7 | 0 | 0 |
| Parents/Grandparents | **18** | **78.3** | 2 | 8.7 | 2 | 8.7 | 1 | 4.3 |
| **Elders In Community** | **18** | **78.3** | 4 | 17.4 | 1 | 4.3 | 0 | 0 |
| RNCS/NCS | **15** | **65.2** | 3 | 13.0 | 5 | 21.7 | 0 | 0 |
| Regular Practice of Herbal Remedies | **14** | **60.9** | 3 | 13.0 | 6 | 26.1 | 0 | 0 |
| Traditional Healers | **13** | **56.5** | 5 | 21.7 | 5 | 21.7 | 0 | 0 |
| Media/Books | **10** | **43.5** | 7 | 30.4 | 5 | 21.7 | 1 | 4.3 |
| **Stories and Legends** | **9** | **39.1** | 10 | 43.5 | 1 | 4.3 | 3 | 13.0 |
| **Sangomas** | **9** | **39.1** | 6 | 26.1 | 7 | 30.4 | 1 | 4.3 |
| **Priests** | **9** | **39.1** | 5 | 21.7 | 9 | 39.1 | 0 | 0 |

There was a noticeable trend for teachers to score in the same way for similar sources of IK, for example the number of responses in the column under "greatly" were more or less the same for, elders in the community (78.3%) and for parents/grandparents (78.3%). Therefore the first step undertaken in the analysis of the survey was to collapse similar sources of IK. The two categories parents, grandparents and elders in the community were collapsed into a category. Similarly the following sources of IK were regrouped:

- Regular practise of herbal remedies (60.9%) and traditional healers (56.5%).
- Media/books (43.5%) and stories and legends (39.1%).
- Sangomas (39.1%) and priests (39.1%).

By doing this, the original ten sources were collapsed into the following six categories:

- RNCS/NCS
- University Module
- Parents/grandparents/elders in the community
- Media/books/stories and legends
- Regular practice of herbal remedies/traditional healers
- Sangomas/priests

### 5.3.1 University (Honours) Science Module

Of the 23 teacher participants in the survey an overwhelming number (19 or 82.6%) chose the B.Ed module (see appendix B for the outline of the module *Issues in Science Education*) as the most important source, which informed the way in which they conceptualized IK for the science classroom. Of the 19 respondents, 17 are African teachers (ten females and seven males) teaching at “ex-African” schools; the Coloured female, Lizzie teaching in an “ex-Coloured” school and the White female, Jane teaching in an “ex-White” school (see chapter four for explanation of categories of schools).

Surprisingly almost all the African teachers rated the university module as an important source when one would expect that they might have this information available to them at home and in their communities. Most of the African teachers may have chosen the module because as part of a university module it is recognized as official or institutional knowledge. Another reason could be that all the examples of IK used as the content of the university module were examples from African IK and since all the African teachers, except one, have only African learners this module then became an important source of IK for them. A third reason related to the methodology, for the B. Ed Module being selected by most of the respondents could be that the survey was administered on the last day of the coursework for the module. By the end of the coursework teachers would have had a great deal of exposure, discussions and understandings of IK, which may have influenced their source.

An interesting point to note is that four of the teacher participants from this group of 17 qualified their choice by reference to their background.

Firstly they referred to their own experience and practice. For example Pindi made the following statement: "*My understanding came from the B.Ed module but it was something that we practiced in the rural area" (FI).*

Secondly they qualified it by reference to their knowledge and awareness of IK as they were growing up. This is reflected in the following comments:

> *"My understanding developed from the university, but I knew about it while growing up" (Toko's TI).*
>
> *"The university module informed my concept of IK but I grew up knowing some of this knowledge*" *(Hlona TI).*
>
> *"It came from the university. I had this knowledge but I didn't know that it was called indigenous knowledge systems*" *(Nomsa TI).*

Another reason for their comments is perhaps their interpretation of the notion of "source" as being the source where the indigenous knowledge originates. They chose the B.Ed module as their source but also recognised that the education programme itself was deriving its knowledge from elsewhere, perhaps not regarding the university as the primary source but rather as a secondary source.

While 17 African teachers chose the B.Ed module as an important source there were also three African respondents - Pretty, Nomagugu and Zama (8.7%) who did not regard the university module as the primary source of their IK. It is worth noting that all three teachers work in rural contexts and are females. A closer look at the data revealed that all three teachers prioritised the following three sources of IK in their survey: parents/grandparents/elders in the community, regular practice of herbal remedies/traditional healers and Sangomas/priests. These teachers seemed to have prioritised original oral sources of IK. It may be that these three sources of IK are especially important to the teachers because they are relevant in the rural areas in which they teach or that they have more personal knowledge of IK outside the school and the university.

It is not surprising that two of the teacher participants Lizzie (Coloured) and Janine (White) chose the B.Ed science module as the most important source, given that all examples used by the university lecturer (who was a White female) were from an African context and that these teachers have African learners in their classes. Therefore this is likely to be an important source of IK information for them.

Lizzie clarified her reason for selecting the university module as an important source as follows:

> Lizzie: "*My understanding of IK came from the module, Issues in Science Education. I thought that it (module) was very good and lecturer's examples (of IK) were good" (TI).*

One remaining respondent that did not regard the university module, as the most important was the Indian male, Deva who stated the following reason:

> *"For me at this stage (module) IK was new and abstract. Initially, I thought of it as knowledge-in-passing and superficial" (FI).*

Perhaps he did not regard the B.Ed module as an important source because the examples used in the module were IK examples from the Life Sciences and Deva teaches Physical Sciences so he did not consider the examples in the module as relevant for his own teaching.

### 5.3.2 Parents/Grandparents/Elders in the Community

The second most selected source that informed the way in which teachers conceptualised IK for the science classroom were their families and people in the community. Eighteen (78.3%) teachers indicated that parents, grandparents and elders in the community greatly informed their concept of IK. However, a closer look at the data revealed that the respondents who were part of the 18 included 16 Africans, (11 females and 5 males) and two “non-Africans”, Lizzie and Deva.

The only respondent who indicated that parents/grandparents/elders in the community played a small role (little) in informing her concept of IK was the White female, Janine. She is from an urban area and teaching in an urban private “ex-White” school. Her choice may stem from cultural differences and her own background about how families live. Semali, (2000) argues that in societies that are undergoing rapid change, the extended family system is giving way to urban style nuclear families. Nuclear families may be perceived as dominant of the White culture in United States (Egan and Kadushin, 2005) and this may not be very different for the White South African community. Semali, (2000) further argues that nuclear families do not have the support and kinship of elders, which exists in extended families, consisting of persons across multiple generations. This could possibly be seen as a reason for her response that parents/grandparents and elders in her community played a small role in informing her concept of IK.

Another possible reason could be due to her particular conception of IK as belonging only to the African culture. This teacher prioritised university module, RNCS, books and media, thereby giving more recognition to official written sources of IK than the oral sources.

Some of the African teachers also did not indicate parents, grandparents and elders as the main source even though they were aware of this knowledge. This is reflected in the following comments made by two of the respondents:

> Toko: “*I learnt about this (IK) while growing up. We also used it” (TI.)*
>
> and

> Hlona: "*I knew about this (IK) but the word Indigenous knowledge system is new to me. It happens at home by our parents and grandparents. Learners have this knowledge and come to school with it" (TI).*

Speculation on reasons why these teachers may have chosen "somewhat" are: they may not have valued it as knowledge for school science, or knowledge from elders is not "packaged" as school material and did not know how to deal with it in the classroom, or perhaps even if they did know, they did not want to do so because of the "sacredness" of this knowledge to particular settings.

### 5.3.3 <u>Sciences in the RNCS and NCS</u>

Fifteen teachers (or 65.2%) of the sample indicated that the RNCS document greatly informed their concept of IK. Mkiza's valuing the RNCS as a source might be linked to the formalising and legitimising of IK in the curriculum as articulated in the following:

> Mkiza: "*I am happy now we are having the awareness-what happened in the past and what is still happening in the present. Science is involved when you look at the RNCS*" *(TI).*

While some teachers rated RNCS as a source greatly informing their concept of IK, they gave conflicting statements in the interviews. For example Toko said:

> *"The RNCS helped me with the outcomes of OBE, but not IK. I asked colleagues and community for examples of IK. There's none in RNCS" (TI).*

Hlona too, indicated that the RNCS was an important source of her IK but provided an opposite point of view as echoed in her statement:

> *"About the RNCS- I'm still confused. I can't link it (IK) clearly" (TI).*

A reason for this anomaly could be that when this data was collected, during the actual process of lesson preparation, which took place after the survey, they

discovered that the RNCS and NCS documents were of little assistance for preparing "IKS in science" lessons. This may be linked to the RNCS and NCS being silent on strategies and examples of IK for lesson development, and to teachers' expectations for greater guidance. It appears that the curriculum policy document as a source of IK is a partial source that might help provide awareness but is inadequate for the practical purposes of lesson development.
For both Lizzie and Deva, who selected the RNCS as "somewhat" as a source there appears to be an expectation from the curriculum policy that was not met. Deva holds the following point of view with regards to the policy document:

> Deva: *" However, I don't know how much or what strategy I should use to include IK in the lessons. The National Curriculum Statement does not spell out how IK should be included in lessons and does not give any examples" (FI).*

Drawing from the telephone interviews, the following comment was made by Lizzie:

> Lizzie: *"I used a latest textbook, which helped me with my assignment and talking to colleagues and trying to make sense of it. The NCS document did not help me. I mean it just makes a statement but it doesn't give you any examples or anything" (TI).*

A reason, for Lizzie and Deva indicating that the university module, as a source of IK which moderately informed their concept probably relates to the subjects they taught. Both teachers, taught Physical Sciences and examples used in the university module were strictly within the Life Sciences context making the IK examples used in the module of little relevance to them. The module also examined only the Life Sciences Policy document and linked it to Life Sciences topics in the curriculum. Therefore an important reason for this view is probably because of the absence of both Physical Sciences examples of IK and the Physical Sciences Policy document in the module.

A significant number of respondents - five African teachers (21.7%) - revealed that the RNCS and NCS were of little help in developing their concept of IK. The five teachers comprised two African males and three African females. One of the respondents Pindi who opted for “little” (concept) was consistent in her rating as illustrated in her interviews.

Pindi: “*The NCS document provided very little guidance for the assignment* (practice)” *(TI) (FI).*

Overall the statement above indicates that the Curriculum Statements were of little help in practice, such as drawing up lesson plans, examples of IK and ways to integrate IK into science lessons. As a National Curriculum Statement the policy documents do not provide guidance on how to accommodate the notion of “alternative ways of knowing” or how one might go about implementing a science curriculum including IKS.

### 5.3.4 Regular Practice of Herbal Remedies and Traditional Healers

A relatively high proportion of the teachers, namely 60.9% in the survey indicated that regular practice of herbal remedies greatly informed the way in which they conceptualized IK. This group of thirteen teachers comprised two African males, nine African females and Lizzie and Deva. The examples that teachers gave of practicing herbal remedies cut across different cultures and IK systems:

> *“In the Hindu culture we use a special thing called “munja” (tumeric spice). A mixture of that is put on the face to cool it-for measles, smallpox and chicken pox. I think that reduces the temperature so you don’t have a fever” (Deva FI).*

> *“After the baby is born, we give the mother, “umthelelo”, which is a herbal mixture to cleanse the mother. All along we were dealing with this (IK) and it was so helpful”(Bongi TI).*

> “Yes, Yes, also we were using it- taking it (herbal remedies) because I’m living in a remote rural area far away from the clinics. We learnt about the herbs from our mothers, our forefathers and from the local area”(Toko TI).

> *"My mother alerted me, my sisters and brother while we were growing of up the different herbal remedies such as flour mixed with water to stop diarrhoea and the use of cabbage leaves pressed around the breast to stop lactation. I have used both these remedies myself and I must say they have worked" (Lizzie FI).*

Thirteen of the teacher participants, all Africans, indicated that traditional healers were a very important source of IK for them. However, not all of the African teachers regarded this as an important source. At least eight of them considered traditional healers as a moderate to small source. It is not surprising that the three "non African" teachers did not indicate traditional healers as a significant source since traditional healers are a significant part of African culture.

From the above statements it seems that herbal remedies are used universally across cultures but traditional healers belong to the African culture.

### 5.3.5 Media/Books/Stories and Legends

From the survey it was found that ten teachers highly prioritised stories, legends, media and books as a source of their IK. This equals to less then half of the sample. While Lizzie regarded textbooks as an important source:

> *"I used one latest textbook, which helped me with my assignment and talking to colleagues and trying to make sense of it" (TI).*

Deva expressed an opposite view, which is reflected in the following statements:

> *"Our textbooks do not cater for the diversity in my class. There is no formal writing where you can quote references as compared to other articles from journals etc.," (FI).*

Although Lizzie used one textbook she seems to imply that the source was inadequate because she engaged colleagues as well.

Twelve teachers indicated that media/books either moderately or slightly informed their source of IK. From the ratings it seems that a lack of resources is one of the challenges facing teachers in integrating IKS and is supported by Naidoo (2002), who argues that there is a lack of adequate written resources addressing IKS issues.

Nomsa and Pindi who prioritised learning from stories saw storytelling as a simple and effective way of learning:

> Nomsa: "*In the evenings our grandparents shared stories about our customs. Many fables had important lessons for us to learn" (TI).*

> Pindi: "*Many legends and myths are told to children to instil moral values. The myth that if you are a boy and you urinate in the river you will turn into a girl. This story puts fear into children and stops them from urinating in the river. The aim of this myth is to prevent pollution of the river because in the rural areas water for drinking is collected from the rivers" (FI).*

### 5.3.6 <u>Priests and Sangomas</u>

The same teachers indicated that sangomas and priests "greatly" (9) informed their source of IK. It appears that these teachers regarded sangomas and priests as the same source of IK. All nine teachers were African, seven females and two males. It is not surprising that nine teachers prioritised sangomas as a source of IK since, according to Binsbergen (2006), it is a well known fact that the majority of Africans in Kwa-Zulu Natal consult sangomas as their primary, and sometimes, exclusive healer. Pindi who indicated that this was an important source made the following comment in the interview,

*"I think that sangomas have a very important role to play in healing illnesses, especially in children" (TI).*

She also considered her experience as *"real"* because it was practised in her presence and *"it really worked" (FI).* For Pindi, sangomas play a role in healing comparable to medical doctors in Western societies.

However, not all African teachers prioritised sangomas or priests as their source of information. The rest of the African teachers (13) indicated that sangomas either moderately or slightly informed their source of IK. This unit of teachers also included Deva, Jane and Lizzie. Lizzie made the following comment:

> *"I was told by my mother that this ceremony must be performed on the 8th day after the baby is born as there would be no bleeding. I think she got that from the priest and the Bible. As a coloured community, we do not have sangomas. It belongs to the Africans" (FI).*

Unlike the group of teachers who regarded sangomas and priests as identical, Lizzie's view of priests is different to her view of sangomas. While she respects the knowledge of the priest she regards sangomas as purely African. The difference between sangomas and traditional healers, according to Masuku (2008), is mainly related to the manner in which they access the wisdom of ancestors. In the case of the sangomas this is done through bone throwing, singing, dancing and going into a "trance-like" state while with traditional healers there is no singing or dancing, instead they silently communicate with the spiritual world.

While sangomas, traditional healers and priests were an important source of IK for some teachers, others were moderately or slightly informed by this source. Traditional healing is part of an alternative way of knowing that prompts understanding and meaning making, a "rationality" that is opposed to western systems based on western rationality. Western science knowledge is viewed as "rational, analytical and objective as opposed to other forms of epistemological consciousness such as IK which is described as non-scientific, irrational and inappropriate. These issues were previously not raised in the classroom because curricula were "sanitised". The inclusion of IK in science curriculum now provides grounds for postcolonial discourses as a way of deconstructing and scrutinizing cultural assumptions inherent in western thinking. Teachers to be agents of such curricula need to have postcolonial awareness.

Besides these sources, teachers say that their conceptualisation of IKS for the classroom, was informed by a range of sources, with the university module being the most significant, followed by parents, grandparents and elders. The next section examines how teachers draw on these sources, some of which may be part of their personal knowledge in interpreting and planning for the teaching of science to include IKS.

## 5.4 PLANNING FOR TEACHING AND LEARNING OF IKS

In the previous section, teachers' sources of IK, which may influence the way in which they conceptualised IK for the science classroom, was explored. In this section, the focus is on the ways in which teachers interpret IK and translate it into their lessons plans. Tasks one and two of the assignment on IKS that teachers designed as part of the B.Ed (Hons) science module were analysed to explore how teachers were thinking and planning for "IKS in science" lessons. The teachers were required to design two lessons in which IKS was integrated. The first task was to develop a lesson incorporating an IKS technology in a science lesson. In the second lesson teachers were required to select a cultural belief or myth that conflicted with modern science and to explain how they would attempt to reduce conflict between these two perspectives. In both these tasks teachers had to pay particular attention to learner activities (see Appendix B). "***Task one****: Design a lesson in which you integrate an indigenous technology. Select a topic from the Life Sciences, Natural Sciences or Physical Sciences curriculum and explain how you would use an example of an indigenous technology in your lesson. Explain the activities that learners would engage in and how learners would engage with indigenous technology.*
***Task 2****: Name a myth and belief of phenomena that learners have brought to class that conflicts with scientific facts about these phenomena and design a lesson to explain how you would attempt to resolve the conflicts that may arise".*

The framework that I used for analysing each of the above tasks mainly draws on the "five-step process" model as outlined by Snively (1995). I integrated aspects from Malcolm's (2001) "learner-centred model" which also pays particular attention to the "learner-centred and activity based approach" advocated by the new curriculum (DoE, 2002a, b and c), in re-interpreting Snively's (1995) model to create a more appropriate framework for analysis of the tasks.

Snively's (1995) five steps are presented and how each step was adapted for the analysis is outlined.

**Step 1 Choose a science concept or topic of interest.** For Snively this means identifying science concepts or topic of interest related to, for example, agriculture, animal migration, sustainability). It is assumed that where (urban, periurban or urban) and what (Natural Sciences, Life Sciences or Physical Sciences) teachers teach may influence their choice of topic. Teachers may also choose examples and contexts that relate to students' interests (environments).

**Step 2 Identify personal knowledge.** This step was reorganised and called "teachers' personal knowledge" because teachers' personal knowledge of the topic may have a bearing on how IK was built into the lessons. According to Snively (1995) personal knowledge may be cultural, social or environmental and about respecting the beliefs of others. These aspects of teachers' personal knowledge are considered to be important in how teachers might manage IK in the classroom. Although Snively discusses "brainstorming" to identify personal ideas, beliefs and opinions under step 2, in my analysis brainstorming" is not discussed under teachers' personal knowledge but under step3. The reason for this is that "brainstorming" in the lesson plans were interpreted by the teachers to mean learner activities.

**Step 3 Research various perspectives.** Snively's understanding of research means research of western and IK perspectives from the community and identifying similarities and differences between the two perspectives. This step was also reorganized and called "teacher-designed learner activities" because, in the tasks, teachers interpreted research to mean that learners would research perspectives from the communities.

Research was integrated with "brainstorming" and re-interpreted in the analytical framework as, "teacher-designed learner activities." This step draws on Malcolm's (2001) "learner-centred model" which has important components that can make lessons more culturally relevant by focussing on the knowledge (IK) that the learner brings to the learning situation (Malcolm, 2002). The model also focuses on pedagogy – choosing examples and contexts that relate to students' interests (environments) in helping them extend and reconstruct their knowledge in ways that engage diversity. Further, Freire (1994) suggests that allowing students or individuals to have ownership of their knowledge is equivalent to respecting their culture, tradition, and identity.

**Step 4 Reflect.** Some aspects considered by Snively under this step are: to consider the consequences of each perspective; to consider the issue of values, ethics and wisdom, to consider the issue from a historical perspective and to build consensus. This aspect was significant, as it would indicate teachers' sensitivity to IKS, which in turn would influence their approach to IKS in the classroom. A feature of Snively's step 3 - "identify similarities and differences between the perspectives" was incorporated in this phase since reflection in the South African context is a process of thinking about events, knowledge, methods, etc. in order to analyse them (DoE, 2007). The Norms and Standards for Educators or NSE (DoE, 2000a) too, as a post-apartheid strategy for change endorses such an expectation because one of its propositions is that a teacher should develop a reflective competence.

**Step 5 Evaluate the process.** According to Snively's interpretation this means evaluating possibilities in terms of future inquiries and evaluating the effects of one's actions. The process of evaluation is critical in contributing to the kind of teacher envisaged in the RNCS and NCS, as one of mediator of learning as well as interpreter and designer of learning programmes. Since evaluation is significant to improving professional practice of teachers, it was retained. However, in the analysis, reflection and evaluation will be discussed together.

The re-interpreted framework builds on the constructivist view of learning, which is evident in the recognition it gives to personal knowledge. The model seems to embrace a critical perspective in step 3, by "reconstructing knowledge in ways that engage diversity" and in step 4, which provides for issues of "values and ethics."

### 5.4.1 <u>Task one -Lesson on Indigenous Technology</u>

Out of the 23 teachers in the survey, assignments from ten teachers were analysed (see table 5 in Chapter four). I analysed tasks one and two of the assignments separately by using "Snively's (1995) re-interpreted Five Step Model" to determine how teachers interpreted IK for the classroom and then attempted to link the ways in which they interpreted IK to their sources of IK indicated in the surveys. Data from the interviews was also used to provide more details on how teachers were thinking of implementing IK for the science classroom.

The following are the general trends that emerged from the analysis of the lesson plans (see Appendix H for analysis).

#### *5.4.1.1 IKS Topic*

The topics that teachers chose for their tasks was analysed and is presented in table 8:

**Table 8: Topics Selected by Teachers based on Indigenous Technology**

| Teacher participants | Learning Area being taught | Task from Learning Area | Science /IKS Topic |
|---|---|---|---|
| **Lizzie** | **Physical Sciences** | **Physical Sciences** | **Electromagnetic/clay masks** |
| **Deva** | **Physical Sciences** | **Physical Sciences** | **Chemicals/Storage of maize** |
| **Pindi** | **Natural Sciences** | **Natural sciences** | **Conductors and insulators/thatched roofs** |
| Toko | Natural Sciences | Natural Sciences | Soil types/clay utensils |
| Bongi | Natural sciences | Natural Sciences | Conductors and insulators/thatched roofs |
| Hlona | Natural Sciences | Physical Sciences | Anaerobic respiration/ homemade beer. |
| MhkizA | Natural Sciences | Natural Sciences | Forces/ rotation of wheels |
| Sithemba | Life Sciences | Life Sciences | Nutrition/herbal remedies |
| Zama | Natural Sciences | Natural Sciences | Seasons, time/use of stars |
| Zondi | Natural Sciences | Physical Sciences | Chemical reactions/food preservation |

All the teachers, except Hlona and Zondi chose topics from Learning Areas that they were teaching. Although Hlona and Zondi were both teaching Natural sciences (from grades 7- 9) they chose topics in Physical Sciences (grades 10-12). Their personal knowledge of IKS, which they indicated that they had, may have provided them with the confidence and security to choose lessons in Physical Sciences, an area that is often perceived as being more difficult than the other sciences.

All topics seem to be more relevant to rural areas where most of the teachers were teaching. One of the teacher participants, Zama developed a lesson on a topic from the newly introduced strand, “Earth and Beyond,” in the Natural Sciences Curriculum. She indicated the Internet and books to be valuable sources of information for this task.

Although the teachers were given a choice to prepare any IKS lesson, all ten teachers chose to design a lesson in the African context, including the two non-African teachers. When the non-African teachers were asked to comment about their choice, they indicated that African indigenous knowledge was easier to access. Only African IKS examples used in the university module that they were taught may also have influenced this choice. This could also be related to their perceptions that IKS in the South African context refers only to African IKS or was influenced by African learners in their classes. This perception may stem from the Curriculum Statement making reference to “re-discovering of valuable knowledge lost over the past 300 years as *people* were forced to move off their lands” (DoE 2002a: 10) by giving the impression that people did not have IK before 300 years ago. However, in the interviews held after the development of the tasks, Pindi, Lizzie and Deva indicated that they were aware that other cultural groups had their own IKS.

#### *5.4.1.2 <u>Teachers’ Personal Knowledge</u>*

The five teacher participants who indicated in their lesson plans that they possessed personal knowledge of the topic (IKS) were Toko (making of clay utensils), Hlona (beer-making), Sithemba (use of herbs), Zondi (food preservation) and Pindi (African huts)- all African teachers. It is not surprising, because three of the teachers, Toko, Hlona and Pindi, also reported in the interview that they learnt and knew about IKS while growing up. Although Bongi did not disclose whether she had personal knowledge about the topic in her lesson plan, in the interview she related her practice of herbal remedies. This could be due to the fact that she did not have personal knowledge on the topic that she chose, which was on “conductors and insulators.”

Three teachers Lizzie, Deva and Zama indicated that they used the latest textbooks and other written material, to obtain examples of IKS for their tasks. The value Lizzie attached to textbooks in the designing of her lesson was also prioritised as a source of IK in the survey. Despite Lizzie and Deva’s reliance on textbooks they complained in the interviews that these resources were inadequate because there were few examples of IKS and even those examples were not done with much cultural inclusions, for examples, activities relating only to cultural legends and pictures of cultural musical instruments. These “superficial” representations in textbooks may distort teachers’ understandings of IKS.

#### *5.4.1.3 <u>Teacher- Designed Learner Activities</u>*

The five teachers who indicated that they would assess personal knowledge of learners were Deva, by using “questionnaires”, Pindi and Hlona by “brainstorming”, Toko by, “baseline” assessment and Sithemba by “concept maps”.

However, all ten teachers indicated that they would request learners to research from parents, elders and other community members, draw on elders’ wisdom and bring this information to the classroom. In this way the IKS will become “accessible to other learners” (and the teachers) (Deva and Pindi FI). Having acknowledged elders as custodians of cultural knowledge suggests that the teachers are aware that elders in the community hold this expert knowledge. This concurs with the survey in which all ten teacher participants prioritised parents, grandparents and elders in the community as their source of IK.

In the interviews some teachers indicated that they would accept the cultural and experiential knowledge that learners bring into the classroom. This is reflected in what Bongi expressed:

> *"The learners have a lot of cultural knowledge that they talk about in the classroom and it can be used as resources. It would make me a better teacher to see another's point of view because we have all been brought up in different communities. By allowing different viewpoints to be discussed might make learners to value their knowledge" (TI).*

The above statement also indicates that the teacher is aware of the various forms of specific knowledge that students gain from living and working in their communities and homes or from other local activities. Some of the areas in which teachers presumed rural African learners to have knowledge in are, for example, homemade beer (imfulemfula), use of herbs, and the traditional storage of food. This is not surprising because beer making is an essential practice for African ceremonies and festivities in both rural and urban areas. So too, is the practice of herbal remedies for healthcare and storage of food in the absence of refrigeration.

#### *5.4.1.4 Reflection/Evaluation*

Seven teachers who indicated that they would consider similarities and differences between scientific and IK perspectives were Lizzie, Pindi, Toko, Bongi, Hlona, Zama and Zondi. The one way, as Lizzie discussed in the assignment, how she would further build on the lesson after examining similarities and differences between the perspectives was for learners to examine the advantages of a combined perspective, that is, clay masks and commercial sun protection. Learners would also indicate which one is superior. A possible reason for this may be that it alludes to her own value system. In her interview she expressed the same method of dealing with IKS information brought by learners to the classroom.

*"I will validate IKS brought by learners against my own scientific background. They can tell you an experience and you as a teacher can help them maybe restructure it in a more scientific way. Their knowledge is good but it is just the way they present their work. It is not scientific. So you can use their work and show them how to present it-forming a hypothesis, designing experiments and coming up with conclusions to either prove or disprove it" (FI).*

For Lizzie utilising the language of science to re-format learners' experiences, seem to suggest that she regards science as being the validating framework. It can be observed that teaching science is seen as an orderly, logically sequenced process in which knowledge is acquired by a systematic testing of ideas and IKS is measured and integrated against and within this framing.

A second way as evidenced by Deva and Mkiza was to keep activities and discussions of IKS and science perspectives apart. Speculations on possible reasons for this approach could be that they did not know how to bring IKS and science together or that they did not consider IKS as science and therefore kept them apart.

Deva emphasized that if IKS and western scientific knowledge were viewed with the same importance it would give learners pride and dignity to be South African citizens and that IKS will take its rightful place with other knowledge systems whilst at the same time upholding the values in the constitution of SA. In his lesson plans, he considered the concept or "issue of values, ethics and wisdom" and allowed for the existence of differing perspectives. Central to his argument was that the western view of science is linked to the centralization of power and control, as well as oppression. This change in direction in education is advocated by many postcolonial theorists and writers.

It is possible that Deva's background as a political activist and a unionist, which he shared during the interview, may have some bearing in the manner in which he has planned to conduct his lessons. In keeping the knowledge systems apart it might appear that he respected IKS and viewed it in the curriculum only as a means of addressing issues of equity and social justice and not as *science per se*. Deva dealt with task two on myths and beliefs in the same way. Lizzie, Zama and Zondi considered the IK topic from a historical perspective providing a broader interpretation of IKS. Only one teacher Hlona who chose the lesson on "homemade beer" indicated that he would try to build consensus between the perspectives IKS and science. For Hlona her interpretation of IK for science lessons might be seen as a way to merge the two perspectives.

## 5.4.2 Task Two –Lesson on Conflicting Myths and Beliefs

As part of the B.Ed module teachers had to indicate how they would use myths and beliefs in teaching and how they would attempt to reduce conflicts in the classroom since most myths and beliefs do not resonate with western science.

For task two, as well, the same framework was used for analysis (see Appendix H for analysis).

### *5.4.2.1 Topic- Myths and Beliefs-*

Topics chosen by teachers for task two on myths and beliefs are as follows:

**Table 9: Topics Selected by Teachers based on Conflicting Myths and Beliefs**

| Teacher participants | Learning Area being taught | Task from Learning Area | Science /IKS Topic |
|---|---|---|---|
| **Lizzie** | **Physical Sciences** | **Physical Sciences** | **Electricity/lightning** |
| **Deva** | **Physical Sciences** | **Physical Sciences** | **Electricity/lightning** |
| **Pindi** | **Natural Sciences** | **Natural sciences** | **Electricity/lightning** |
| Toko | Natural Sciences | Natural Sciences | Evaporation/ancestors drinking beer |
| Bongi | Natural sciences | Natural Sciences | Formation of day and night/indigenous story |
| Hlona | Natural Sciences | Physical Sciences | Sex with virgins cures HIV/AIDS |
| Mhkiza | Natural Sciences | Natural Sciences | Shadows and rotation of earth/indigenous story |
| Sithemba | Life Sciences | Life Sciences | Immunisation by cutting and rubbing *'muti'* in the wounds |
| Zama | Natural Sciences | Natural Sciences | Menstruation and indigenous stories |
| Zondi | Natural Sciences | Physical Sciences | Electricity/lightning |

All myths and beliefs that teachers used as topics for lessons were from the African context. The fact that two African and two "non-African" teachers chose to design lessons on causes of lightning suggests that this belief is well- known across most cultures. The content of the module also indicated that "inyangas causing lightning" was a topic of discussion during the coursework. In the African community lightning is believed to be caused by people to do harm, such as kill a person or put an end to a ceremony. This does not reconcile with the science, that lightning is a natural phenomenon and raises the question, how can teachers resolve the conflicts and tensions that such discussions might bring to the classroom?

#### *5.4.2.2 Teachers' Personal Knowledge*

Five teachers indicated that the beliefs chosen, as lesson topics was either from their personal knowledge (Bongi), their culture (Zama) or tradition (Zondi) which they gained from parents, grandparents, elders (Pindi) and communities (Mkiza). Although Mkiza indicated that he was aware of the myth from the community he also accessed the myth from "modern textbooks", such as Natural Sciences books recommended by the Department of Education's School textbook catalogue. He drew on one particular textbook content on the "universe" which included an African ancient belief about the moon. Lizzie, Deva, Toko, Hlona and Sithemba did not give any indication whether they had the personal knowledge or whether they used textbooks for the lesson plans. It might be assumed that their sources of IK as indicated in the survey were used to inform them in interpreting this task.

#### *5.4.2.3 Teacher- Designed Learner Activities*

Five African teachers indicated that they would identify learners' personal knowledge by "brainstorming", topics such as "ancestors drinking beer, beliefs about HIV/AIDS, formation of day and night and African beliefs on the causes of lightning. These teachers assume that learners have knowledge on these beliefs. At least seven teachers requested learners to research the myths and beliefs from their communities. From this group of seven, Zondi indicated that learners would go specifically to *'inyangas"* (traditional healers) who were considered the "experts" in the community. It is not surprising that he would choose this route since he was aware that IKS resided with traditional healers and indicated that traditional healers was a very important source of IK for him.

All four teachers who chose the topic “causes of lightning” designed conduction of experiments as part of learner activities. Mkiza indicated that learners would conduct experiments on the rotation of the earth. From this group of four teachers who chose causes of lightning Pindi indicated that learners would compare their beliefs and science explanations whilst Zondi reported that learners would debate both the perspectives.

#### *5.4.2.4 __Reflection and Evaluation__*

In dealing with myths and beliefs none of the teachers indicated how they would reduce or resolve conflict. Perhaps they were unaware that it existed or did not know how to do so. The manner in which the teachers dealt with the myths and beliefs and western science in the reflection step can be analysed in three groups: those that linked IKS and western science; those that kept both perspectives separate and; those that engaged with only one perspective - either IKS or western science. Those that linked IKS and western science were, Lizzie who tried to see how IKS aspects bests matches science, Pindi who linked the history of the myths to science probably to find out what informs the myth to provide a broader understanding in context, Toko and Hlona who engaged with both perspectives but indicated that they would choose the science perspective while Bongi, Sithemba and Zondi who also engaged with both perspectives but did not indicate which route they would take, the scientific or the IKS route. Deva was the only teacher who chose to keep the perspectives separate. Two teachers (Mkiza and Zama) engaged with only one perspective. While Mkiza engaged with only science and indicated that he would choose science, Zama engaged with only the IKS and chose this perspective.

Bongi, Sithemba and Zondi who teach in rural schools reported in their lesson plans that they have this personal knowledge from their traditions and cultures. A possible reason for their ambivalence could be that they did not want to make the belief available and visible or they could not make judicious choices or chose not to resolve the issue.

Were these teachers aware of the complex dynamics and conflicts that may arise when involving complicated philosophical issues? Or did the teachers feel that by exposing the learners to both the traditional belief and the claims of science they would empower learners to evaluate both systems and then make an informed decision about the conduct of their lives?

Lizzie responded to the teaching of myths by the following statement:

> *"I would do the whole scientific explanation of how lightning is formed and I would leave it then to the learner to decide. But I hope that my scientific explanation would make it clearer and understandable to them" (FI).*

Although the above excerpt indicates that the teacher wants to maintain a neutral stance and not influence learners' decisions, by implication she suggests that she expects them to choose the scientific knowledge.

The only teacher who indicated that she would take the IKS route was Zama, an African female, and teaching in a rural school. It may be expected for her to choose the belief on African myths about menstruation, because this belief may be held sacrosanct by her community because she specified it to be part of her culture. Her decision to embrace the indigenous knowledge could be related to her own experiences or respect for the authority of elders in the community.

Deva on the other hand indicated that he would consider the possibility allowing both perspectives to exist alongside each other. The following vignette from the interview with him shows how he would deal with myths in the class, which concurs with his lesson plan.

> *Researcher: "If it (myths) comes up in the class how would you deal with it?"*
>
> Deva: "*Myths come with contradictions with science. (Learners must) Keep the belief, but provide the scientific explanation. This is how science explains it, don't destroy the belief, but it doesn't mean that it is the scientific explanation. Learners had to speak about it" (FI).*

One teacher, Mkiza whose topic was on the "rotation of the earth" presented only the science view. He did not engage with the belief possibly because he did not know how to do so.

## 5.5 CONCLUSION

Teachers say that they draw on a wide range of sources of IKS with the university module being their most important source. The second, most selected, source was parents, grandparents and elders in the community. The third highest category chosen was the RNCS and NCS, followed by regular practice of herbal remedies/traditional healers and stories and media. The category that least informed the teachers was sangomas and priests. Topics chosen for the tasks of lesson development were from either the Learning Area being taught at school or from their personal knowledge. A common feature of the tasks was that all ten teachers designed learner activities to use parents, elders and the other community members as sources of IK. In interpreting IK for the classroom they attempted to link it to their sources of IK.

Teachers' lessons ranged from indigenous knowledge that was highly consonant with western science (indigenous technology) through to situations where conflicting claims (myths/beliefs) were involved. The way in which teachers engaged with the lessons can be grouped into the following categories: Engaging with only one perspective "science" or IKS; keeping both knowledge systems separate; using a "combined" approach. The chapter concluded with a discussion of the different approaches used by the teachers in interpreting IK for the classroom.

The second level analysis presented in the next chapter draws from the data in the second and third phase that is, the implemented/actual phase and the reflective phase, which consists of face-to-face interviews, classroom observations and reflective interviews. It deals with the construction of narratives from the data for the three teachers who formed the three case studies, that is, Lizzie, Deva and Pindi. The analysis addresses how teachers implement IK in the class and the third critical question of why the teachers interpret and implement it in the way they do. The question of why they implement it in the way they do will be further elaborated and theorised in chapters seven and eight.

# CHAPTER 6

## WHAT TEACHERS DO WITH IKS IN THE CLASSROOM

In the previous chapter a range of sources of IKS, which informed teachers and how teachers planned to use these in their teaching of "IKS in science" lessons were presented.

This chapter attempts to address mainly research questions two and three, namely how teachers interpret and implement IKS in the science classroom and why do they interpret and implement IKS in the ways that they do. It presents a second level of analysis by developing three narrative cases by making use of information gained from the face-to-face semi-structured interviews, classroom observations (video-tapes) and reflective interviews conducted with the three the teachers [vignettes and excerpts from the data were used to construct narratives for each case].

This chapter provides a narrative for each of the three teachers, Lizzie, Deva and Pindi. In each narrative the data, in addition to describing the personal and school background of the three teachers, describes what sources of IK they draw on, their "IKS in science" lessons and how they view IKS and the school curriculum. The relationship between science and IK and excerpts from the interviews provided their reflections on their lessons. In the concluding section three different emerging approaches capture what teachers do with IK in the science classroom.

## 6.1 LIZZIE'S STORY

- **Personal background**

Lizzie was born in rural KwaZulu Natal and spent the major part of her growing up years on a farm. She was one of the siblings of a family of eight. She belonged to what may be described as a traditional family that is, having both parents. Her mother, as a young girl, lived with a farming community among culturally diverse groups of people, namely, Africans, Indians and Coloureds. Her experiences were shaped to a large extent by the community. Her mother is Coloured and her father is Indian and is Muslim by faith while she is a church-going Roman Catholic. Lizzie's tertiary education involved attending a university where she obtained a Bachelor of Science degree with majors in Chemistry and Applied Chemistry. On completion of her degree she was appointed as a Physical Sciences and Mathematics teacher at a historically coloured school.

- **School Background**

Lizzie currently teaches Physical Sciences at the Redvale Secondary School, which is an "ex-Coloured" school (historically demarcated House of Representatives) in Wentworth, a suburb of Durban where predominantly Coloured people live. Redvale Secondary is located in a low socio-economic area of Wentworth. The school's population is still mainly Coloured with a minority of African learners.

### 6.1.1 Lizzie's Indigenous knowledge

- **Personal experience**

Lizzie's informal IK was largely shaped by her mother and senior family members. Her mother's own IK was shaped by members of the community, (predominantly African and Indian) in which she lived. Some of the indigenous knowledge that her mother passed on to her were the different herbal remedies such as flour mixed with water to stop diarrhoea and the use of cabbage leaves, pressed around the breast, to stop lactation. In the interview she reported that she used both these remedies successful, for example when she returned to work after maternity leave she used cabbage leaves on her breasts, which intercepted the lactation. According to Lizzie this is a practice she will pass onto her children. She indicated that she would use only those remedies passed down by her parents, and elders in her family, as she believes these are valid and do not question them. Those that do not come from her parents and elders she questions, and does not believe in for example, the *"Indian practice of using camphor oils and camphor bags around the neck of someone who has influenza."* In these instances she prefers western practices.

Her mother also provided her with indigenous knowledge of ceremonies, for example the circumcision ceremony of her two sons. The ceremony must be performed on the 8th day after the confinement of a baby since there is no bleeding. After the foreskin was cut she used oils that her mother taught her about, to keep the wound moist so that it would heal. She thinks her mother learnt this from the Bible. She claims that this knowledge does not hail from doctors.

- **School Experience**

Lizzie maintained that as a school learner she had no exposure to IKS knowledge. Instead she was taught what she understands to be western science knowledge.

> *"We were taught Western science knowledge and the textbooks we used were mostly imported from the United Kingdom. The examples of plants and animals used in the texts were examples from Europe. This is what my friends and I wanted to identify with, because we were subtly told that everything from the 'west is best.' Schools taught us other cultures besides our own. We learnt about the British and Americans. In fact whatever the Western people tell us we treat it as Bible. People choose to go with America and England because they are first world countries and regard them as advanced and they know better than us" (FI).*

- **University Experience**

In 2005 Lizzie enrolled for a B.Ed (Honours) science module and it was then that she was first introduced to IKS formally. In the interview she chose to share the sweet water story, which was part of the B.Ed module. Lizzie's interpretation of the indigenous practice associated with the story may be slightly different from the "Sharenet Resource"[16] which was used in the university module.

This is the interpretation provided by Lizzie. The scientific explanations that she offered have been bracketed. "*The indigenous story is called "Amanzi Amnandi"*

[16] This story is from the Sharenet Resource, part of the SADC Regional Environmental Education Programme.

*[sweet water], a commonsense way of collecting and storing water practice of the early Nguni people [Zulu] of Southern Africa. The Zulu King Shaka's mother was called Nandi and it was disrespectful to use the queen's name in this way. Shaka then referred to the water as "amanzi amtoti". This is how the town of Amanzimtoti on the south coast of Kwa-Zulu Natal got its name. Historically water was collected in areas where people could hear it running over stones. The site of water collection became a meeting place for young people. Young men would hang around these water sites, playing musical instruments and admiring the maidens. Girls would saunter along slowly and gracefully, singing. Water collecting was not seen as a tiring chore because of the hope of courtship.*

*The surface film of water [it has more bacteria] was brushed aside and clay pots were used to collect the water [water was kept cool by evaporation from the pores of the pot and reproduction of bacteria was slowed down in the cool, dark pot]. Water from below the surface of the river was collected. The clay pot was covered with a piece of skin or mat. Water would not be collected immediately after heavy rains because rains washed human and animal waste into rivers.*

*Today people in rural areas take plastic drums down to rivers to collect water. The water in the plastic drums does not cool down. When carried home the water warms up [increasing the bacterial production]" (RI).*

Another example of IK that she offered was that of the Masai practice of cultivating land and raising livestock.

> "*Over the years Masai farmers have been using tried and tested traditional methods, which were not recorded but yet it is science. They have been practicing it and it has been working and therefore was passed to one another. These indigenous ways may be useful, economical yet this was discarded for western ways" (FI).*

- **Peers**

*"Two very good examples"* that were shared by colleagues, that is a part of rural life, is the practice of African women carrying sticks/twigs (firewood) on their heads without even using their hands to balance. She indicated that this could be combined with the lesson on Newton's Law and that all forces are in equilibrium. The next example was that of the wheels (tyres) blowing out of an overloaded taxi and that there is a resultant force at play here. *"So you can see in people's practice there is science and you can merge it up with modern scientific knowledge" (FI).*

When she designs lessons and she is not totally sure that she is doing the right thing she asks a colleague to assist her. This was evident in one of the lesson observations where Lizzie made prior arrangements with the deputy principal to assist her.

- **Learners**

Lizzie regarded learners in her class as another source of IK. Learners conducted interviews with parents/elders in the community about traditional beliefs. This generated a great deal of IK that she was not aware of such as the advantages of African women using clay masks as a sun block and protection against the ultra-violet rays.

*"For example, clay mask has no expiry date, causes no allergies because it is natural, has no side effects and acts as an insect repellent. The learners brought this cultural knowledge and I used them in the lesson on electro-magnetic" (FI).*

### 6.1.2 “IKS in Science” lesson

**Grade 10 Natural Sciences**

**Topic: Human nutrition / IKS aspect of indigenous food.**

*Lizzie started the lesson by walking around briskly through the aisles of the laboratory handing out worksheets to the learners. She then went to the front of the class to get the learners attention and directed the learners' attention to the worksheets and gave them instructions. As she walked around she scanned what the learners wrote in their worksheets. Learners pondered over questions in the worksheet. She then introduced the different food groups, carbohydrates, proteins, fats and vitamins and their functions in the body. She discussed the concept of "energy" that is provided by food. She then gave them a list of food, chicken, cereal, potato, yam and a cheeseburger and asked them to name the main nutrient in each food.*

*She continued the lesson by asking learners if they had visited a farm during the holidays. Learners were requested to list the food that people on the farm, rural people, eat and those in the urban areas eat. Learners said that a lot of "putu" (mealie meal porridge) and "imfino" (herbs), cabbage and pumpkins were eaten in the rural areas while in urban areas it was more fast foods like hamburgers and pies. As learners responded, she wrote their answers on the chalkboard. The teacher then listed each type of indigenous food, discussed the nutrients and related it to "energy" needed by the body. For example "putu" provides carbohydrates, which serves as one of the main sources of energy in the food of rural people.*

*Lizzie then asked learners to tabulate in their worksheets what rural and urban families eat for breakfast. As homework the teacher requested the learners to research from parents, grandparents and other elders what rural people eat for lunch and supper.*

*She then proceeded to discuss diseases that may be associated with nutrition explaining the need for a balanced diet. In the rural area because of the lack of proteins, children are more likely to suffer from malnutrition and kwashiorkor and urban people, because of the excessive fatty food they may suffer from obesity.*

*The buzzer heralded the end of the period and the learners left.*

### 6.1.3 IKS and the School Curriculum

As a teacher of science she understands that she is required to adopt an inclusive approach by "accommodating" IKS in her lessons. The Natural Science Policy Statement makes space for the inclusion of IKS to cater for the different cultural groups living in South Africa. She identified that Learning Outcome 3, which is "Learners are able to demonstrate an understanding of the inter-relationships between science and technology, society and the environment," specifically promotes the idea of indigenous knowledge in the curriculum.

It was a challenge for her to get information for lessons plans. Lizzie claimed that the curriculum documents did not help her instead *"it just makes a statement but it doesn't give you any examples or anything".* It is clear that although this is a policy statement, she clearly expected more from it. The example that she used was from a latest science textbook and she got more information by *"talking to my colleagues and trying to make sense of it. You will not get this information from the NCS documents or libraries."*

### 6.1.4 Relationship between Science and IKS

In her class she often uses African Indigenous Knowledge because she has predominantly African learners in her classes and because of her own experiences. In the higher education module too, the lecturer utilised only African Indigenous Knowledge but she mentions that she is aware that:

*"other cultures also have their IKS that they have kept to themselves because of segregation in South Africa. With the demise of apartheid in 1994 different cultures now work and socialise together and this interaction allows for mixing of different races and blending of knowledge. This causes IKS to continually change because of new contributions from other cultures"(FI).*

Most learners, she claims, are urbanised and IKS comes from the rural communities. Therefore she starts with the modern scientific concepts and then *"brings in"* IKS. In order not to overwhelm learners she starts from the known and then moves to the unknown for example, *"When I teach the children concepts, I look for applications in everyday life and from there I try to bring IKS into the lesson" (FI).* When she teaches IKS in the class the learners get excited and the class becomes interactive. When the learners see that the teacher is impressed with their knowledge it gets them even more excited. Lizzie thinks it can make for more interesting lessons by linking the knowledge they are learning to what they are doing everyday and the fact that *"they have been using science in their everyday life" (FI).* She maintains that, pure science lessons are boring for learners because of its abstract nature and since it is difficult for learners to understand principles and theory they do not participate in the lessons. In most Physical science lessons she sees that the usual format is, to teach the concept and the theory, do calculations and give the learners more examples.

### 6.1.5 Reflections

> *"Although the lessons require a lot of thought and planning, it's fun, quite enjoyable and lends itself to exciting lessons. It makes me a better teacher to see another's point of view because we have all been brought up in different communities. By allowing different viewpoints to be discussed in the class would allow for a democratic classroom environment. It is still a learning curve for me, where it is not the usual way (traditional method) of teaching where we are telling the children. I was trying to link the two (IK and western science) because for me to teach something, it must first make sense to me and so that I can understand it better. I always feel a need to find out whether the IK that learners bring to the class is true. I try to validate the IK because it is my way of making sense. I validate it against my own scientific knowledge because I keep comparing the two, IKS and western science.*
>
> *As a teacher maybe I can help the learner restructure the IKS experience in a more scientific way. It can be written as a statement of hypothesis, designing an experiment and in the end to either prove or disprove the hypothesis. In fact I'm still unsure of whether I'm doing the right thing. When I taught that lesson I was actually scared"(RI).*

## 6.2 DEVA'S STORY

- **Personal background**

Deva was born in a small "Indian" village in the South Coast of Kwa-Zulu Natal in an extended family of uncles, aunts and grandparents. In his early teen years his family was displaced from their home because of the Group Areas Act in South Africa. Group Areas Act, Act No 41 of 1950 forced physical separation between races by creating different residential areas. It led to forced removals of people living in "wrong" areas, for example Indians living in Cato Manor in Durban.

As a result Deva's family was relocated to a suburb, outside Durban, which was created to house displaced Indians. After qualifying as a teacher of Physical Sciences he was appointed to the Hillview Secondary School, an ex-Indian School. He completed his matriculation examinations at the same school prior to democracy. In the 1980's as a student Deva was part of the African National Congress (ANC) activist group fighting for the dismantling of the apartheid system. For him this dream was realised in 1994.

- **School Background**

The school is situated in a low-socio-economic area where gangsters and drug addicts are rife. Access to the school is limited by high walls which surround the school and gates, which are kept locked at all times. Hillview Secondary can be regarded as a true multicultural school in that the school has African, Coloured and Indian learners. In Deva's class there are "about 50% Indians and 50% Africans".

### 6.2.1 Deva's Indigenous Knowledge

- **Personal experience**

While Deva was growing up he incidentally learnt a lot of cultural traditions from his parents, grandparents elders in the community, stories, legends and herbal remedies. He distinctly recalls two specific examples of IKS. The first one that he refers to was when his cousin had measles. His mother put a special thing called *"munja"* (turmeric powder mixture) on his face to stop the pimples from coming up and to reduce his body temperature. A bunch of syringa leaves was placed in a brass vase and left at the entrance of the house to signify to relatives and neighbours that they should not visit because of the contagious air-borne virus. The second example he related was his grandmother's practice of smearing the floors of their house with cow-dung, which was collected from the nearby fields. At that stage he did not know what purpose it served but later learnt that it is was an insect repellent. He referred to these examples as real experiences of part of his *"Hindu traditional knowledge because he saw it take place and it worked".* This knowledge is not found in textbooks, journals or libraries. A belief cited by him to be a common Indian belief is that *"if you go out with a baby you should not come home late at night because it will affect the baby."* He added that scientifically this belief cannot be explained but instead there is a conflict with science.

Deva was also exposed to African indigenous knowledge despite the fact at that time in South Africa various laws and policies determined that different races live separately, which restricted people from associating with different race groups. The different racial groups therefore kept their IKS to themselves because it was passed on by word of mouth and not documented. Fortunately for Deva, their family had an African "helper" who came from the rural area to assist with household chores and this is how he was exposed to some of the African herbal remedies.

His personal IKS became more extensive when he registered for the B.Ed module at the university.

- **School Experience**

At no stage in the interviews did Deva comment on knowledge gained from his own school experience. Instead his comments were directed to the knowledge he gained during his growing up years from his family.

- **University Experience**

For task one of the module Deva explored the manner in which the early Nguni people stored maize. Deva's interpretation of the indigenous story may be slightly different from the original "Sharenet Resources" which was used as part of the module. This story would be related to his learners:

> *"In Africa the suitability of land for growing maize and rearing cattle determined where people settled. Hence the contest for suitable land resulted in many wars such as the Anglo-Boer war and the Battle of Blood River. As commonly thought maize is not indigenous to Africa but was brought from Mexico during the 17th century and it became the chief diet of the African people.*
>
> *Sunning the maize grain before storage is an ancient practice, which reduced the moisture in the seed to prevent it being attacked by pests. The grain was then stored in a grain pit, which was made with great care. A hole about one to two metres was dug in the soil and a fire was made inside the pit to kill red ants and reduce moisture. The inside of the pit was smeared with cow-dung and left to dry after which the pit was covered with grass and cow-dung to seal it. The grain was stored in the pit until the family needed it. The scientific explanation, that is, ($CO_2$) produced by the fermenting grain preserved the seeds."*

Deva reported that learners would be taken to a milling company to observe how maize grain is processed, ground and stored in large silos by making use of carbon-di-oxide. In this task he planned to start with the IKS and then relate it to the scientific knowledge.

- **Peers**

Deva did not seek the assistance of peers or colleagues either during the preparation of tasks or for classroom teaching. There may be many reasons for this, one of which could be that his perception was that they did not possess the skills or knowledge for "IKS in science" lessons.

- **Learners**

Deva acknowledged learners as sources of information. This is clearly illustrated in the following example. While driving through the rural areas of Ndwedwe, Deva saw tyres on the tin roofs of houses and was under the impression that the tyres were there to hold the roof down. Some learners clarified the purpose of the tyres for him by comparing the tyres to lightning conductors found on modern buildings.

Deva provided the following response when asked about his feelings about obtaining knowledge from learners:

> *"I had not planned this as part of my lesson because I did not have this knowledge. However, I was able to elicit responses from the learners. This was a new experience for me, learning from the learners. There was no tension in the class and teaching and learning became a two-way process. Utilizing learners as resources is something that I need to get used to in our new system of education. This is a new experience for the learners too, interacting at this level" (RI).*

### 6.2.2 <u>"IKS in Science" lesson</u>

**Grade: 11 Physical Sciences.**

**Topic: States of matter and indigenous preservation of foods.**

*Deva started the lesson with the following:*
*Let's take a trip to the North Pole. Gigantic icebergs (ice blocks) are floating in the sea - like the one that struck and sank the Titanic. When water starts to freeze it expands and the molecules move further apart and as a result becomes less dense than liquid water and floats. Dry ice (solid carbon-di-oxide) changes from a solid directly to a gas and is used for cooling.*

*He then elicited from learners some alternative ways of keeping things cool by asking the question, how was foodstuff preserved in the past when there were no fridges?*

*Nosipho, a learner explained that food was kept in the middle of the roundavels. The teacher asked Nosipho to explain exactly where in the roundavel it was kept, near the door or window. Nosipho explained that the food was stored in the middle of the roundavel, the coldest part where there was no light and heat. She went on to explain that jelly is also kept in a cool place to set. The teacher explained after the lesson that he knew about this because his family helper bought jelly when she went home for Christmas although she had no fridge. There was a buzz in the class as learners shared experiences in their groups. In fact it seemed that everyone was talking at the same time. As the teacher walked around the class he listened to their lively discussions.*

*Wiseman brought in another method "My aunt told us that when she was young they herded cattle. When they came across a small stream they would cover the stream with a cloth and store food underneath in the shade of the cloth. Sometimes they dug a hole in a river bank and put the food into it." Rajen added to the discussion by explaining that when he goes fishing and has no cooler box he digs a hole in the sand and buries the bottle of coke to make it cold. Someone in the class says that red soil is the coolest. The lesson then ended (CO).*

In the lesson Deva started with modern science and then examined IKS. When questioned about his choice of starting with western science in his lesson he provided the following response:

> *"As a political activist and unionist I believe that one of the ways to address the injustices of the past apartheid educational system is to include indigenous knowledge systems in the science curriculum, but science teaching must still include a body of science knowledge (modern science in textbooks)" (FI).*

It is clear from Deva's response that although he believed that including IKS in the curriculum was essential and beneficial especially in South Africa at a personal level his belief is to teach the concepts and theories of western science.

### 6.2.3 <u>IKS and School Curriculum</u>

Deva acknowledges that the new education system, the Outcomes Based Education (OBE) mirrors our constitution and caters for the full potential of learners of all cultural groups. His opinion is that the curriculum is open and there is a space where IKS can be addressed. The "slot" where different knowledge systems can be examined is in Learning Outcome (LO3) three, which states: "Science, Society and the Environment" and the Assessment standard linked to the attainment of this Learning Outcome is: "Understanding science as a human Endeavour in cultural contexts." Deva views IKS in the curriculum as a good way of protecting our heritage and is useful information that can benefit all race groups. His following comment indicates that his outlook to IKS has changed after it was introduced to the curriculum:

> *"Initially I thought of it as knowledge-in-passing and superficial. By now being introduced into the science curriculum I have gained a different insight and have more respect for IKS. Learners also need to give IKS the necessary respect and dignity it deserves especially since IKS was always looked down upon when compared to school science" (FI).*

> *"This takes into account the learning of all cultural groups leading to a more relevant science. It mirrors our constitution and caters for the full potential of learners of all cultural groups. Including all cultures in the lessons indicates that all cultures are respected and this would help build new South Africa. In a nation emerging from apartheid I think it (IKS) can be used to instil in learners tolerance" (RI).*

Deva provided a political reason for the inclusion of IKS in the new curriculum. In the new democracy he saw new priorities in the teaching of science, which included not only intellectual but cultural and social justice issues. From Deva's discussion it seems that "getting" IKS in the science curriculum is not enough, as it does not address the fundamental problem that led to the devaluing of IKS of different cultural groups. A meaningful discussion about these issues would therefore require recognisation and respect for different ways of knowing (epistemology) and recognition and respect for different worldviews (ontology).

Although he acknowledged the new curriculum he also indicated that he did not know how much or what strategy to use to include IKS in the lessons:

"*The National Curriculum Statement does not spell out how IKS should be included in lessons and does not give any examples" (FI).*

### 6.2.4 <u>Relationship between Science and IKS</u>

Deva explained the manner in which he implemented IKS:

> *"As I come across it I just introduce it (IKS) side-by-side with similar scientific knowledge and depending on the class environment and area, it works. I motivate the learners through discussion, make them feel comfortable and ask leading questions to involve them in the lessons. Not all science lessons lend themselves to IKS teaching for example an electron is an electron and an atom is an atom in pure science"(RI).*

From the above statement it seems that Deva keeps IKS alongside science in the lessons. It may be that he does not have an adequate understanding of indigenous knowledge, and therefore cannot make the links between the two.

In both the lessons observed Deva started with western science and when questioned about his practice he responded:

> *"In my lessons I start off with the modern science knowledge to see what they know and then I draw on childrens' experiences of IKS… Don't destroy the belief. I move from the known to the unknown."……… However, since I am a traditionalist in the western science (though I am trying to change) for me science is about imbibing scientific facts" (RI).*

He believes that teachers should not try to replace learners' personal knowledge with scientific knowledge and that both must be discussed.

### 6.2.5 Reflections

> *"When we first spoke about indigenous knowledge in the class some learners were surprised. Talking about IK generates a lot of excitement in the class. There are debates and philosophical discussions bordering on metaphysical and religious aspects. The atmosphere in the class is more relaxed and I think that the reason for this is that IKS has been a part of the learners' experience and it is not something abstract from science textbooks, books written in Europe. It is contextual and linked to their environment and community.*
> *I noticed that the learners were actively involved in the lesson. The increased participation was something out of the ordinary that did not happen in my other Physical Science lessons. Discussing IKS is part of learners' experience, something that is being done at home. It made my task as a teacher so much easier because I was getting the maximum out of the learners.*
>
> *I am still not really confident to teach IK lessons because it's still new and I am finding my way but I have implemented IKS into lessons and I feel that it is*

*a new window to the teaching and learning experience as compared to the old traditional way called 'the jug and mug method' which characterised the apartheid system of education" (RI).*

## 6.3 PINDI'S STORY

- **Personal background**

The Sotho people like other cultures and ethnic groups are well known for their rich heritage of cultural traditions. Pindi is a Sotho born of Sotho parents. While growing up traditions and customs has always been very much a part of Pindi's life. She grew up in rural northern Kwa-Zulu Natal and attended a rural school five kilometres from her home. She pursued her tertiary education at a college where she qualified as a teacher. She is now a teacher of Biology, called Life Sciences in the Further Education and Training (FET) band, at Lithembilwe Secondary School.

- **School Background**

Lithembilwe Secondary School is located in semi-rural Inanda, a suburb of Durban. When entering the school one is greeted by a friendly atmosphere created by the colourful vegetable gardens with neatly laid out rows of beetroot, spinach, cabbage and carrots. Some of the vegetables are used to feed the learners who come from very poor socio-economic neighbouring areas. The surplus vegetables are sold to the community at a nominal rate. The school building consists of ten classrooms built of metal, without ceilings or insulation and become furnaces in summer and are unbearably cold in winter. This was an ex-African school and still has only African learners and teachers.

## 6.3.1 Pindi's Indigenous Knowledge

- **Personal experience**

For Pindi the most important vehicle for the learning of traditional knowledge was through the many ceremonies and rituals. She remembers clearly that when she reached puberty she was taken away with her peers to what is commonly referred to as "bush schools". Here she was taught traditional knowledge of her culture by traditional healers and elders. At the "bush school" she learnt many skills, for example, dancing and the skill of preparing Sotho food and the introduction to motherhood.

Boys, entering manhood during "lebello" (initation) ceremonies are taken to the forests or the wilderness to be circumcised. For the healing process no western medicines are used, only herbs mixed by the traditional healers. They were told that this ceremony was held in winter because healing is faster at lower temperatures. Another reason for choosing winter is that there is no rain in winter and these boys are not provided with any kind of shelter. The thought is that if the boys can withstand these harsh conditions then they are regarded as "real" men. After about two months of training where they are taught morals, values and spiritual aspects they return and are regarded by the community as acceptable, responsible and decent citizens of society.

Healing is a very important aspect of IKS and Pindi recalls her grandmother preparing "imshublano" (traditional medicine mixed with soup for drinking) when her sister, Zola had a fractured hand. Modern medicines for example, plaster of paris that is used as a cast to keep the fractured bones together were not used. Zola was not taken to a hospital and the wound healed rapidly. This mixture is also given to a woman who has a baby by caesarean section.

The elders having gained this knowledge and experiences in their lifetime are regarded as the people with the most knowledge. It is for this reason that they are chosen to teach the younger generations. Two examples of trees that Pindi cited are the, "Ibosa", commonly known as the Aloe which is used for the treatment of influenza and the “amatulwa” which children are warned not to cut for firewood, as it would start a severe flood. This is a Sotho way of using the biodiversity and cultural beliefs for conserving the environment and to survive.

Pindi also obtained personal knowledge from her practices of consulting traditional healers and sangomas. She does not practice IKS at home in Newlands West, an urban suburb of Durban, but does so when she visits the rural areas by consulting the sangomas and traditional healers who live there.

- **School Experience**

During her primary school years some of her teachers occasionally mentioned their Sotho traditional knowledge but Pindi did not think it had any relevance to her schoolwork.

> *“Because IKS is typically associated with myths and superstitions it was considered “backward” while textbook science being associated with Europe and America is perceived as the better of the two” (RI).*

Pindi’s personal indigenous knowledge, gained while growing up, was extended formally at university.

- **University Experience**

For task one of her assignment she reported that she found her own experience as the most valuable resource. She also considered her experience as “real” because her grandparents practised it in her presence and “it really worked”. She indicated that she used some textbooks but that they did not provide detailed information and she also sought assistance from some colleagues at school.

The topic she chose for the task was on heat conduction. She chose this topic probably because, as indicated, she had the personal knowledge. Learners were to record temperatures in huts with thatched roofs and huts with metal roofs. She linked this observation with the science topic of examining the properties of different conductors.

Learners would be required to share their daily experiences of materials used for making cooking pots in the past and present. The teacher would use learners' experiences connecting it to good and poor conductors of heat.

- **Peers**

Pindi reported that she does seek the assistance of her peers when she is not sure of the IKS brought in by learners.

- **Learners**

The following statement expressed by Pindi indicates that both learners and peers were her source of IK.

> *"Learners interview parents and elders in the community and bring IKS to the classroom. In the class we have to share knowledge. They should learn from me and I should learn from them. The learners are resources but for me it does not end there. Because I don't want to rely on something that I am not sure of, I go to colleagues and use my knowledge to find out whether the IKS is true" (RI).*

### 6.3.2 “IKS in SCIENCE” LESSON

**Grade 10 Life Sciences**

**Topic: Biodiversity and cultural traditions for sustainable living**

*Pindi introduced the lesson by looking at the word biodiversity and made reference to the assignments submitted by learners on the “Different Types of Leaves.” It seems that Pindi chose the topic of biodiversity because the learners had researched, written an assignment on plants and the topic lent itself to biodiversity and herbal remedies. She tabulated (with the help of the learners) on the board some common plants and animals. She encouraged learners (which she told me that she usually does) to use Isizulu names. She questioned learners on the use of the plants and animals in rural areas and discussed it. In the rural areas there are no doctors and clinics and people there rely on herbal remedies. Learners were able to explain to her in great detail how the plants could be used as remedies. Kuhilisa, a learner said that the leaves of “Ibosa” are crushed and the juice drunk to cure “kushelan” (influenza). She integrated these examples to explain the concept of photosynthesis, which occurs mainly in the leaves of plants. Musa, another learner shared some interesting uses of animal products which seemed to surprise Pindi. He said that pig’s fat is smeared on the lips to protect yourself if somebody wants to bewitch you. Jabula added that his grandparents use the skin of the cow as a mattress. To these examples the teacher added her own example of the Khoisan of Africa and their practice of eating the succulent Hoodia plant. It provides them with water, suppresses their hunger and keeps them slim which helps them to be good hunters. Pindi used the example of the Hoodia plant to introduce the concept of “biopiracy”. She explained how the pharmaceutical companies have exploited the traditional knowledge of the San, extracted the chemical suppressing chemical and used it in the manufacture of the slimming product “bioslim”. This was done without any credit given to the San[17] for their knowledge. The lesson was concluded by the teacher “linking how the cultural traditions have lead to the sustainable use of plants and animals.”*

[17] The Khoisan also known as San are the original inhabitants of Southern Africa and are a diverse group of hunter-gatherers who share historical and linguistic connections. There are many different San groups; they have no collective name for themselves, and the terms 'Bushman', 'San', 'Basarwa' (in Botswana) are now commonly used.

Pindi integrated her lesson with IK and western science drawing on both as required during the lesson. Western science was first presented, IK, then western science, each one having a bearing on the next as the lesson proceeded.

### 6.3.3 IKS and the Science curriculum

The following statements made by Pindi seem to indicate that there has been a shift in her perception of IKS since its introduction in the curriculum:

> *"IKS is given due consideration in the new curriculum and I now look at traditional knowledge with different lenses. Being exposed to the National Curriculum Statement (Learning Outcome 3) at the University of Kwa-Zulu Natal I realized that my tradition knowledge was actually given a name and called indigenous knowledge systems. I was very excited about this change in the curriculum because thus far there was little appreciation for this knowledge" (RI).*

Pindi appreciated the fact that the new curriculum addresses the diverse cultures within the South African context by including both formal (scientific) and informal (IKS) knowledge.

She understands that the Sciences NCS Learning Outcome 3 is flexible enough to include IK. However, she is of the opinion that the NCS documents provide very little guidance for lesson plans that she was required to prepare as part of the university module. This is indicated in Pindi's statement below:

> *"The NCS document provided very little guidance for the assignment" (TI) (FI).*

Pindi's view's on the NCS, as being of little assistance, is consistent with her response on the survey form where she indicated that the NCS "least" informed her source of IK.

### 6.3.4 <u>Relationship between IKS and Science</u>

Pindi reported that she would take the learner from "known to unknown," meaning that she would recognise learners' existing knowledge as a baseline for the introduction of new concepts.

Pindi indicates that the "known" could be IK or western science depending on the topic and the knowledge of the learners in her class. This is reflected in the following statement:

> *"When I teach an IKS lesson the main aim is to start from something they know and move to the unknown. The manner in which I will deal with IKS will depend on the topic being taught. Depending of the topic in some lessons I start with the scientific concepts and then introduce IK. If, for example, I were to teach a lesson on reproduction I would introduce the theory and link it to some of the indigenous practices during pregnancy and childbirth. For example some herbal mixtures make childbirth easier. If I was teaching a lesson on filtration, then I would start with their outside experience, i.e. learners' personal knowledge from their everyday lives (beer-making at home) and then introduce and link it with modern science. The contents of the lesson become more appealing when linked to their IK experiences. I do not have a fixed way of introducing IK into lessons" (RI).*

When asked about the relationship between IK and science the following was her response:

> *"I think that indigenous knowledge is science because like modern science, experiments were done and by trial and error this knowledge was learnt. Initially my understanding was that since IKS is regarded as science it can stand alone and modern science can stand-alone. I now think that by linking IKS and modern science, it can act as a powerful tool in the classroom to teach all the students" (RI).*

It is not unusual for teachers to argue that the rationality of IKS is similar to that of western science, since many proponents of IKS, such as, Leeuw (2004) and Kraak (1999) make similar claims. Although Lizzie claims that IKS is science, her practice of restructuring IKS according to western frameworks seems to suggest otherwise. Deva also claims that the rationality of science is the same as that of science. However, in keeping the knowledge systems apart, it seems that he does not regard IKS as science, but perhaps knowledge with equal value to science. Pindi goes further and links the two systems, which seems to suggest that her claim that IKS is science is followed up in practice. By linking IKS and science she is of the opinion that it would better serve the needs of all students, since they would benefit from two domains of knowledge. From a postcolonial perspective, it can be argued that some ways of knowing and some forms of knowledge are considered more highly than others.

### 6.3.5 Reflections

> *"I am now required to integrate IKS in my classes. I have not been to any workshops or conference on IKS. When subject advisors trained us on the new curriculum they only touched on IKS. Therefore I am not yet fully confident to teach IKS but because of my background I can engage with it.*
>
> *However, I think that if I taught in the rural areas learners' understanding would be enhanced because they can relate to it and they are comfortable with this knowledge. For example plants and animals have meaning for a rural child because he sees its value as firewood and medicine. Teaching and learning would be contextual and learner-centred, taking the child from what is "known" to what is unknown."*
>
> *When I include IKS in the lessons, learners are very excited and participate fully in the lesson. I think that the reason for this response is that this knowledge is part of their experience. The classroom becomes an interactive environment for teaching and learning. I found very little or no participation from learners in lessons that deal with purely scientific concepts. Abstract scientific knowledge from books fails to capture and maintain their interest since it is not a part of the learners' experience. In the old curriculum, in the "banking method" of education I was the active depositor…just telling and telling" (RI).*

## 6.4 TEACHERS' UNDERSTANDING OF IKS AND NATURE OF SCIENCE (NOS)

One of the essential and constitutive tenets of scientific literacy is knowledge and understanding of the nature of science (NOS) and the connections amongst technology, science, society and the environment. According to Newton and Newton, (2001) the teacher's knowledge and understandings of science and to which, I add IKS is said to influence the way in which the teacher teaches science and IKS in the classroom. If the goals of the RNCS are to be achieved then there is a need to ensure that teachers have an understanding of NOS and IKS which, would enable them to operate effectively in the classroom. In the constructivist sense it is critical to first examine teachers understanding of the nature of science (NOS) and IKS before exploring the approaches through which teachers include the two knowledge systems in the classroom.

All three teachers in their interviews claimed that after engaging with the module "Issues in Science Education" their understandings of IKS changed. They said that initially they had a superficial and abstract understanding of IKS but the designing of tasks one and two of the assignment lead to a deeper understanding of IKS. All three teachers in their interviews, assignments and lessons equated herbal knowledge, traditional medicines and home remedies to IKS and provided numerous examples, for example, how the juice of the "Ibosa" plant is used to cure influenza. They also related IKS to rurality and linked it to survival. The teachers maintained that their understandings came from their own personal experiences at home. Their definitions of IKS were mainly concerned with tried and tested traditional knowledge of parents, grandparents and elders that was transmitted from generation to generation verbally.

Teachers claimed that IKS is not unique to a given culture or society but rather that IKS absorbs new aspects through interactions with other cultures and hence is not static or stagnant, but rather an open and dynamic system.

The teachers' dilemma about the categorisation of IKS was echoed in their interviews. Teachers finally identified two kinds of IKS, namely, IKS in which science is embedded and IKS of myths, beliefs and superstitions which is inseparable from religion. The three teachers expressed a desire to separate myths and superstitions (lightning is caused by witchdoctors) and spiritual aspects related to the metaphysical from IKS that is beneficial to people. This understanding is probably due to the manner in which IKS was presented in the module and to the tasks which required two separate lessons, the first one using an indigenous technology and the second one using an indigenous belief or myth. The teachers also displayed a variety of ideas on the difference between superstitions and IKS, for example, IKS is based on real experience while superstitions and have no explanations; IKS is based on reality while superstitions are based on myths; and IKS may be equated to science while superstitions cannot.

All three participants claimed that IKS fitted the criteria for being classified as science because it involved the approaches used by science, namely observation and trial and error and tested experiments. Teachers claimed that since the rationality of IKS is similar to that of western science it may therefore be equated with science.

Although none of the teachers attempted to define science during the interviews, the word came up on many occasions. From these occasions it became evident that the different teachers had different ideas about what science means.

The following meanings of science could be found in the interview data.
Science is:

- The canonical knowledge, skills, and values of western science found in university science courses, in school curricula and textbooks.
- Knowledge that is backed by theory.
- A process identified by prediction, hypothesis testing including experiments, interpretation of results and drawing conclusions, for example, scientists trying to find a cure for cancer.
- Has a specialised language of its' own.

There is a mismatch, however, between what Lizzie says and does in regard to IKS being science. Although she says that IKS is science, she also validates the IKS against her modern scientific knowledge in order to make sense. Pindi, indicated that initially she regarded the two knowledge systems as separate entities but has since realised that the needs of the learners could better be served by combining the two and that in fact IKS and science are compatible. Deva initially did not understand IKS and had vague ideas about it relevance to science education. He thought it to be abstract and superficial knowledge for the science classroom. However as his understanding of IKS deepened he perceived it as assisting in making science more contextual thus enhancing learning. He saw IKS as a route for democracy and social justice in post-apartheid South Africa.

Pindi discussed appropriation of knowledge or “biopiracy” where ideas were stolen from people and developed by specialists, for example Hoodia sp. Her view was that IK should not be simply viewed as a resource to be exploited for economic gains.

This picture about teachers’ understandings should not be construed that teachers have comprehended fully the epistemological, ontological and other socio-cultural dimensions of the knowledge as well as how these may be represented in classroom practice. However, all three teachers felt that the inclusion of IK in the science lesson would provide a more reflective and insightful education.

## 6.5 THREE EMERGING APPROACHES

How are these teacher participants dealing with the reality of including IKS in their science teaching? Lizzie completed her secondary education in a girls’ only school and has learners who are predominately Coloured with very few African in her class. Pindi’s own schooling and professional experience is limited to schools consisting of learners of similar culture (Isizulu) and social class while Deva attended an “Indian” school and has a multiracial and multicultural class.

In this concluding section of the chapter I draw from chapters five and six for each of the three teachers, using excerpts from the data, to illustrate three different approaches used by the teachers for IK teaching. The picture emerging is that although teachers expressed a strong belief to include IK for various reasons, its practice is realized in different ways in the classrooms. Each case appears to exemplify a different approach taken by the teachers in how they dealt with IK in their teaching. Lizzie’s approach may be described as more of an incorporation approach where IKS, corresponding to science, was identified and merged with science. Deva developed a separate but equal, "stand alone" approach where IKS and science were both taught but not really brought together while Pindi's approach may be characterised as an integration approach because of the constant links she makes between the two knowledge systems. For each case the approach is discussed with reference to their IKS, their "IKS in science" lessons, the relationship between science and IKS and conclusions.

### 6.5.1 Lizzie: Incorporating IK into Science

Lizzie's sources of IK that she obtained from colleagues and claimed were *"very good examples of IKS"* was the *"practice of African women carrying sticks and twigs (firewood) on their heads.* This she indicated could be combined with Newton's Laws in the teaching of Physics. Her statement *"so you can see in people's practice there is science and you can merge it with modern scientific knowledge"* suggests the manner in which she would like to approach "IKS in science" teaching is to bring IKS into science teaching and to combine it with science.

The same approach of interpreting IKS is evident in task one and task two. In task one on "clay masks and commercial types of sun-protection" learners would be requested to look at the advantages of *"combining"* both the perspectives. The need for IKS to "make sense scientifically" is apparent in task two on "lightning" where Lizzie seeks how "best IKS fits into science." Making IKS correspond to science is also obvious in the manner in which she related the "Sweet Water" story by trying to include scientific explanations for each step of the discussion.

Lizzie's explanation "I was trying to link the two (IKS and western science) because for me to teach something, it must first make sense to me so that I can understand it better"- seems to suggest that IKS must first be changed to "usable western forms" before being acknowledged in the classroom. Lizzie selectively admits in her classrooms only the IK that she can understand and that which she does not understand and cannot see links to science are not allowed. The incorporation approach implies the application of a validation process based on scientific criteria that supposedly separates the useful from the useless, objective from the subjective, "science" from "beliefs." Through this process, knowledge corresponding with the paradigm of western science is extracted and incorporated.

Lizzie puts a high premium on incorporating IK in science lessons more than the other teachers by "restructuring the IKS experience in a more scientific way" which is indicated by her statement, "It can be written as a statement of hypothesis, designing an experiment and in the end to either prove or disprove the hypothesis." This is also evident in her teaching of the topic nutrition by "listing each type of indigenous food, discussing the nutrients and relating it to *energy* needed by the body." Restructuring and validating IK seems to suggest that teaching strategies and techniques carrying "scientific design" labels are more inclined to be promoted, and adopted in the classroom. This approach of embracing western science signifies Lizzie's slant towards universalism.

"When I teach the children concepts, I look for applications in everyday life and from there I try to bring IK **into** the science lesson" clearly spells out that for IK to be used in the classroom Lizzie accommodates it ***within*** western science. It seems to suggest that IK is smaller and hence can best be accommodated within western science.

Lizzie understands that she is required to adopt an inclusive approach by "accommodating" IK in her lessons and the curriculum makes a "space to slot it in" but at the same time lamented the fact that the National Curriculum Statement was not helpful for lesson development. The same sentiments were expressed by some of the other teachers in the telephone interview (Toko, Hlona). Lizzie's anguish at the absence of examples of IKS in the RNCS and NCS led her to generate her own examples of IKS. It directed her to obtain this knowledge from textbooks, her colleagues and learners.

### 6.5.2 Deva: Keeping IK separate from Science

Deva interpreted task one and two in a similar manner. The topic for task one was "Storage of Maize". For the IK aspect he chose to explain in detail the Nguni practice of grain storage but he kept this separate from the commercial storage of maize in silos.

In task 2, on "lightning," he designed two activities for the learners. Firstly, learners would be required to research the beliefs associated with the causes of lightning from the community and thereafter perform experiments on electrostatics using the van der Graff apparatus in the laboratory. In his approach he compartmentalised the belief aspect from the scientific explanations and experiments. Deva's statement -*"don't destroy the belief"* - illustrates respect for the belief and suggests that he does not plan on replacing learners' personal knowledge with scientific knowledge.

In the lesson observed, Deva started with scientific concepts of density, sublimation, and states of matter. He then elicited from learners alternative sources to preserve food in the absence of refrigeration. In a way he kept the knowledge systems "dichotomised" and did not attempt to merge them, as Lizzie did, or link them in any way and did not seem to have a rational basis for his choice.

However, there is some evidence, to suggest that Deva believed the two knowledge systems to be separate but equal. For example since Deva did not attempt to validate the IKS as Lizzie did, this suggests that by recognizing IKS on its own terms he considered knowledge from different cultures as being equivalent. Although he valued IK he did not attempt to make connections to western science in his lessons, perhaps because he wanted to maintain them as separate knowledges or perhaps did not know how to connect them. Political reasons were offered for the inclusion of IKS in the new curriculum for example:

*"it would give learners pride and dignity to be SA citizens and that IKS will take its rightful place with other knowledge systems whilst at the same time upholding the values in the constitution."*

It is clear that while he values IKS he may have a more political commitment to the inclusion of IKS, which may not be entirely linked to science. He recognized that there was a “space” in the curriculum where IKS may be addressed but at the same time complained, as did most teachers that the NCS did not provide examples and details on how to implement “IKS in science” lessons. Textbooks did not provide this information either. Therefore he relied mostly on learners to acquire this knowledge. *“I just introduce it (IKS) side-by-side with similar scientific knowledge,”* clearly illustrates the “separatist” approach used by Deva to include IKS in his lessons.

By keeping the two systems separate and not validating IK Deva is inclined to admit more IK in the classroom. Since he does not attempt to link IK to science, he allows for “debates and philosophical discussions bordering on metaphysical and religious aspects” because he will not have to manage conflicts and contradictions that may arise when IK is related to science.

### 6.5.3 Pindi: Integrating IK and science

Pindi sees IK as her personal knowledge and, as such, her strength in the classroom: *“because of my background I can engage with it.”*

In the university task she created for learners, she required learners to share their daily experiences of materials used for making cooking pots in the past and present. Pindi expected to use learners’ experience to connect it to good and poor conductors of heat. In the task two learners would be requested to research beliefs on causes of lightning from the community and to conduct experiments on electrostatics. Pindi’s comparisons of similarities and differences between both perspectives gave an indication of how she planned to integrate the two systems in the classroom.

When she got to the classroom, in her lesson she made continuous links with learners’ examples of herbal remedies to explain science concepts and *“linking how the cultural traditions have lead to the sustainable use of plants and animals.”*

Pindi stated that the *“Sciences NCS Learning Outcome 3 is flexible enough to include IKS”.* Pindi’s choice of the term ***flexible*** to describe the NCS seems to reflect her own

IKS teaching. Her approach can be described as flexible and adaptable as she moves from one knowledge system to the next making constant connections and drawing on both as required during the lesson. Pindi's approach may be regarded as an "integrationist" approach.

The RNCS and NCS policy documents, not having IKS examples, also created possibilities for Pindi to use her own personal IKS in the classroom. It provided her with opportunities of acquiring this knowledge from her colleagues, elders and learners. Whereas Lizzie validates knowledge against her science understanding Pindi claims that she does so against her own knowledge and that of colleagues:

*"I don't want to rely on something that I am not sure of I use my knowledge and go to colleagues to find out whether the IKS is true."*

Pindi explained that if she were to teach filtration she would start with "learners' personal knowledge from their everyday lives (beer-making at home) and then introduce and link it with modern science."

Initially her understanding was that *"since IKS is regarded as science it can stand alone and modern science can stand alone."* Currently Pindi puts a high priority on *"linking IKS and modern science, as it can act as a powerful tool in the classroom to teach students" (FI).*

Pindi explained that she had not attended any workshop on IKS organised by subject advisors yet she is *"now required to integrate IKS in my classes"* and indicated that perhaps if she was teaching in a rural area learners may relate to it better and it would have meaning for them. Throughout her interviews Pindi relates IKS to rurality as if people other than rural have no IKS.

## 6.6 CONCLUSION

From the above discussion it is clear that the three teachers have developed three different approaches to include IK in science lessons. Lizzie's approach is one of incorporating IK into science while Deva's approach keeps the two knowledge systems separate. A very different picture was painted by Pindi, who made connections between IK and western science. These approaches will be further theorised and developed by linking them to literature in chapter seven.

# CHAPTER 7

## THREE APPROACHES TO IKS IN THE SCIENCE CLASSROOM

### 7.1 INTRODUCTION

In the previous chapter the narratives of the three teacher participants constructed from the interviews (both face-to-face and reflective) and class observations were presented. By using empirical evidence from the narratives the three emerging approaches used by the teachers in implementing "IKS in science" lessons were illuminated in the concluding section of the chapter.

The three approaches have given rise to several themes in response to the research questions, which were influenced by the theoretical orientation made explicit in this study. In this chapter the themes will further elaborate each of the three teacher's approaches.

Lizzie's "incorporationist approach" is illuminated in the excerpt below:

> *"I always feel a need to find out whether the IKS that learners bring to the class is true. I try to validate the IKS because it is my way of making sense. I validate it against my own scientific knowledge because I keep comparing the two, IKS and western science. As a teacher maybe I can help the learner restructure the IKS experience in a more scientific way. It can be written as a statement of hypothesis, designing an experiment and in the end to either prove or disprove the hypothesis" (RI).*

Deva’s “separatist approach” is clearly articulated:

> *“As I come across it I just introduce it (IKS) side-by-side with similar scientific knowledge and depending on the class environment and area, it works. I motivate the learners through discussion, make them feel comfortable and ask leading questions to involve them in the lessons. Not all science lessons lend themselves to IKS teaching for example an electron is an electron and an atom is an atom in pure science”(RI).*

Pindi’s “integrationist approach” is evident in the following extract:

> *“Initially my understanding was that since IKS is regarded as science it can stand alone and modern science could stand-alone. I now think that by linking IKS and modern science, it can act as a powerful tool in the classroom to teach students. If I was teaching a lesson on filtration, then I would start with their outside experience, i.e. the learners’ personal knowledge from their everyday lives (beer-making at home) and then introduce and link it with modern science. The contents of the lesson become more appealing when linked to their IKS experiences” (RI).*

The three approaches are analytical categories. No teacher can be described with reference to any one to the exclusion of the other. In reality each teacher uses aspects of all three approaches. However, for the purposes of analysis it is possible to develop each approach to make visible and explain teacher thinking and action in driving particular theoretical underpinnings of how a teacher interprets and implements IK in his/her science lesson in three very different ways.

In this chapter instead of developing each approach in terms of themes that have emerged, the themes are explored by referring to each approach and thereby developing each approach.

## 7.2 EMERGENT THEMES

How the teachers managed each approach, and the complex dynamics in the classroom, what influenced them in the ways in which they engaged with IK in their science lessons and what influence did their approaches and pedagogical practices have on learner agency are elaborated.

Each of the approaches is developed and interrogated by and through the following:

- Teacher identity, biography and context
- Pedagogical practices
- Issue of Indigenous language
- Learner agency
- Teaching through learning, Learning through teaching
- Validation and access to IKS
- Nature of IKS
- Approaches to IKS in lessons

### 7.2.1 Teacher Identity, Biography and Context

Lizzie's own belief that western science is the "real science" seems to have largely influenced her in the manner in which she engaged with IKS in the classroom. Her perception seems to stem from values instilled by the Christian National based education during her school experience where western science was presented as fully epistemologically adequate while subjugating other knowledge systems. Intentionally or not, the "west is best" attitude has persisted in her classroom teaching and has influenced her level of engagement with IKS. By incorporating IKS into western science there appears to be the notion that IKS is a subset of western science and therefore it can be argued that Lizzie accords western science a higher status than IKS.

A second possible reason for taking an incorporationist approach could be attributed to the fact that she only believes the IK imparted by her mother, which she does not question. IKS that does not come from her mother and is not in the form of written

texts, she questions, validates or restructures into easier western ways. The manner in which Lizzie engages with IK seems to lean towards an "outsider" perspective.
Deva like Lizzie was also educated in a Christian Nationalist Education curriculum and his exposure to politics during his early secondary schooling years had a profound effect on his views on IK and the manner in which he engaged with it. In the new democracy he saw new priorities in the teaching of science, which included not only intellectual, but also cultural and social justice issues. He recognises that all cultures must be given equal respect and equal opportunities in the curriculum (not specifically in science), which he caters for by using the "equal and separatist approach."

His multicultural teaching environment may have also had a bearing on how he chose to teach IK in the classroom. One strategy to promote and acknowledge all cultures is to allow for different worldviews to exist alongside each other, that is western science (which is a subculture of the West) and IKS. This seems to justify why, unlike Lizzie who chose to "incorporate" IKS into western science he kept both knowledge as "stand alone," each valued for its own merits.

Pindi, like Lizzie and Deva, was also educated in Christian National values and principles during her schooling. Science textbooks used in the classroom depicted only European and American contexts and she went through similar "west is best" instructions as Lizzie. However, in her approach to IKS teaching she does not follow an incorporation practice but an "integrationist" one. She moves effortlessly between IKS and western sciences making constant links between the two. A possible reason why she takes this approach is that she had the security of her personal IKS to negotiate the move between IKS and science. Perhaps her personal IKS gained from an insider perspective through cultural practices, protocols, and direct transmission of elder knowledge while growing up and which was especially reinforced during "bush schools" was strong enough to suppress or balance out the "west is best" attitude experienced at school.

Another possible reason for her choice may be that her own schooling and professional experience has been limited to schools consisting of learners and teachers of similar culture (Isizulu) and social class. Monocultural learners holding similar personal knowledge may have facilitated Pindi's attempts to integrate IKS and western science.

### 7.2.2 <u>Pedagogical Practices</u>

Lizzie's strategy of using IKS as a "stepping stone", as part of building on what students already know about science concepts is located within the constructivist paradigm with reference to how learners engage with building knowledge. This approach has some resonance with the views of Jegede and Aikenhead (1999) who maintain that the prior or indigenous knowledge of the learner is of significance in accomplishing the construction of science meaning in a new situation.

Where indigenous knowledge is referred to in the interviews it may be seen as a pedagogic device to assist students with understanding western science. Lizzie expressed that her ultimate goal is to facilitate the empowerment of students with an indigenous knowledge base to understand and evaluate what conventional science has to offer. In support of such pragmatism, George (1999a: 20) believes that the aim of science teaching to students of indigenous cultures " ... should be to help students access conventional science. Whether or not the student accepts the conventional science to the point of making it direct his/her life, is a matter of choice for the student."

Deva, unlike Lizzie claimed that he had no particular classroom strategies, but teaching IK was about building comfort levels. By asking leading questions IK was drawn upon, as required in ways that were comfortable to learners. Contrary to his claim, observations in his class indicated that in both his lessons he started with western science and then introduced IK. His response to starting with western science was that he was a traditionalist implying that he saw his role as a teacher of western science, which seems to suggest that Deva may be caught in a dilemma, between the desires to include IK and delivering the products of science.

In the cross-cultural teaching unit, "*Rekindling Traditions*" Aikenhead (2002b) champions the method of using western science to learn more about the indigenous world of learners, which reflects Deva's approach rather than using the indigenous world to learn western science. Aikenhead (2002b) claims that this approach celebrates the co-existence of both sciences, a condition essential to culturally sensitive lessons. Mosimege (2005) adds another dimension to this argument claiming that if IKS were only used as a springboard for accessing western science as Lizzie did, then it would appear as if IKS has no value in itself. This problem of competing purposes in the science curricula, are far from resolved.

Unlike both Lizzie and Deva, Pindi established an African indigenous framework at the beginning of the lesson building on what students already knew about traditional cultural practices of healing and linked it to associated scientific concepts. As various concepts in western science (Biodiversity) were studied, they were enriched and exemplified by additional, relevant indigenous content. According to O'Donoghue and Neluvhalani (2002:131) "one of the most obvious spaces for IK processes is constructivist strategy of mobilizing prior knowledge, tuning in and bringing forth of what is known and meaningful to the learners so that the curriculum provides relevant learning challenges that engage and build on existing knowledge."

Pindi's classroom practice seems to correspond to Lugones (1987) view of teaching science within an "ecocultural paradigm" which aims to empower pupils to feel a sense of ease in each culture, for instance, the culture of science and the pupil's indigenous life-world cultures. For Linkson, (1999) too the indigenous perspective should be used to promote differing worldviews in an attempt to facilitate a two-way exchange of knowledge and cultural understanding.

### 7.2.3 Issue of Indigenous Language

Since language is the main medium for the representation and transmission of indigenous knowledge learning indigenous peoples' languages and cultural practices by researchers and representation of their (indigenous peoples') knowledge in their own languages is a key aspect towards more comprehensive representation of their knowledge systems (Shava, 2008). He further argues that it is a process that is necessary to attend to power and/or knowledge relations that exist in Africa today, emerging from its colonial history.

Ntuli (2002) maintains that translation of indigenous knowledge into English usually results in alteration, adjustment and distortions to fit the new language and he further argues that there are words and concepts that elude translation. According to Shava (2008) problems with IK representations stem from being represented by or as “the other”. These problems are four-fold: appropriation, distortion or misrepresentation, exclusion, and romanticisation or idealisation.

The argument that language defines the way a person behaves and thinks has existed since the early 1900's. Sapir (1921) believed that language and the thoughts that we have are somehow interwoven, and that language not only aids thought but at times also constrains it. He further argued that languages contained the key to understanding the differing world views of peoples while Ntuli (2002) claimed that language represents a specific ontology. It can be argued therefore that knowledge of more than one language holds promise for an expanded, worldview, for understanding other people on their own terms.

In his writings, Sapir (1921) espoused the viewpoint that because of the staggering differences in the grammatical systems of languages no two languages were ever similar enough to allow for perfect translation between them, and that because language represented reality differently that also meant that speakers of different languages perceived reality differently. Social theorists such as Berger and Luckman (1967) in their emphasis of the social construction of reality point to the foundational role of language as a social practice. According to Forrester (1996) learning a language involves attaining a deep understanding of the social practices, which underline the use of a particular expression in a specific context.

Effective knowledge translation also requires an understanding of local and cultural knowledge systems or “ways of knowing” of the communities (Ntuli, 2002). Indigenous languages embody the true spirit, history and culture and therefore a deeper meaning of knowledge (Forrester, 1996). Therefore in order for teachers to translate IK he/she in addition to having a knowledge of indigenous languages, he/she needs to be familiar with the cultural aspects of the community.

The problem arises when the teacher is not of the same cultural and linguistic background as the students. Knowledge of indigenous languages or lack thereof seems to have largely influenced the manner in which the teacher participants engaged with IKS in the classroom. Although Lizzie did not understand indigenous language, however, she was familiar with some cultural aspects, which were part of her childhood experiences. Deva had neither an understanding of the African indigenous language nor an understanding of African cultural experiences and this is probably the reason why he kept the two knowledges as “stand alones”. Although he valued IK he did not attempt to make connections to western science in his lessons, perhaps because he wanted to maintain them as separate knowledges or perhaps did not know how to connect them.

Pindi has the same linguistic and cultural background as her students. Her knowledge of African languages allowed her to tap into deeper layers of meaning and understanding. This probably explains why Pindi puts a high priority on “linking IKS and modern science” She used the practical knowledge of the various linguistic elements of her indigenous language to her advantage by constant code-switching and the use of IsiZulu terms. She had both the security of language competence and her personal knowledge of IKS to negotiate the move between IKS and science.

### 7.2.4 Learner Agency

Learner agency according to Carver et al (2006) refers to the learners’ sense of being the actors who influence what happens to them. Boaler (2002) has noted that students in traditional classrooms have little opportunity to develop agency. Rather in traditional classrooms, teachers seem to operate with the assumption that their teaching practices control the development of students and shape their behaviour externally (Boaler, 2002). This view is challenged by Savignon (1983) who argues that it is only the learner who can do the learning, by being motivated to take on challenges when they perceive themselves as agents of their actions. By its very nature IKS learning supports students’ sense of agency by building authentic experiences into their education that affords an opportunity to engage students.

Lizzie, not being an African, relies on learners as a source of IK and maintained that teaching IKS in the class allowed for the transfer of responsibility of learning to the child. Lizzie's accounts indicated that there was more learner participation and enthusiasm in the lessons. Through observation of Lizzie's classrooms it has become apparent that using IKS in the class made a "sizeable" impact upon patterns of classroom interactions. She found that students' level of engagement and enjoyment was lifted by the inclusion of IKS in the science classroom. Many researchers have also espoused similar views, for example, Manzini (2000); George (1999b) and Clark and Ramaphale (1999) reported that classes literally spring to life when teachers draw on the cultural backgrounds of learners and how the atmosphere in the classroom changed, as students had opportunities to speak about their own beliefs in a science lesson.

Like Lizzie, Deva too, used the strategy of building on students' existing knowledge as a baseline for the introduction of new science concepts. Srikantaiah (2005) supports the assessment of personal knowledge and makes the argument that the first important pedagogical technique is the recognition of students' personal knowledge, which can also be thought of as their IK.

The atmosphere in the classroom changed dramatically through the inclusion of IKS based on learner experiences, a phenomenon that did not exist in conventional science lessons. Classes were more relaxed with more peer interaction evident in the IKS lessons indicative of children as active learners. Students reacted positively to IKS and the emergence of the "student voice" during discussions plays a critical role in "opening up" debates on issues of IKS. This created opportunities for students to be more open and questioning in the classroom, which in turn allowed the teacher more critical insights into students' personal beliefs. Similar findings were reported by many researchers, for example Bruner (1986); Cummins and Swain (1986); Machingura and Mutemeri (2004) who claimed that students enjoyed a positive learning experience, became motivated to learn, while Clark and Rammahlepe (1999) reported that students became embroiled in lively discussions when IKS was included in the classroom.

Deva's approach of compartmentalising science and IKS may have restricted "border-crossing" for some learners resulting in delayed or hindered access to science. But, it is possible that the relaxed atmosphere in the class may have created the right conditions for "border crossing". Learners' enthusiasm for science and Deva's belief that the teaching of IKS was important may have also provided incentives to facilitate crossing borders.

Pindi's use of activities and instructions that built on learners' personal IKS derived from their culture promoted a sudden increase in inputs by learners. Some theorists, for example Gershaw (1989) claim that relevancy helps students to be more motivated to learn while others (Davison and Miller, 1998; Srikantaiah 2005) assert that students need to draw on their prior experiences to make real meaning of the curriculum. Pindi, like Lizzie and Deva also observed that students' level of engagement and enjoyment lifted dramatically by the inclusion of learners indigenous experiences in the classroom.

However, it seems that Pindi's "insider" perspective makes it easier for her to recognise connections amongst the ideas and experiences that learners bring, and western science. For Stanley and Brickhouse (2001) an effective teacher who can make "border-crossing" possible is a "culture broker" and being a successful culture broker (Lugones, 1987) demands making links and flexibility in moving between the learners' worldview and the worldview of science. Pindi does so in both tasks one and two of her university assignment and in her teaching of "IKS in science" lessons positioning her as a more effective "culture-broker" teacher than Deva.

### 7.2.5 Teaching from learning, Learning from teaching

A picture of changing patterns of classroom interaction emerged from the analysis, in the form of more teacher-pupil interaction in all three approaches. Although Lizzie acknowledged that learning IK through the learners required a paradigm shift from conformist "teacher-leader" to one of "teacher-learner" she does not fully embrace the learner position. This is evident in the manner in which she handles IK for the classroom. While acknowledging learners as resources of IK she at the same time undermines the IK brought by learners by validating and restructuring it according to western science interpretations. This position of a learner is contrary to Freire's view of an educator-learner who also learns from the person being educated in the same way that the latter learns from the educator.

Deva commented that due to the teaching of IKS the previously, autocratic relationships between teachers and pupils have been replaced by more collaborative ones. For Deva, in order to successfully teach science lessons in which IKS is elaborated requires a shift in mindset from one of teacher to one of learner and a positive attitude to being open to learning from learners. It emerged from the data that while Deva is the "expert" in conventional science lessons, instead in IKS teaching, he willingly adopts the learner position and allows the students to become the "experts" by learning from their communities. According to Freire (1994) and Breen (2004) adopting a "learner approach" to teaching revolutionizes the concept of education from the transmission of contents to establishing dialogue as a new concept of the teaching relationship. Such a novel outlook is congruent with the wider national agendas in the Norms and Standards for Educators that envisions teachers as scholars, researchers and lifelong learners. The RNCS document with the time allocation of 70% for core concepts and 30% of the time available for extending the core attempts to open spaces for dialogue between teachers and learners, a factor crucial for this manoeuvre.

Pindi too, recognised and commented on the transition she made from the world of the teacher - from one of knowledge giver to the world of the learner. Literature reviewed recognises that teachers must become learners and the learners must become teachers (Breen, 2007; Freire 1994). Use of the term "both ways" indicates that both teachers and learners are a community of learners together. The acceptance of knowledge as something to be continuously shared between teachers and learners is a new concept of teaching for most teachers used to conformist practices and Pindi is no exception.

### 7.2.6 Validation and Access to IKS

The three teachers chose to address validation and access to IKS in three different ways. There is a mismatch between what Lizzie says and does in the teaching of IKS in science lessons. Although Lizzie says that IKS is science, she does not accept it as "useable" knowledge for classroom teaching. Firstly she continually validates IKS against western science in order for IKS to "fit" school science. She then selectively admits to the classroom only that IKS that meets the criteria for science and which she can make "sense of scientifically." IKS, that is not compatible with science, she dismisses from the lesson. Lizzie's approach of accepting as valuable IKS only that which western science can validate, is not unusual and conforms to the actions of many western scientific archivists who refuse to accept this "raw" indigenous knowledge and upon collection insist on testing its validity via western scientific testing (Rajan and Sethuraman, 1993).

Debates abound in literature (Goonatilake, 1984; Leeuw, 2004; Ntosane, 2005; Onwu and Mosimege, 2004) whether modern science should be the starting point for evaluating IKS or whether it should exist in its own right without trying to justify itself in terms of other knowledge systems. Onwu and Mosimege (2004) question whether it is necessary to accord IKS a measure of legitimacy for its inclusion in the science curriculum and how does one do so?

Unlike Lizzie, who validated the IKS brought by learners from the community, Deva chose not to validate it suggesting that he intended to retain the integrity of IKS by not linking it to science. He regards IKS to be equally grounded as western science and to be able to "stand alone". Acknowledging IKS on its own terms seems to reinforce Deva's belief of using IKS in the curriculum to address concerns for equity, heritage and nation building. Deva's concerns, which are particularly important in the context of South Africa may be similar to that of Gay's (2000) who points out that a "culturally responsive" teacher realizes not only the importance of academic achievement, but also the "maintaining of cultural identity and heritage". Contrary to Deva's approach Semali and Kincheloe (1999: 45) maintain that an indigenously informed curriculum is not one that "simply admits more people into the club of science but in seeking legitimacy challenges the epistemological foundations of the ethnoknowledge."

Many researchers such as Mosimege (2005), Ntosane (2005) and Mwadime (1999) are of the opinion that it would be a mistake to subject IKS to the same verification or validation processes as one usually does with respect to western science and that one should not look at IKS with the same lens of judgement as one does with western science. Mosimege (2005) and Ntosane (2005) further argue that the two systems are different and therefore require different standards for validation. Pindi's approach seems to respect the views of the above researchers in that, unlike Lizzie who used a western framework, she used her own personal knowledge and those of her colleagues to validate IK brought by learners. Mwadime (1999: 252) sees value in the method of going to other teachers to validate IKS since the local community know and understand their IKS better than "outsiders" and advocates the use of local consultants like elders, teachers, midwives, religious and traditional leaders. He further maintains that failure of a certain IKS to meet "one's understanding" should not be a reason to render it irrelevant due to the fact that IKS differs from "formal scientific knowledge" in the contextual sense and many aspects may remain invisible.

Hountondji (1997), on the other hand, argues that one should always look for ways and means to question the truth and validity of IKS before accepting it even if it means using western science as a verifier. Mosimege (2005) and Ntosane (2005) oppose Hountondji's (1997) view of using western science as a verifier of IKS because they claim that the exclusivity that accompanies the rational and linear framework of science will then determine what is to be included or excluded as science (in the classroom). Extending Mosimege's and Ntosane's idea further, it may be argued that the standard for authenticating IKS should also take the cultural context of IKS into account. From the analysis it may be argued that teachers have a limited understanding of theoretical underpinnings of IKS.

Another school of thought opposite to researchers who argue for western science to be used as a validating framework, such as, Hountondji, is that of Agrawal (1995) who maintains that IKS does not derive its origin in the individual, but in the collective epistemological understanding of the community and the belief that indigenous knowledge can be extracted on a piece-meal basis without disrupting the whole system is extremely fallacious. They claim that IKS would be regarded as "subjugated knowledge" in its relationship to western epistemological and curricular power as long as western science remains the hegemonic milestone by which IKS is measured.

In addition to validation before admitting IKS into the classroom Lizzie restructures IKS according to the logic of the western science, a process she identifies as hypothesis testing, including experiments, interpretation of results and drawing conclusions. Her assumption is that like western science, IKS can be broken down into categories corresponding to set scientific categories, be examined and tested separately, categorised and pronounced "true". Utilisation of the language of western science to reformat and reorganise learners' IKS experiences suggests that Lizzie plans to use the methodology and reasoning of western science, the "scientific method," which is not used with other systems of knowledge. Lizzie seems to privilege western science in two ways. Firstly, by using it as a yardstick to measure IKS and secondly, by interpreting IKS through western science representations. This is clear evidence of the importance she attaches to western science. An important aspect emanating from the above arguments is that although "some aspects of IKS" meet the criteria set by western science Lizzie accepts it, not as science, but as a "kind of science."

In extreme contrast, Parker and Binker (1990: 514) argue that scientific thinking is not simply a matter of running through a set of steps, but rather it is about continually moving back and forth between questions we ask about the world and observations we make and students should be encouraged to use this approach in their everyday thinking. To this Tema (2002:137) adds that the nature of the scientific approach tends to distort the nature of knowledge by not viewing it as a human construct, thus suppressing the possibility of alternative interpretations. Garrouttee (1999) does not support altering IKS and argues that extractive approaches [*validation and restructuring*] can rob IKS of one of its special values and the cultural context. Garouttee (1999) elaborates that when parts of IKS that does not "fit" science are excluded from the class, something vital to IKS is lost.

What Deva preferred was written knowledge from textbooks and journals, which could be authenticated by referencing. This opens up another debate, which is extensively discussed in the literature and raises the question; can IK be transposed, that is, rearranged, written down, and analyzed according to scientific parameters, without being distorted? Agrawal (2005) raises concerns about the strategy of translating oral form to written form because it runs counter to the very concept of indigenous knowledge and detaching IKS from its human and natural context is tantamount to foretelling its death. Heyd (1995) points to what he regards as another shortcoming of *ex situ* storage of knowledge systems in that it creates a mausoleum for knowledge fixed in “time and space” contrary to IKS which is not static but evolves and changes over time through interactions with other knowledge systems. Therefore he maintains that efforts to document, archive, assess, validate, classify and disseminate indigenous knowledge, however well intended, not only fail to do justice to indigenous knowledge, but also contradict the dynamic nature of indigenous knowledge. Heyd’s argument may be extended to knowledge in general which includes the nature of science that remains in a constant state of flux as new theories and concepts are developed and adopted.

Contrary to Heyd’s (1995) argument, Warren (1990) is of the opposite view. For him the recording of knowledge will make it available to the global community and he is confident that community-based knowledge systems will in the near future begin to be regarded as contributions to global knowledge. If a very important component of a knowledge system is access to that knowledge the ultimate irony may lie in adopting western methods of documenting and codifying IK for the sake of posterity.

From the above discussions it can be seen that validation and access to IKS is becoming an extremely difficult and daunting affair and that teachers too are grappling with both these issues.

### 7.2.7 Nature of IKS

The dilemma one faces in defining IKS is central to postcolonial debates on the origins of knowledge and the manner in which it is produced, archived and disseminated (Martin, 2007). Cobern and Loving (2001) and Ogunnyi (2003) are struggling to address, whether IKS is in fact science or "kind of science". Is IKS science, one kind of science amongst many sciences or a science, but not science according to the "Standard Account" of western science? Where is the place of IKS and of myths and beliefs in the science classroom? These questions do not lend themselves to easy and concise answers. As interrogated in the literature review the RNCS policy also does not resolve the issue of whether IKS is science.

Although Lizzie did not attempt to define science during the interviews, the word emerged on many occasions. From these occasions it became evident that for her science is a process identified by hypothesis testing including experiments, interpretation of results and drawing conclusions and science is seen as promoting some sort of check or proof.

There are many interpretations of "ethnoscience", which differ vastly but in the following section three meanings given to "ethnoscience" are examined as they might relate to the teachers' approach of including IKS in the science lessons. The first interpretation is that of Gerdes (1994) who argue that there is a tendency to distinctively label that IK which when translated meets the criteria for science as "ethnoscience". This denial of the label of "science" creates an obvious bias - IKS is seen as "lesser" than western science. "Ethnoscience" denotes a culturally based science, while science is perceived as universal (Semali and Kincheloe, 1999) and the "truly objective study of natural reality, and the standard against which all others must be compared" (Cajete 1994).

The manner in which Lizzie views IKS in relationship to western science can be regarded as "ethnoscience" according to the meaning given by Bishop (1990) and Gerdes (1994) who write on ethnomathematics. Applying their view on ethnomathematics to science would mean that the term "ethno-science" tends to carry a rather negative connotation as an inferior or deficit science relegating it to a lower order of knowledge than western science. Howard (1994) argues that this method of transforming alternative knowledge systems and calling it "ethnosciences" informs holders of IKS that their knowledge is of an inferior type that can be improved by validation, classification and rearrangement according to the logic of western science. Gerdes (1994) further maintains that if we accept that western science is a cultural entity itself, one of many subcultures of Euro-American society, are we not implying that western science is just another "ethnoscience"? How then can one form of "ethnoscience" have greater legitimacy than another?

The second meaning, according to Hountondji's (2002:35) understanding and one that he does not subscribe to because it does not seek out truths is the view that "ethnoscience" "does not ask any questions about the *truth* of the knowledge systems. It just describes it and leaves it there". If we accept the meaning of ethnoscience according to Hountondji's (2002:35) understanding, which is, "it does not ask any questions about the truth of the knowledge systems. It just describes it and leaves it there" then Deva's classroom practices of IKS in relationship to western science may be regarded as "ethnoscience". Like Hountondji, Malcolm (2002 b) too, strongly contradicts this view of ethnoscience. For him IKS needs to be authenticated because he believes that the "value" of an idea in science depends on not simply where it came from but its "truth" and usefulness. Thus as part of the curriculum, the criteria for "truth" and usefulness have to be surfaced and discussed, so that learners can decide the value of the idea. In support of his argument he cites the oft-quoted (but poorly sourced) African belief that having sex with virgins cures HIV/AIDS and such instances bring the science curriculum face-to-face with moral responsibilities. Deva's approach of not verifying IKS either scientifically or by using other sources and keeping the knowledges separate, seem to serve the purpose for which he intented to use IKS, that is, of respecting heritage and culture.

A third and opposite interpretation of "ethnoscience" is presented by Davison and Miller (1998) whose view of "ethnoscience" does not have connotations of relegated status. They view "ethnoscience" as being the body of science knowledge used by culture to make the science curriculum relevant to students and that it must interface with every aspect of the student's life while Semali and Kincheloe (1999) cite ethnobotany, ethnomedicine and ethnoastronomy as such examples of "ethnoscience".

Pindi's classroom practice can also be classified as ethnoscience if we consider Davison's and Miller's (1998) interpretations of "ethnoscience" where IKS is not considered inferior to western science but are seen as ways to enrich curriculum by the inclusion of cultural experiences.They claim that developing the curriculum to make it relevant to the students' interests by building on the students' cultural knowledge, providing that it interfaces with students everyday life, is "ethnoscience." Pindi identified plants in her lessons, which acording to Davison's and Miller's (1998) interpretations will not qualify as ethnoscience, but since her discussions also included medicinal properties of the plants which related to students' life, her view of the nature of IKS then aptly fits with Davison's and Miller's (1998) interpretations.

At all levels, indigenous knowledge is sometimes consonant with western science, sometimes not. What is a teacher supposed to do with the enigmatic aspect of IKS? Ignore it as irrelevant superstition? Accept it as equivalent to scientific explanations? The most difficult perspective to realise in class and also the most contentious is the metaphysical aspects of IKS. Malcolm (2001) has a firm belief that if IKS is to be included in the science classroom, it is necessary to manage dissonances as well as consonances.

By choosing not to respond to a learner who referred to a spiritual issue in the lesson was Pindi aware of the complex dynamics that can arise when metaphysical issues are addressed in the classroom or could it be that she was unable to make the connections between the science and the "spiritual aspect?" However, she believes that even though certain beliefs may really seem to be out of place and viewed as superstitious beliefs they may have been designed to serve a particular purpose and that one needs to dig deeper to find out what informs a belief.

There seems to be a difference between the classroom IKS and the theoretical IKS as provided in the literature review. IK that emerged in the classroom are specific examples such as, herbal medicines, homemade beer, food preservation etc. These are in fact a part of a "broader system" of IK. When IKS is juxtaposed with western science in the classroom it brings with it the many debates and dilemmas that were interrogated in earlier chapters. Since almost no inferences (except for Deva) were made to the larger epistemological issues it seems that teachers are unaware of the "broader systems" of IK.

### 7.2.8 Approaches to "IKS in Science" lessons

Lizzie's incorporation approach of starting the lesson with western science and then bringing in IKS reflects her own perception that western science is superior to IKS. This style of presentation can also be interpreted as if IKS is not foundational in the lesson but as an additional "add-on" perhaps for the sake of creating interest or to meet requirements of Learning Outcome 3. An "add-on" or tokenism approach is contrary to the RNCS which portrays IKS as a "way of knowing", "knowledge about the environment" (DoE, 2002a: 11) suggesting a role of IKS as *content* of science instruction (see Appendix A).

Clark and Ramahlape (1999) hold an opposite viewpoint to Lizzie and arguing against the strategy of trying to "fit" IKS in western science they maintain that the success of science instruction will depend on the extent to which western science can find ways of "fitting" into students' worldview and not the other way around which Lizzie favoured. In incorporating IKS into science, Lizzie would be more inclined to use topics for science lessons that harmonise with pupils' beliefs, or alternatively, activities that attend to those beliefs but incorporate "authentic" aspects of the beliefs to scientific content.

It is clear that Lizzie treats IKS in varying ways. Lizzie validates IKS and accepts those that "fit" western science, rejects those that cannot be verified by science, some she restructures and still others she accepts because it comes from her mother and has worked well in her life. Using western science as a benchmark for validation and reorganisation of IKS brings with it notions of the superiority of western science and the inferiority of IKS as an "ethnoscience". This manner of engaging with IKS once more seems to illustrate her own western bias.

If IKS is seen as a "kind of science", an "ethnoscience" but not equivalent to western science it may necessitate a redefinition of science to broaden it's meaning to include "ethnoscience" so that there is no controversy about the nature of IKS.

For Deva, it appears that he wishes to maintain the mutual existence of both IKS and western science side-by-side in his lessons in his separatist approach. IKS was respected, compartmentalised, that is, each "way of knowing" was like having ideas in "different pockets". Providing support for such an approach, Roberts (1995) believes that IKS can be taught alongside western science as distinct domains, provided that they are not entirely dissimilar knowledges.

Deva's approach also conforms to McGregor's (2000: 454) claim that "because of hegemonic power relationships, we should not integrate or bridge Western science and IKS, but instead we should actively support a postcolonial model called *co-existence* which promotes functioning of both systems side by side. The model of co-existence encourages equality, mutual respect, support, and cooperation."

Further support is provided by the RNCS Natural Sciences (DoE, 2002a: 12) as "it is not unusual for people to use different ways of thinking for different situations, and even scientists in their private life may have religious frameworks". Peat (1994) too, maintains that the capacity to think differently in diverse cultures, are familiar human traits. For example, on a topic like evolution in the science classroom a learner may subscribe to the theory of evolution but in the conduct of his/her private life he/she may subscribe to religious beliefs.

Deva's dilemma in terms of preserving what is good in pupils' personal cultural tradition while at the same time allowing them to benefit from western science is also voiced by Kaunda (1966) and Gay (2000) who argue that juxtaposing the knowledge systems conveys respect for learners and affirm their differences and becomes the basis for meaningful relationships between teachers and learners. Deva's claim of "don't destroy the belief," seems to conform to Kyle (1999) argument that educators have the fundamental obligation to explore divergent views, including those that are radical (for example, myths).

Traditional beliefs were identified, acknowledged and respected and at no point in the lessons was there a confrontation between IKS and scientific knowledge. Deva did not indicate that answers and explanations given by students were incorrect. Deva's "equal and separatist" approach and his argument for IKS in the curriculum on political and moral grounds is indicative of his belief that IKS was beneficial but more for the purposes of human rights and social justice issues rather than for science teaching.

Keeping domains separate, that is, IKS and western science have also been criticized by many theoreticians (Corsiglia and Snively 2000; Stanley and Brickhouse, 2000) who argue that such domains cannot exist entirely separately and that it is healthy for aspects of each domain to contribute to the other in mutually supportive and inclusive ways. Pindi's "integrationist" approach illustrates how this may be accomplished.

It can also be argued from traditional versus western worldviews (in chapter three) that the knowledge systems overlap and they are not mutually exclusive and that constant links promote a more inclusive system that can better serve the needs of all learners. Pindi attempts to bring the two systems together in a manner that promotes the integrity of IKS while simultaneously embracing the important concepts of western science.

Her lesson was directed towards engaging students in science activities and discussions that made connections to students' everyday world. Pindi integrated her lesson with IKS and western science drawing on both as required during the lessons. It appears that having an "insider" status, solidly grounded in her African identity, gave her the confidence and security to move back and forth between the two knowledge systems in her lessons.

## 7.3 CONCLUSION

In this chapter the three different approaches to teaching IKS used by the teachers were developed, namely: an approach that incorporates IKS into science which exemplifies Lizzie's approach; an approach that keeps IKS and science separate which is indicative of Deva's approach, and an approach that integrates and draws connections between IKS and science which represents Pindi's approach. Each of the different approaches was interrogated through different themes in an attempt to find out what influenced the teachers in the way they engaged with IKS teaching.

In the final chapter the implications of the three different approaches for policy, curriculum issues, teacher education programmes, IKS teaching, theories and research are addressed.

# CHAPTER 8

## TEACHERS' APPROACHES AS A LENS FOR SCIENCE AND IKS

In the previous chapter the three different approaches used by the teachers, namely the incorporationist, the separatist and the integrationist in science lessons in which IKS was included and some possible reasons for taking such approaches were presented.

In this chapter what this would mean for each of the following is interrogated through using the approaches developed as a new lens:  policy, classroom practice, teachers, teacher education, "IKS in science" teaching and theory/research.

On the basis of the discussions presented in chapters five, six and seven I make the following claims that constitute the main argument of my thesis. There may be three very different approaches in which IKS is brought in the science curriculum. Interpretation and implementation depends on the approaches that teachers take which is informed by their biographies, values, cultural backgrounds and worldviews.

## 8.1 IMPLICATIONS FOR POLICY

In contrast to some researchers (Desai, 1995; Pieterse, 2004 and Miller, 2008) who argue that a disjuncture exists between policy and practice, this research found that teachers were indeed implementing the policy, albeit in very different ways. It seems that contrary to the rigid and prescriptive curriculum demands of the past, the OBE policy framework for Natural Sciences, Life Sciences and Physical Sciences allow educators ample space to be creative and innovative. The 70/30% rule of the Natural Sciences Policy Statement (70% of the time for the core knowledge and 30% of the time for extending the core concepts and around contexts which are significant to learners and the local community, see appendix A) opens up a space for teachers to contextualise the teaching and choice of content and creates opportunities for dialogue between teachers and learners. On the one hand, the policy, by not being prescriptive, creates possibilities in the classroom and allows for different interpretations by the teachers. On the other hand, because the policy provides little assistance for actual lesson development and implementation teachers may pay lip service to IKS in the curriculum or may do very different things.

The RNCS and NCS gave teachers room to adapt the science curriculum in accordance with their knowledge and beliefs, personal factors and school context. The flexibility allowed teachers to make their own choices in terms of selecting content and instructional strategies that they valued or thought were more relevant to their students. One can assume that this was the thinking behind the Natural Sciences policy statement, which is an "enabling document rather than a prescriptive one," (DoE, 2002a: 12) for its silence on methods of including IKS in the science curriculum and leaving such approaches to the teachers.

The NCS Physical Sciences (Grades 10-12) which has ***"infused"*** indigenous knowledge systems into the Subject Statements" (DoE, 2003a: 4) may be interpreted as combined or merged into the Subject Statements. The assessment standard of LO3 (G11) *"recognizes, discusses and compare the **scientific value** of knowledge claims **in indigenous knowledge systems**."* The approach that best fits both these descriptions is the incorporation approach. In (G12) assessment standards learners are expected to…."*compare and evaluate scientific and IKS claims by indicating the **correlation** among them"* may be interpreted as connections or links which is supported by another approach, namely the integrationist approach. It is evident from the assessments standards that the policy vacillates between the incorporationist and integrationist approaches.

The NCS Life Sciences statement, "exploring IKS ***related*** to science exposes learners to different worldviews and allows them to compare…"explicitly eliminates the separatist approach of keeping IKS and science apart but seems to advocate the integrationist approach. However, another view is expressed in LO3 in that it, *"raises learners awareness of the existence of different viewpoints in a multicultural society, encourages open-mindedness towards all viewpoints. These viewpoints are based on scientific knowledge, beliefs, ethics, attitudes, values and biases."* Clearly to include these different viewpoints in the NCS Life Sciences, the separatist approach would be the most suitable. The policy wavers between the integrationist and separatist approaches. It is clear from the above discussions that *different approaches* are being advocated in the policy documents.

Although it may be argued that the policy at this stage is exploratory in nature but raising awareness and encouraging open-mindedness to the existence of different viewpoints is not enough. More is required of it in terms of providing teachers with clear directions related to the implementation of IKS in science lessons. The policy also needs to move to the next phase of critically addressing postcolonial discourses of power, social justice, and equity among alternative ways of knowing. This would expose teachers to the debates on IKS, which might help teachers to contextualise their thinking and teaching in a broader personal, social and political context.

A critique of the policy addressed in chapter two is that only the Life Sciences statement makes clear reference IKS in LO3, whilst in the Natural Sciences and Physical Sciences Statements IKS is addressed only in the assessment standards and illustrative examples. Oblique reference or implications of IKS in LO3 is not sufficient to ensure that teachers would embrace IKS in their lessons. IKS need to be clearly spelt out in LO3 to ensure that teachers understand what is required of them and their learners.

It is crucial that the National IKS Policy (DST, 2004) be critiqued, as the creation of IKS policy was a significant milestone and a commitment by the government of South Africa in engaging IKS in education. The policy in seeking to address the transformation of the education syllabi makes the following comment: "*it will further require that appropriate methods and methodologies for mobilizing IK in various learning contexts be identified and used"* (DST: 17). However, in specifying the role of different national departments, it identifies the role of Department of Education "*as **integration into** the curriculum* (DST: 39). This explicitly advocates the incorporationist approach. Using this approach would mean that western science would co-opt and dominate IK if it were incorporated ***into*** science. By accepting only the knowledge that 'fits' science, it fails to recognise IKS on its own terms as the policy seeks to do (DST: 4), the status quo will not change and power and/or authority is not contested.

## 8.2 IMPLICATIONS FOR CLASSROOM PRACTICES

This study offers a window on how IKS may be addressed in three very different ways in the science curriculum and provides us with insights as to how classroom practices can be changed with respect to learner agency, kinds of IKS topics chosen and IKS resourcing.

***Learner Agency***

The study provides support that IKS can act as a catalyst in stimulating participation in the teaching and learning of science in new ways previously unheard of in the apartheid science classroom. The recognition of IKS that learners brought to the class served as a catalyst to transform traditional classroom methodologies to learner-centred-OBE practices. Teachers claimed that the strategy of contextualising science by deliberately including learners' cultural backgrounds seemed exciting with numerous possibilities that encouraged discussions, debates and dialogues. IKS learning supported learners' sense of agency by building experiences into their education that were authentic and afforded an opportunity to engage and motivate learners. Teachers using an incorporationist approach of bringing only that IK that "fits" with science may see a less significant effect on established patterns of interaction in the their classes than teachers who may choose to use either the separatist or the integrationist approach. Using an integrationist approach is bound to generate a far more interactive teaching and learning environment than the separatist approach due to its creation of an indigenous framework at the beginning of the lesson, preceding the introduction of western scientific concepts. The approach of constantly drawing upon IKS during the lesson and making links to science facilitated "border-crossing" for learners between their own life world and that of the science classroom more than in the other approaches. The separatist approach where IK and science were kept separate may inhibit or delay border crossing. However in all three approaches teachers may assist border crossing by creating a friendly, caring and nurturing classroom environment.

***IKS Topics***

Using the incorporationist approach would require teachers to validate and perhaps to also restructure IKS according to western framings. Topics chosen will be only those that can be related to science. IKS that is bound to conflict with science will not be admitted in lessons, for example IK that deals with metaphysical aspects or religion. This would limit the IKS that would be introduced into lessons and teachers may accommodate only that IKS which relates to his/her own underlying beliefs and values.

Teachers who choose to use an equal and separatist approach are more likely to ignore validation of IK that learners bring and to readily accept all IK into the lessons. By allowing all IK in the classroom it allows for different worldviews to exist simultaneously in the classroom to address issues of social justice, equity, human rights more than for science. IK was validated by personal knowledge and the knowledge of local teachers in the integrationist approach. Teachers using this approach would use IK that is relevant to the local context of the school for more meaningful learning.

***IK resource***

An emerging constraint associated with “IKS in science” teaching was that of lack of resources. Teachers who choose to use an incorporationist approach would be more inclined to seek out IK in written texts, of which there are very few and those that exist have been criticised for the superficial manner in which IK is presented. Teachers who use the separatist and integrationist approach are more likely to use learners as resources for IK.

While the NCS is flexible and allows for engagement of diverse knowledge systems, examination requirements exert a strong influence on what is taught and how it is taught. Currently there is almost no consideration for IK in the senior certificate examinations and there is a danger that IKS will be neglected in classroom teaching.

## 8.3 IMPLICATIONS FOR TEACHERS

In the current milieu of curriculum reform, overwhelming attention is being paid to the educator from one of knowledge giver to one of learner (DoE, 2001). This was the most significant pedagogic shift reported and observed in all three approaches. Inclusion of IKS in the classroom allowed for a marked shift in the dynamics of classroom interaction between teachers and learners. Teachers taking an incorporation approach may not be able to embrace the position of learner fully because validating IKS against western science tends to undermine IK brought by learners. Teachers who are not of the same culture as the learners may rely more on learners as a source of IK.

A finding emanating from this study is that learner's worldviews are not the only concern and that the worldviews that teachers bring into the classroom have implications for approaches that teachers take to include IKS in their lessons. The approaches taken by teachers were significantly influenced by their values and beliefs, experiences at home while growing up, at school, at the university and as teachers.

Given teachers' backgrounds (cultural, political and social) it may be inferred that they would interpret and implement IKS in different ways in the curriculum. For example, teachers with a strong empirical worldview would tend to focus more on science explanations by using the incorporation approach. Teachers with political affiliations may include IKS for purposes of social justice and a separate and equal approach would better this purpose. Teachers who have the cultural background or the personal knowledge of IK being used in the classroom may be more adept at taking the integrationist approach.

In the teaching of science lessons teachers are the "knowledgeable experts" who have the subject content knowledge and confidence (Schulman, 1987) because he/she knows more than the learners. These teachers have the qualifications, educational backgrounds and intellectual authority to teach science. In IKS the "knowledgeable experts" are located in the community and a high value is accorded to this knowledge. However, IKS is not "packaged" as school material is. Therefore teachers taking either the incorporation or integration approach must first access the IKS, and then understand it and its likely relation to what is being taught in the science class. These are unfamiliar activities for most teachers. What a drastic change, educators learning from the local community members!

The initial lack of confidence indicated by the teachers stemmed from the fact that they had insufficient “IK subject content” and were largely dependent on learners or texts for this knowledge. Literature reviewed suggests that, not having content knowledge does not pose a serious challenge because teachers acquire this knowledge during the preparation for the lesson (Parker, 1985), provided that the interest and belief to include it (IKS) are present. This study together with other studies (Jegede, 1995; Garrouuttee 1999; Ogunnyi 1988) found that teachers did not possess adequate IK. This study went further and showed that teachers possessed the adequate instructional skills to translate the IK brought by learners to implement “IKS in science” curricula.

For teachers, who may have knowledge of IK but inadequate science knowledge, this would also be a problem. Interpreting and implementing lessons including IKS would not be an easy task because these teachers will not be able to link the IK with relevant science concepts.

Indigenous knowledge is not a singular concept. No single indigenous experience dominates other perspectives and no two heritages produce the same knowledge. Therefore homogenous methodologies and curricula used in most schools are not helpful for including IKS in the lessons. Any attempt to include IK must take into account the fundamental diversity of indigenous knowledge. Teachers in developing curriculum material need to recognize the great diversity and local variations in language, knowledge, customs and traditions of communities and cultures in South Africa and ensure that the curriculum is flexible enough to accommodate local variations of IKS.

As teachers begin to teach IKS they will need to decolonize education and its knowledge systems, a process to include the voices of those who were marginalized, to expose the injustices in our colonial history, to deconstruct the past by critically examining the social and political reasons for excluding experiences of the “marginalized” in the curriculum. The incoporation approach, leaning towards an empirical position may not be able to easily address issues of equity and social justice as the separatist and integrationist approach.

However, Ng'etich (1996) cautions, against the idea of a single "integration"[13] blueprint that suits every form of indigenous and western knowledge. Teaching that reflects OBE and the constructivist perspective cannot be reduced to a rigid prescription that, if faithfully followed, automatically results in student learning. On the contrary, it requires thoughtful decision-making in the present South African context that is characterized by curriculum transformation. Teachers in South Africa are required to accommodate various forms of diversity in terms of race, ethnicity, gender, cultures etc. Therefore many approaches to teaching of science to include IKS curricula would be more suitable.

Science educators may find difficulty in moving from western science to include other cultural concepts in the classroom. Therefore one cannot expect teachers' perspectives to shift rapidly especially for science teachers embarking on shifting from a universalistic to a cross-cultural perspective. However, it remains the responsibility of educators to interpret the changes and to make them a part of the new science curriculum so that they become meaningful, and take root in the consciousness of the people of South Africa.

## 8.4 IMPLICATIONS FOR TEACHER EDUCATION

The study has potential value for institutions undergoing curriculum reform in teacher education programmes. The feasibility of implementing "IKS in science" teaching means that teachers need to undergo in-depth changes especially during in-service programmes. It is crucial that teachers are equipped with the necessary skills and therefore what is needed is well-planned and supportive teacher education.

Examination of the B.Ed module showed that all the examples used in the course were from the African context. However, the lecturer of the module who was White did not

[13] Some researchers, for example Semali (2001) and Ng'etich (1996) use integration and incorporation synonymously. In this research I use integration and incorporation to means two different things.

have the competence in indigenous languages and therefore decontextualised, misrepresented or misunderstood translations might have been presented to the students. Drawing from Chapter 3 it has also been argued that translation occurs in the paradigm of the translator, not in that of the translated.

It might also be concluded that the lecturer's perception of IKS is that it belonged mainly to Africans and this might have influenced teachers' choice of topics for the assignments since all topics selected were from the African context. It is important that lecturers, when selecting IK examples take cognisance of the diverse worldviews that exist in the new democratic classrooms and to ensure that teachers are given the appropriate experiences of South African reality by including other IKS perspectives. It was noted that while the tasks required teachers to deal with conflicts, none of the teachers attempted to do this. If this was not done as part of the module or not made explicit then there is a need to do so because conflicts are bound to occur when diverse worldviews come together in the classroom. Re-education of teachers is necessary where they understand the critique of western science that IKS scholarship offers and the postcolonial and political underpinnings of their work.

It is common-sense to assume that what a teacher knows will influence what he or she does in the classroom so one-way to improve teacher effectiveness must surely be to ensure that teachers have the IKS knowledge. But effective practice is not simply a matter of adequate knowledge. Besides the IKS understanding, teachers need to know how to translate the knowledge into effective practice. The B.Ed programme must strive to ensure that pre-service and in-service teachers are given this opportunity by building practical approaches to teach IK into the course. Despite these limitations there were strong indications from the survey and from the teachers' stories that the B.Ed module was considered by most teachers to be their most important source of IKS. In addition to retraining teachers a promising area for change would be re-orientation of lecturers. A useful educational tool for re-training would be for universities and other institutions to team-up with experts in the field of IKS, such as elders, community leaders and sages etc. who are the primary sources of IK.

Teachers' willingness was found to be critical in implementation of science curricula that include IKS because teachers normally teach best what they value. Teachers must "want" and "know" before they can "act". If teachers do not believe in including IKS having the understanding and knowledge is not enough to convert it to classroom practices. Teachers may have the knowledge but not know how to implement it, and then teachers need to be trained in this skill. Rather than merely imparting knowledge with a view to changing teaching practice teacher education programmes should be geared towards providing teaching experience of "IKS in science" curricula.

In science education, many teachers exposed only to Western science often perpetuate the "universality of science" and "superiority of science" perspectives. These teachers may reinforce these ideas amongst learners, leading to subjugation of their indigenous ways of experiencing the world. Thus there is a dire need to address IKS issues in Africa and to seek ways to assist teachers to grapple with the socio-cultural aspects in a science classroom (Cobern and Aikenhead, 1998; Jegede and Aikenhead, 1999).

## 8.5 IMPLICATIONS FOR IKS TEACHING

Using and valuing IKS by the teachers would happen in different ways in each of the approaches.

***IKS to Access Western science***

In the incorporationist approach, particularly, IKS is viewed as a pedagogical tool to stimulate science learning. Here the aim of indigenous knowledge was to help learners to gain access to western science. This approach ensured that learners were not robbed of the necessary concepts and skills to survive in the increasingly global world. In this approach attention to traditional knowledge detracts from the more important task of putting forth western science.

***IKS as a Knowledge System in Itself***

Maintaining the autonomy of IK will not only validate IK on its own merits but will further allow for a critique of the hegemonic western science model. In both the separatist and integrationist approach IK was viewed as a domain of knowledge with equal value to western science.

***Western science to affirm IKS***

The teacher whose frame of reference was westernised used the reference of western frameworks, its nomenclature, understandings and concepts to explain and to communicate in the classroom. Teachers who see western science as a way of affirming IK would be able to take the incorporationist approach.

It seems that although there are those teachers who think that traditional knowledge is beneficial, it is science, they insist on validating IKS against modern science. In one case it is validated against science, while in another case it is done through the teacher's personal knowledge and that of her colleagues. In the third case IKS is not validated and all IKS brought by learners are accepted. This practice of validating IKS against western science implies that science remains the valued knowledge, the useful knowledge, against which other forms of knowledge are measured. Or does this mean that IKS is seen, as being inferior in status to western science and by constant comparison tends to elevate the status of IKS to that of western science?

***IKS as Political Transformation***

Teachers recognised that engaging western science and indigenous knowledge in the classroom was in itself a transformative act. Being included in the RNCS and NCS grants indigenous knowledge respect it has traditionally not received in education. In pursuit of the transformation in post-apartheid South Africa, the teachers believed that including indigenous knowledge in the science curriculum was essential and valuable. Some of the reasons provided by these teachers for their choice were:

- IKS being a part of nation building, and fostering tolerance amongst learners of different cultures.
- Development of morals, values and increasing the self-esteem of learners.
- The importance is to learn from and respect all people in a multicultural society, namely South Africa.

***IKS as Science***

All three teachers believed IKS to be science but two teacher's classroom practice show otherwise. In the incorporation approach only that IKS that related to science was considered, in the separatist approach it was not linked to science whilst only in the integrationist approach IK was perceived as science and connected to it.

Generally teachers have limited understanding of IKS by quoting and using specific examples in their teaching. Teachers have a responsibility to teach to transgress the norm that reproduces Western values. For this teachers need to be aware of the wider epistemological and ontological issues.

## 8.6 THEORY/RESEARCH

Mobilizing IK in the curriculum is not just a technical or practical process. It involves a range of complex, often sensitive socio-political perspectives.

The answer to research on IKS is not in the choice of one paradigm over another, but in the use of multiple paradigms, each shedding light on particular aspects of a situation. Critical constructivist and postcolonial research is needed as additional paradigms. The critical approach can be used to help confront and eliminate racism, ignorance, stereotyping, prejudice and feelings of alienation and critically engaging ideologies, which reify western science as being superior, more scientific, and therefore more legitimate. What would researching indigenous knowledge using the lens of post-colonial theoretical perspectives mean? Drawing on post-colonial theoretical perspectives may assist in getting beyond constructivist research to more effectively addressing inequities and power and moving in the direction of eliminating these inequalities from society.

The call for endogenisation [indigenisation] (Crossman, 1999), a rethinking of ways of knowing, a "deconstruction of old epistemologies," and the concomitant demand that there be a transformation in our education, in how we teach and what we teach, has been a necessary revolution - a revolution that aims to restore human dignity, environmental justice and peace. This would require critical reflective research by teachers to extend and enhance their understanding of IKS, which currently covers only the specific practices, skills and customs to include the theoretical and epistemological underpinnings of IKS. Teachers would then be able assist learners to move towards a new awareness of relations of power, myths, and oppression.

## 8.7 CONCLUSION

As a democracy, South Africa's promise is quality educational opportunity for all our young people. Now, more than ever, our society is in the middle of a number of significant social, cultural and economic changes. The present is a complex and professionally demanding environment for teachers. Not only are teachers expected to work harder, but also there is a lot of new learning involved. This task will not be made any easier unless teachers and schools have genuine commitment to including IKS. We need to ensure that appropriate levels and types of support for IKS and science teaching are in place for teachers to enhance the prospect of success for all our students. Quality education, relevant to the conditions of the present and those we can envisage for the future, is the means by which we can survive and thrive in such circumstances.

IKS in the science classroom is a vibrant field full of contradictions, challenges, uncertainties and directions. Despite these challenges the study showed some of the ways in which teachers can continue to push the boundaries of what teaching might look like in the future.

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