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DEDICATION

This work is a culmination of a period that denied my family the role of a husband, father, guardian, leader, and head of the family. I therefore dedicate this work to my wife Gloria Mutimbwa Siseho for enduring these four years, taking care of our children, and also encouraging me to move on. This made it possible for me to work peacefully because she took the responsibility of taking care of the family. Our children did not miss me too badly because of her efforts to keep the family intact.

I know the spirit of my father, Mr Daniel Siseho Sinvula (Thozo) and my mother-in-law, Ba Ellen Namasiku Mukuni always inspired me. Wherever they are, I report that I have finished the task that they have supported and sent me forth to accomplish when they blessed my endeavours to pursue further studies. This work is, therefore, partly a product of my father's love for education. My sincere gratitude goes to my surviving parent, my mother, Ms Regina Kachana Mubita "Bana Inonge", for her persistence that I needed good education even when herself did not have an opportunity to see the inside of a classroom. I owe this work to them.

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DECLARATION

I declare that **"The Effect of an Argumentation Instructional Model on Pre-service Teachers' Ability to Implement a Science-IK Curriculum"** is my own work; that it has not been submitted before for any examinations or degree purposes in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

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ABSTRACT

This study investigated the effect of an Argumentation Instructional Model (AIM) on the pre-service teachers' ability to implement a Science-IK Curriculum in selected South African schools. I examined what instructional practices the pre-service teachers engage in when they introduce scientific explanation and whether those practices influence learners' ability to construct scientific explanations during a natural science unit of a South African school curriculum. My study began with a pilot study of 16 pre-service science teachers who completed a B.Ed university module, *Science for Teaching*, which included an IK component. Data collection for main study took place from 2010 to 2011, and used questionnaires, face-to-face and reflective interview protocols, case studies, lesson plans and classroom observation schedules. I took videos and audios of each of the pre-service teacher's enactment of the focal lesson on argumentation and then coded the videotape for different instructional practices.

The study investigated firstly, what currently informed teachers' thinking, knowledge and action of IK. Secondly, the research questioned how teachers interpreted and implemented IK in the science classroom. A sample of the three pre-service teachers were followed into their classrooms to investigate how they specifically implemented Learning Outcome Three using argumentation instruction as a mode of instruction and what approaches relevant to the inclusion of IK were developed. The study found that the three pre-service teachers used three very different approaches through which IK was brought in the science curriculum. An *assimilationist* approach, that brings IK into science by seeking how best IK fits into science. A *segregationist* approach that holds IK side-by-side with scientific knowledge. Lastly, an *integrationist* approach makes connections between IK and science. The approaches developed by the pre-service teachers were found to be informed by their biographies, values, cultural backgrounds and worldviews. Meticulously, the study explored how shifts were being made from a theoretical phase at the university where the pre-service teachers engaged IK to an actual phase of implementation in their school science classrooms. Finally, I attempted to explain why the pre-service teachers interpreted and implemented IK in the way they did.

Keywords: Indigenous science, instructional model, worldviews, argumentation instructional model, science curriculum, integrating Indigenous knowledge system, teaching, natural science, culture, Western science.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Chapter one presents a broad background to the South African colonial history and exemplifies how the Western form of education through the instrumentation of colonialism and apartheid became the dominant way in which most literate South Africans view the world in which they live. However, with the attainment of freedom and the demise of the apartheid system of government the first democratically elected government of South Africa could no longer justify the continuation of the Western-oriented and racially based curriculum. In a way, it used the implementation process to authenticate itself as well as fulfill the mandates of independence.

The first challenge faced by the new government in 1994 was to formulate a curriculum policy statement, which redressed the ills of the past as well as catered for the diversities within the country. After much consideration and consultation, the new government formulated a new curriculum known as Curriculum 2005 (C2005) to indicate the time it would be fully implemented into the entire school system (R-12). The public outcry against the new curriculum and the revisions that followed, though a crucial issue in its own right, is not the focus of this study. Rather, the central concern of the study was to determine the effect of an argumentation instructional model on teachers' ability to implement a science-Indigenous knowledge curriculum.

In a foreword to the National Curriculum Statement (NCS): Curriculum Assessment Policy Statement the Minister of Basic Education Angie Motshekga (Department of Education, 2011) stated that the outcomes-based education was introduced in 1997 to overcome the curriculum divisions of the past. The apartheid so-called "National Curriculum" was anything but national in character. Rather, it was an omnibus and grotesque and largely incoherent collocation of topics, which learners were supposed to master in order to pass the examinations set by the 17 Departments of Education. South Africa under the apartheid system of education was many countries in one; each political entity doing its own thing. The worse off in this scenario were schools in the Black poverty-striking homelands bereft of adequate human and material resources to produce good results. Of the whole jumble, the most discernible curricula in terms of order, coherence and quality of content were, in order of quality, those meant for the White, Indian, 'Coloured' and lastly the Black children.

However, since coming to power after the first democratic election in 1994 the new government in South Africa has embarked on a massive curricular reform. The focus of the new curriculum known as its inception in 1997 as the outcomes-based Curriculum 2005 (C2005), to indicate the year of its full implementation in grades R-12, was on social relevance and transformation. It was the view of the new government that the apartheid curriculum was not only discriminatory but it was also largely irrelevant to the daily experiences of the majority Black children in that it tended to denigrate their local or Indigenous knowledge about the world around them.

Since its inception in 1997, however, the new outcomes-based curriculum has received several public criticisms. Critics have called for its total replacement with a "back-to-basics curriculum" (Jansen & Christie, 1999; Ogunniyi, 1999, 2004, 2007a & b, 2011). Jansen, perhaps the most vocal critic of the curriculum gave 10 reasons why the curriculum would fail; the most pronounced of these being the poor preparation of teachers, the incoherence of the curriculum and related assessment documents and the top-down implementation approach (Jansen & Christie, 1999).

In her Foreword to the Curriculum and Assessment Statement (CAPS) the current Minister of Basic Education; Angie Motshekga (Department of Education, 2011) argues that despite its limitations the new curriculum is more relevant to learners in a diverse and multicultural society as South Africa than the apartheid curriculum. Further, she justifies the various revisions that the curriculum has undergone since its inception in 1997 based on experience and the need for transformation of the South African society. According to her:

> *Our national curriculum is the culmination of our efforts over a period of seventeen years to transform the curriculum bequeathed to us by apartheid. From the start of democracy, we have built our curriculum on the values that inspired our Constitution (Act 108 of 1996)…In 1997, we introduced outcomes-based education to overcome the curricular divisions of the past, but the experience of implementation prompted a review in 2000. This led to the first curricular revision: the Revised National Curriculum Statement Grades R-9 and the National Curriculum Statement Grades 10-12 in 2002. Ongoing implementation challenges resulted in another review in 2009…From 2012 the two National Curriculum Statements, for Grades R-9 and Grades 10-12 respectively, are combined in a single document and will simply be known as the National Curriculum Statement R-12. The National Curriculum Statement for Grades R-12 builds on the previous curriculum but also updates it and aims to provide clearer specification of what is to be taught and learnt on a term-by-term basis (Motshekga, 2011: forward page).*

Some of the general aims of the National Curriculum Statement (NCS) R-12 include such notions as:

- Equip learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfillment, and meaningful participation in society as citizens of a free country.
- Social transformation: ensuring that educational imbalances of the past are redressed, and that equal educational opportunities are provided for all sections of the population.
- Learners acquiring and applying knowledge and skills in ways that are meaningful to their own lives.
- Promoting knowledge in local contexts, while being sensitive to global imperatives
- Redressing the ills of the past.
- Active and critical approach to learning, rather than a uncritical learning of given truths.
- Emphasizing human rights, inclusivity, environmental and social justice.
- Valuing Indigenous knowledge systems through an acknowledgement of the rich history and heritage of the country as important contributors to nurturing the values contained in the Constitution and so on.

The general aims above imply the need for teachers to acquire necessary knowledge and pedagogical skills to promote inclusivity of worldviews compatible with science in the classroom. At the same time ensuring that, barriers to learning are identified and addressed in an atmosphere where learners are able to express their views freely, learn cooperatively, have opportunities to externalize their doubts and even change their minds in the light of a more convincing argument. Also, active and critical learning stressed in the curriculum statement cannot happen in a vacuum or in an atmosphere where all learners do is to copy chalkboard notes verbatim (e.g. Aikenhead, 2006; Ogunniyi, 2007a & b; Osborne, J., Erduran, S., and Simon, S. (2004); Scholtz, Z., Braund, M., Hodges, M., Koopman, R., & Lubben, F. (2008). These value-laden goals suggest the need to pay more attention to issues of local or Indigenous significance. In the spirit of *ubuntu* (i.e. collectivity, togetherness or unity in diversity) the curriculum stresses that, "Inclusivity should become a central part of the organization, planning and teaching at each school. This can only happen if all teachers have a sound understanding of how to recognize and address barriers to learning, and the pedagogical skills "to plan for diversity" (Department of Education, 2011:5).

One of the most challenging aspects of the new curriculum has been the demand to integrate school science with Indigenous knowledge (Ogunniyi, 2004). The nagging issue at the inception of the new curriculum and even now is:

- Have the teachers been well equipped to implement such an inclusive curriculum?
- Have teachers been exposed to instructional models that would enable them to organize a discursive and argumentation-based lesson where learners are free to externalize their views, which often may be incompatible with that of science?
- Are the teachers schooled in Western science aware of the nature of Indigenous knowledge prevalent in their learners' Indigenous communities?
- Are there textbooks and/or resource materials that teachers can use to draw up their lesson plans?

These and related issues certainly warrant consideration by the policy makers and curriculum planners. Added to these issues is how do teachers cope with the barrages of assessment protocols called for which in the final analysis contribute very little to the overall goal of producing a scientifically and technologically literate society? The amended National Curriculum Statement Grades R–12 now known as Curriculum and Assessment Policy Statement (CAPS) came to replace the National Curriculum Statement Grades R-9 (2002) and the National Curriculum Statement Grades 10-12 (2004) (Department of Education, 2011). The CAPS document is based on several principles, amongst others, is the valuing Indigenous Knowledge; acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution (Department of Education, 2010).

Policy implications for education involve the integration of Indigenous Knowledge (IK) into the school curriculum and underscore the need for science, mathematics and technology teachers in South Africa to review and adopt teaching approaches that will help learners to relate school science to their socio-cultural environment; appreciate the interface between science and IK; and affirm their dignity as citizens in a democratic multi-cultural society (Mushayikwa and Ogunniyi, 2011). So far, the teaching of science in non-Western classrooms, especially in South Africa as elsewhere in Africa has tended to indicate that the *mechanistic worldview* is the only legitimate way of viewing natural phenomena (Michie, 2002; Ogunniyi, 2004 & 2007; Sharwood, 2005). Consequently, very little is known about non-Western learners' Indigenous knowledge base, the way they learn, and the cognitive processes and their interactions, which occur when learning science concepts. Across the globe the curricula, teaching methodologies and assessment schemes connected with school science as it is presently being taught, projects predominantly one worldview, a *Western worldview*, which holds claims of superiority to other forms of knowledge (Kawagley and Norris-Tull, 1998, Ogunniyi and Hewson, 2008).

Science curricula appear to be somewhat homogeneous around the world (as evidenced by the applicability of testing programmes such as Third International Mathematics and Science Study [TIMSS, 1997; TIMSS-Repeat, 1998 and 2000] (Howie, 2001). They neither recognize the disparity among people nor the different worldviews that learners bring to the classrooms. Therefore, the education of children in many third world communities including South Africa has been deprived in significant ways. The dilemma of cultural mismatch between different worldviews is further exacerbated by the numerous cultures present in South Africa. This study investigated the effect of an argumentation instructional model (AIM) on the pre-service teachers' ability to implement a science-IK curriculum in selected South African schools of the Western Cape.

Two main reasons given in the new curriculum for the call to integrate science with IK are firstly that such systems reflect the wisdom and values that people living in Southern Africa have acquired over the centuries. Secondly, much of this valuable wisdom is believed to have been lost in the last 300 years of colonization (Ogunniyi and Hewson, 2008). Indeed, many of modern-day South African teachers, especially the Whites and westernized 'Coloureds' and Black teachers, are unfamiliar with African Indigenous Knowledge (IK) and with strategies to include IK i.e. knowledge generated from IK within the conventional science classroom (Ogunniyi and Hewson, 2008).

The ambition of conventional science teaching has been to convey to learners the knowledge, skills, and values of the scientific community. This content transmits a particular Eurocentric worldview because science is a subculture of Western culture (Pickering, 1992). Teaching science in schools is not easy because the curricula, teaching methodologies and assessment strategies associated with conventional schooling are based on a worldview that does not satisfactorily recognize or appreciate Indigenous notions of a mutually supporting universe and the value of place in their societies (Kawagley, and Norris-Tull 1998). Many learners have felt alienated from the subject matter and have traditionally not continued with scientific studies (Harlen, 2000; Fleer and Hardy, 2001; Bennet, 2003).

The notion that science is an alienating subject is even more widespread and challenging amongst African Indigenous children. Indigenous learners, particularly in the remote areas, grow up with an understanding of the world that is subsumed within the anthropological, meta-physical or supernatural worldview in contradistinction to the discursive and argumentative scientific ways of understanding (Baker, 1996; Michie and Linkson, 1999; Michie, 2002; Ogunniyi, 2004; Sharwood, 2005). Learners 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 unfamiliar institutional culture, rather than any lack of innate intelligence, ingenuity, or problem-solving skills on the part of the learners (Kawagley et al, 1998).

Ogunniyi and Hewson (2008) contend that the increased global awareness of the negative impact of scientific, technological and industrial activities on the environment and copious examples of sustainable practices existing in many an Indigenous community provide justifiable reason for including the latter in the science curriculum. They further argue, based on their considerable research in cultural studies in science education, that the inclusion of IK in the science curriculum has been long overdue. Indigenous people have had their own customs of looking and relating to the world, the universe, and to each other (Ogunniyi, 1988, 2004; Jegede and Aikenhead, 1999). Their traditional education processes were carefully constructed around observing natural processes, adapting modes of survival, obtaining sustenance from the plant and animal world, and using natural materials to make their tools and implements. All of this made understandable through demonstration and observation accompanied by thoughtful stories in which the lessons were imbedded (Kawagley, 1995; Cajete, 1999).

However, Indigenous views of the world and approaches to education brought jeopardy to the spread of Western social structures and institutionalized forms of cultural transmission (Kawagley and Barnhardt, 1999). Consequently, many Indigenous as well as non-Indigenous people began to recognize the limitations of a mono-cultural education system. New approaches have begun to emerge that are contributing to our understanding of the relationship between Indigenous ways of knowing and those associated with Western society and formal education (Ogawa, 1995; Aikenhead and Jegede, 1999; Corsiglia and Snively, 2001; Ogunniyi and Onwu, 2006; Ogunniyi and Hewson, 2008). The challenge now is how to devise a system of education for learners that respects the epistemological and pedagogical foundations provided by both Indigenous and Western cultural traditions.

It has been argued by many scholars and suggested that the culture of a learner's immediate environment plays a very important role in learning, shaping how concepts are learned and how they are stored in the long-term memory as schemata, (Ogawa, 1989, 1995; Aikenhead and Jegede, 1999; Corsiglia and Snively, 2001; Ogunniyi, 1997, 2004, 2007). Collateral learning has been recommended to explain how non-Western learners endeavor to cope with science learning within a classroom environment, which is hostile to their Indigenous knowledge systems. Although collaterals occur in every society of the world, the relations of the two worldviews in which non-Western learners learn complicate the learning process. The implications of such a scenario for the teaching-learning process and of understanding collateral learning for curriculum and instructional design, research, and professional expert advice shall be highlighted in the forthcoming chapters. At this stage, it is necessary to account for the South African colonial times past and forms of European power.

1.2 Rationale of the Study

A rationale outlines the reasons for an activity or a decision. Many teachers use a rationale to explain why a given component of a curriculum was selected. In an effort to make teaching more transparent for both learners and parents, a rationale provides background information and discusses the foreseen benefits and potential challenges of a classroom activity. In South Africa, the Natural Science and Technology policy documents of the Curriculum and Assessment Policy Statement (CAPS) encourage the inclusion of Indigenous Knowledge in the classroom implementation of the curriculum (Department of Education, 2011).

The documents also state that the learners themselves *bring different worldviews to the classroom*. Therefore, teachers are encouraged to begin at least some of their instruction with an exploration of the prior knowledge that the learners themselves bring to the classroom. An area under discussion that has been amplified among science teachers globally is the professed worldview (Makgato, 2003). One feasible rationale for this interest may be due to the general consciousness among science teachers that learners' conjecture to the study of science is habituated to a great degree by the worldviews prevalent in their socio-cultural milieu and their confidence in what teachers hold to be true about natural phenomena, whether or not such views are historically or philosophically valid (Cobern, 1996; Jegede and Okebukola, 1990; Ogawa, 1986, 1989; Ogunniyi, 1983, 1987, & 1988).

Science teachers in non-Western cultures serve as a major source of scientific information. They command great admiration among their learners as the people who know the secret of the cosmos. Whether learners' confidence in the knowledgeability of their teachers is justifiable is another matter altogether (Ogunniyi, 2007a). Many young people have refused to embrace Indigenous knowledge practices because they associate them with poverty, scarcity, and lack of material wealth (Louw, 1998). This is so because when missionaries first came to Africa, the first thing they talked about was spiritual poverty. Their misguided ignorance, arrogance, and lack of respect ensured that Africans became even poorer as their natural African spirituality and religions came under deliberate attacks (Louw, 1998). Then government workers came with their knowledge about food production, and Africans were told that their Indigenous food production techniques were inferior. The assault continued as Africans were pushed into cultural poverty as their knowledge was replaced by that of the colonizers. The result was large-scale poverty among most Africans.

On the integration of IK in education, the South African IK Policy which was adopted by Cabinet in November 2004 (Mangena, 2005) asserts that this will require that appropriate methods and methodologies for mobilizing IK in various learning contexts be identified and used, and that the Department of Education should take steps to begin the phased integration of IK into curricula and relevant accreditation frameworks. Such a policy framework, adopted at the highest level of government, may guide the mainstreaming of IK across all the various government departments, education included. Under such a policy framework, education curriculum planners may explore ways of developing culturally sensitive curricula for the education system. Such curricula may cascade down to culturally sensitive learning environments, which optimize the utilization of the learners' Indigenous knowledge. Research findings have indicated that the incorporation of IK in teaching the various school disciplines can enhance the learners' mastery of concepts (Lesiba, 2006; Brown, Muzirambi and Pabale, 2006; Ogunniyi & Onwu, 2006; Mtetwa, 2006).

It is not enough to acknowledge that teachers play a critical role. We need to know what their role is in order to help support teachers in the difficult task of creating an argumentative-oriented classroom. Teachers have difficulty helping learners with scientific inquiry practices such as asking thoughtful questions, designing experiments, and drawing conclusions from data (Marx, Blumenfeld, Krajcik, & Soloway, 1997). Many science teachers may not have the appropriate expertise to create an inquiry-based learning environment or argumentative discourse (Krajcik, Mamlok, & Hug, 2001). Teachers need to learn new ways of teaching to promote scientific inquiry, which may differ from their own earlier socialization into school science as learners (Lee, 2004; Metz, 2000).

Although teachers often have difficulty supporting learners, little research provides guidance on what types of teacher practices may help learners with scientific inquiry. Research literature about inquiry classrooms often does not describe the classroom practices, rather classroom inquiry is summarized as "doing science", "hands-on science", or "real-world science" (Crawford, 2000). Furthermore, researchers often label a classroom as inquiry-oriented based on the nature of the curriculum materials used by the teacher and not by what the teacher and learners are actually doing (Flick, 1995). Since teachers' beliefs about the nature of science, learner learning, and the role of the teacher substantially affect their enactment of inquiry curriculum (Keys & Bryan, 2001), this raises the question of how using inquiry materials actually translate into inquiry-oriented classrooms. There is probably a range of inquiry occurring in these research studies labeled as exploring inquiry-oriented classrooms.

Since South Africa took a bold step in reforming the curriculum by introducing Indigenous knowledge alongside a major reform of the new curriculum from objective driven curriculum to outcome based approaches, and that science would begin at lower primary and go across the twelve classes, I was interested to find out how teachers would cope with the newly introduced topics, especially those with a slant to Indigenous knowledge. Since literature indicates that inclusion of Indigenous knowledge creates language challenges and opportunities for creating a foundational base in the teaching of science (Herbert, 2006; Klos, 2006), I was interested to see how the theoretical and pedagogical knowledge of teachers will play in the implementation of Science-IK curriculum.

Results from this study have the potential to inform the curriculum developers, inspectorate in South Africa (responsible for quality control), and teacher educators in institutions of higher learning. Inspectors may use these results to decide issues to monitor or deal with during the rolling out of the implementation phase of the new natural science curriculum. Such knowledge would therefore shape decision-making processes at classroom level up to educational management structures. Furthermore, findings from this study would inform other stakeholders who aspire to embrace the integration of Indigenous knowledge about issues that need attention in the design and implementation of such a curriculum.

In the natural science area, it is highlighted because of development needs, which concurs with Brown-Acquaye's (2001) contention that Western technology and science are highly sought after by developing countries, but he also says the need to use traditional knowledge is still valid. It is not surprising, therefore, that the new curriculum reform in South Africa encouraged inclusion of Indigenous knowledge in science learning area. Although suggestions to include Indigenous knowledge in the science area were made, I have come across very limited local studies that show the possible content or pedagogical insights that would help the pre-service teachers implement Indigenous knowledge inclusion in science teaching in South Africa. However, even at international level, few studies on integrating Indigenous knowledge in the science curriculum have been conducted. Again, since science tends to be place-based; studies conducted elsewhere may only reflect problems and solutions that are specific to those areas. Furthermore, most literature that I have come across only shows theoretical justification for integration of Indigenous knowledge and there are not as many primary studies on Indigenous knowledge.

Literature lobbying for integration of Indigenous knowledge came to the peak recently (between 2000 & 2006). For example, Ninnes (2000), "Representations of Indigenous knowledge in secondary school science textbooks in Australia and Canada;" Brown-Acqwaye (2001), "Each is necessary and none is redundant: The need for science in developing countries;" Dei (2000), "Rethinking the role of Indigenous knowledges in the academy;" Cobern and Loving (2001), "Defining 'science' in a multicultural world: Implications for science education;" Corsiglia and Snively (2001), "Rejoinder: Infusing Indigenous science into the Western modern science for sustainable future;" Michie (2002), "Why Indigenous science should be included in the school curriculum;" Boyne (2003), "Utilizing traditional knowledge in a scientific setting;" Klos (2006), "Using cultural identity to improve learning".

1.3 Purpose of the Study

The purpose of this study was to investigate the effect of an argumentation instructional model on the pre-service teachers' ability to implement a Science-IK curriculum in four selected South African schools. I investigated whether a curriculum involving argumentation-based instruction would allow the pre-service teachers to distinguish better between Western science and Indigenous knowledge and to select appropriate instructional methods to integrate IK into the science classrooms. Although the study was purposely done for my thesis, its era and milieu was so timed as to provide feedback to the South African education system as a whole on the viability of the curriculum.

1.4 Research Questions

The four research questions that guided this study were:

1.4.1. What conceptions of the Science-IK curriculum did the pre-service teachers hold before and after being exposed to an argumentation instructional model?

1.4.2. How did the pre-service teachers use an Argumentation Instructional Model to enhance their ability to implement the Science-IK curriculum?

1.4.3. How did the pre-service teachers justify the way they implemented the Science-IK in their classrooms?

1.4.4. What practical challenges did the pre-service teachers experience as they attempted to implement the science-IK curriculum in their classrooms?

1.5 Methodology

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 and hence these were kept at the forefront. Focusing on the research questions, I found the interpretive paradigm with case study, as the main organizing perspective, to be the most appropriate in serving the needs of this research. This study involved mixed methods reported in Chapter 3. Four methods were classroom observations; questionnaire; focus group interviews with the pre-service teachers and document analysis. The above was discussed in the methodology chapter.

1.6 Theoretical Framework

A theoretical framework helps a researcher to focus his or her study and prevents him or her from the pursuit of mere fads (Patton, 1990). The theoretical framework underpinning this study is Toulmin's Argumentation Pattern (TAP) and the Contiguity Argumentation Theory (CAT) characterizing and evaluating the effects of an argumentation instructional model on teachers' ability to implement a Science-IK curriculum (Toulmin, 1958/2003 and Ogunniyi, 2005). Argumentation is a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before a rational judge' (Van Eemeren & Grootendorst, 2004). Ogunniyi and Hewson (2008) contends that within the last decade there has been an increased interest in determining the effectiveness or otherwise of argumentation in enhancing teachers' and learners' understanding of the nature of science (NOS) (e.g. Driver, Newton, & Osborne, 2000; Ebenezer, 1996; Ogunniyi, 2004, 2006, 2007 a & b; Zohar & Nemet, 2002).

Many of these studies have shown the importance of argumentation and dialogue as useful tools for enhancing teachers' and learners' conceptual understanding as well as increasing their awareness of the tentative and material-discursive nature of scientific practices (Barad, 2000). Toulmin's Argumentation Pattern (TAP) has been one of the most frequently used argumentation models by science educators to enhance teachers and learners' understanding of the NOS. The TAP is more applicable to a deductive-inductive classroom discourse when integrating IK with school science.

The Contiguity Argumentation Theory (CAT) on the other hand deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IK. The TAP essentially involves the processing of data, warrants, support, and claims (Toulmin, 1958/2003). It has been applied as a methodological tool for the analysis of a wide range of science curricula and as a heuristic for the assessment of learners' work of both large and small group learner discussions (Erduran, S., Simon, S., & Osborne, J. 2004). Both the TAP and the CAT forms the core base for the theoretical framework under this study. According to Lawson (2004), effective instruction encourages an atmosphere where ideas may be raised and then contradicted by evidence and by the arguments of others. It is understood that the effect of an argumentation instructional model on teachers' ability to implement a Science-IK curriculum will benefit from this theoretical framework. More detail of the TAP and CAT will be presented in chapter 3.

1.7 Significance of the Study

To improve science teaching, current thinking is that teachers ought to know more about the influence of local culture on science learning. Consequently, some teachers are developing strategies to include acquiring knowledge of relevant aspects of the cultural background of the learner as part of the normal teaching/learning process (Van Driel, Bulte & Verloop 2005). Before any cross-cultural science teaching can be implemented, teachers' own views with regard to integrating Indigenous learners' everyday culture into Western school science must be understood.

The worldviews of teachers might also play an important role in the style of teaching and learning of science. However, sometimes learners and their teachers bring to the classroom certain ideas, beliefs or experiences that appear to be in conflict with Western science. Teachers are not always aware of the magnitude of the cultural gaps that exists between Western and non-Western interpretations of reality. Teachers should be aware that learners do not come to the science classroom with *tabula rasa* minds (Ogunniyi, 1988, 2006). In the African context, learners can come to the classroom with a worldview that may not be scientifically *correct* because of their cultural backgrounds. Therefore, *teachers should make a concerted effort* to identify those elements of the learners' cultures that differ with the scientific culture and to treat the elements of the learners' culture with the appropriate care they deserve (Kesamang & Taiwo, 2002).Given the growing multicultural composition of South African classrooms, teachers of science, like teachers across the spectrum of all learning areas, are increasingly challenged to reflect how they and their learners conceive of and, as a result, construct knowledge. The reality is that in an expanding globalised world, learners can easily become alienated from what is taught in science, as well as the way it is taught. Indigenous Knowledge, as a broad framework of thinking about our local context, seeks to problematise the insufficient integration of the cultural-social and the canonical-academic dimensions of natural science education (Ogunniyi, 2007b).

In this study, I conceptualize and clarify Science-IK Curriculum, particularly towards the effect of an argumentation instructional model in which teachers may assume that all learners are similar in terms of identity and cultural dynamics. Natural sciences, in particular, have assumed a definite culture of power, which has marginalized the majority of learners in the past. IK strategically wishes to transform this view and therefore holds valuable implications for teachers in the learning areas of natural science. Many African and Western learners underachieve in school science and one of the reasons given is the perceived low relevance of school science taught to both types of learners in relation to their everyday circumstances. To make the Western science more relevant for learners in developing countries, teachers should also focus on Indigenous knowledge, (Cobern, 1996).

1.8 Scope and Limitations of the Study

This research has some limitations. First, because different the pre-service teachers taught different types of learners, it is likely that the teacher factor might have influenced the outcomes of the study despite the concerted effort envisaged to ameliorate the effect of such a factor. Whatever is done to determine the genuine feelings of the pre-service teachers, it is not always easy to decipher whether a new instructional model or a combination of other factors (including extraneous variables) such as the presence of an observer, the pre-service teacher’s enthusiasm or changed instructional behaviours has motivated expressed feelings. Another limitation might be the short duration of teaching practice for the pre-service teachers in schools, that is, about four months. In other words, the duration may be too short to bring about improvement in the affective characteristics of the learners. Perhaps a longer duration might result in more noticeable attitudinal changes among the teachers and learners, especially toward controversial issues in Science-IK curriculum.

In addition, the restricted duration used to orientate the pre-service teachers towards argumentation teaching is a further limitation. Kyle, Penick, and Shymansky (1979) cited Supovitz and Turner as claiming from their study that teachers experiencing fewer than 40 hours of professional development did not make any meaningful pedagogical shift and that they did so only after 80 hours of training. Although the sample was limited to a specified number of selected schools, a cohort of the pre-service teachers and one subject area (Natural Science), generalization is not a concern because in qualitative studies there are several other standards for quality check.

1.9 Definition of Terms

1.9.1 Qualitative Research Design (QRD): *Is a research method used extensively by scientists and researchers studying human behavior and habits.* It is a social inquiry involving methods of observation data collection and analysis, which are more natural than contrived or laboratory-based settings (Ogunniyi, 2011a)

1.9.2 Case Study Design (CSD): Yin (1989) defines the case study research approach as a pragmatic inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between occurrence and context are not obvious; and in which multiple sources of evidence are used. He further maintains that it is an approach when the investigator has little control of events and when the focus is on some contemporary phenomenon in a real-life context (Yin, 2003)

1.9.3 Western Science: Is the philosophy of science that is concerned with the assumptions, foundations, methods and implications of science by the dominant scientific discourse which informed by the first world countries. (Ziman, 2000)

1.9.4 Indigenous Knowledge: IK refer to intricate knowledge acquired over generations by communities as they interact with the environment. Indigenous knowledge (IK) is the local knowledge – knowledge that is unique to a given culture or society (Ziman, 2000)

1.9.5 Science-IK Curriculum: Is a school curriculum that integrates school science with Indigenous Knowledge (Ogunniyi, 2007a)

1.9.6 Instructional model: Is a model representing the broadest level of instructional practices that present a philosophical orientation to instruction. Models are used to select and to structure teaching strategies, methods, skills, and learner activities for a particular instructional emphasis (Joyce and Weil, 1992)

1.9.7 Worldview: Is a paradigm, a fundamental way of looking at reality that functions as a filter; it admits information consistent with our deeply held expectations about the world while guiding us to disregard information that challenges or disproves those expectations (Cobern, 1996)

1.9.8 Argumentation instructional model: Is a model designed to engage learners in scientific argumentation to develop complex reasoning skills and critical thinking skills understand the nature and development of scientific knowledge and improve their communication skills (Duschl & Osborne, 2002)

1.9.9 **Socio-scientific** refers to issues that involve deliberate use of controversial scientific topics that require students to engage in dialogue, discussion and debate. They require a degree of moral reasoning of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues. The intent is that such issues are personally meaningful and engaging to students, require the use of evidence-based reasoning, and provide a context for understanding scientific information." (Zeidler and Nicols, 2009)

1.9.10 **Traditional culture**: Traditional culture consists of the beliefs and practices held or observed by specific human groups that have been passed down from their ancestors through their grandparents, parents and the society around them (Cobern, 1996)

1.10 Summary

Chapter one presents a broad background to the South African colonial history and exemplifies how the Western form of education through the instrumentation of colonialism and apartheid became the dominant way in which most literate South Africans view the world in which they live in. One feasible rationale for this study was the general consciousness among science teachers that learners' conjecture to the study of science is habituated to a great degree by the worldviews prevalent in their socio-cultural milieu and their confidence in what teachers hold to be true about natural phenomena, whether or not such views are historically or philosophically valid. Many young people have refused to embrace Indigenous knowledge practices because they associate them with poverty, scarcity, and lack of material wealth (Louw, 1998).

The purpose of this study was to investigate the effect of an argumentation instructional model on the pre-service teachers' ability to implement a Science-IK curriculum in four selected South African schools. This study involved mixed methods reported in Chapter 3. Four methods were classroom observations; questionnaire; focus group interviews with the pre-service teachers and document analysis. This study was guided by four research questions. Focusing on the research questions, I found the interpretive paradigm with case study, as the main organizing perspective on data analysis. The theoretical framework underpinning this study was Toulmin's Argumentation Pattern (TAP) and the Contiguity Argumentation Theory (CAT) characterizing and evaluating the effects of an argumentation instructional model on teachers' ability to implement a Science-IK curriculum.

Since South Africa took a bold step in reforming the curriculum by introducing Indigenous knowledge alongside a major reform of the new curriculum from objective driven curriculum to outcome based approaches, and that science would begin at lower primary and go across the twelve classes, I was interested to find out how teachers would cope with the newly introduced topics, especially those with a slant to Indigenous knowledge. Since literature indicates that inclusion of Indigenous knowledge creates language challenges and opportunities for creating a foundational base in the teaching of science (Herbert, 2006; Klos, 2006), I was interested to see how the theoretical and pedagogical knowledge of teachers will play in the implementation of Science-IK curriculum.

CHAPTER TWO

BACKGROUND STUDY

2.1 Curriculum Reforms in Science Education and IK in South Africa

The purpose of this chapter is to position pre-service science teachers within the context of transition from an apartheid political dispensation to a democratic one, particularly in reference to the introduction of Indigenous knowledge (IK) and its implementation. These considerations are central to this research. All the pre-service teachers (in this study) were schooled in the post-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 pre-service science teachers and their engagement with IK are contextualized.

Although conjectures and refutations are part of scientific inquiry, very little of this critical aspect of the nature of science is reflected in most South African classrooms. In addition, not much has been done to examine the effectiveness of the pre-service teachers' pedagogic training programs aimed at equipping them with necessary knowledge and skills to facilitate meaningful discourses in their classrooms (e.g. Driver et al., 2000). Hence, this study aims at contributing towards efforts made to fill this research chasm. It is also a response to fulfill the goal of the new South African curriculum, which demands that teachers develop process skills among their learners and integrate IK with school science. The curriculum urges teachers to develop critical process skills in their classrooms as a means to facilitate conceptual understanding among learners. According to the new curriculum published by the Department of Education (DOE, 2010), "process skills refer to the learner's cognitive activity of creating meaning and structure from new information and experiences. Examples of process skills include observing, making measurements, classifying data, making inferences and formulating questions for investigation."

One of the key factors that accounts for the utter suppression of effective learning science in Africa has been the controversial status of knowledge that African learners bring to the learning situation (Jegede & Aikenhead, 1999, Ogunniyi, 2004). Philosophers of education recognize the importance of prior knowledge or existing knowledge as a factor in entrenching new knowledge and as a baseline for curriculum development and for introducing new concepts. However, Ogunniyi (1988 & 2004) asserts that the discourse relating to African thinking (Indigenous knowledge) in relation to science seems to have progressed from a position of total rejection, which prefers to see the African learner as a *tabula rasa* with regard to contextual knowledge that can be used as a basis for learning science. This point will be clarified later in the course of this chapter. At this stage, it is necessary to account for the emergent interest in Indigenous knowledge (IK). In other words, it is important for me to locate IK in the context of the historical moment. What is the nature of the instant that have provided stimulus for the interest in IK to such an extent that it can be used as the basis for future approaches to science education in Africa?

Science education in Africa has largely, not only copied curricula from Western countries but it closely borrowed approaches to practice whenever they could be afforded. As in most Western countries before the 1960s, 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 learners (Popper, 1959). The 1960s also heralded a period of curriculum reform in the newly independent African countries and the process approach as introduced in the west was adopted in most African countries. However, Ogunniyi (1986) points out that, in Africa, process science never really took off because of the expansion of school enrolments in the post-independence period and the attendant financial constraint. This resulted in the shortage of qualified science teachers and lack of adequate laboratory facilities. In the west, philosophers of science were questioning the nature of the scientific method on which process skills in science is based, even rejecting the idea of its existence. Popper (1959) rejected the inductivity basis method of the scientific method. He pointed to the theory-driven nature of observation in science. Feyerabend (1975) rejected the existence of a specific method that is generally followed by all scientists. He pointed out evidence from the history of science showing how various scientists have contradicted the so-called scientific method.

Over the years, a growing frustration about the efficacy of the process approach as practiced in schools also developed. It was found out that most practical work done by learners consisted mainly of scheduled experiments in which learners followed steps clearly put down by the teacher to reach certain conclusions. The purpose of this kind of practical work was done to verify claims made in class or to reconstruct some of the processes by which discoveries were made (Cawthron & Rowell, 1978). As stated earlier, the introduction of African learners' prior knowledge into the science classroom has always been contentious. Many writers on curriculum development in various parts of Africa have shown that it is possible to incorporate traditional concepts and practices into science curricula. For example, Cole states: "….there has always been a rich collection of cultural substance and belief with scientific bases in all African societies. The scientific bases maybe very elementary but could serve as a valuable link between what is familiar and new knowledge and understanding that is to be required" (Cole,1975: 51). This also asserts that everywhere science does already exist in one form or another albeit not as structured and articulated as in modern science (Cole, 1975).

Some influential teachers in South Africa however, do not share this view. The De Lange Report that was commissioned in 1981 to investigate, among others, the learning of science and mathematics in South Africa, dismisses the idea that science concepts can be related to concepts from traditional African culture. It maintains that no science-related concepts exist in the African culture (National Education Conference, 1982). As pointed above, such concepts and practices do exists. The need, therefore, seems to be for a change in attitude on the part of some teachers in South Africa in order to allow African learners to bring their cultural experience into the learning situation.

To gain a better vision of the theoretical base that propels the Indigenous knowledge integration agenda and the surrounding issues that spin along and around this momentum, I now turn to the key theoretical frameworks that all interested parties (teachers inclusive) need to know as they seek an understanding of the process or indeed participate in the implementation phase of the new curriculum. In this study, I employed several frameworks, which act as lenses for processing the information that arose from both the field and the documents during the analysis of findings from this and several other studies. Among theories that come to play during the integration of Indigenous knowledge in science education are Argumentation, Worldviews, Border crossing, Collateral learning, Multiculturalism, Constructivism and place-based education. A brief review of some of these theories provides a framework for the discussion on integrating Indigenous knowledge with science in a classroom context.

2.2 Argumentation as an instructional Tool

In any discourse, argumentation is a handy tool for resolving conflicting ideas. It enables arguers to externalize their viewpoints, clear their doubts and even change their minds in the face of a stronger argument. Although argumentation is a prominent part of a scientific discourse, science educators have not until recently paid much attention to the importance of this rhetorical tool of communication in their instructional practice Erduran, Simon & Osborne, 2004). An argumentation model underpins this study. However, before going further it is apposite to clarify the concept of ‘model’ used in the study. The concept of ‘model’ adopted in the study draws on a discursive framework used in the Science and Indigenous Knowledge Systems Project (Ogunniyi, 2004). Argumentation and discussion are used to resolve controversies on a given topic (e.g. the integration of science and Indigenous knowledge (IK) in a classroom context) starting from the individual to the small group and lastly the whole class where the final consensus is reached. More of this framework will be discussed in chapter 3.

Although science and Indigenous Knowledge (IK) derive their essence from human interactions with nature, their representations or models of interpretation are distinctly different. While science is based largely on a mechanistic model, IK is based largely on an anthropomorphic model (Ogunniyi, 1988, 2004, & 2007a). In other words, the scientific model of human interactions with nature, though stemmed in metaphysical roots, is largely mechanistic while those of IK are partly mechanistic and partly metaphysical. Despite this, both systems of thought depict the complex, holistic and dynamic nature of knowledge and how it is continually changing in response to the dynamics of change. A common picture of science in the extant literature is that it is dynamic while those of IK are not. This antipodal view of the two systems however, is far from the truth in that the survival of any organism depends to a great extent depends on its ability to adapt to change; otherwise it would cease its characteristic life.

An argumentation instructional framework that has been featuring prominently in the science education literature for about a decade now has been Toulmin’s (1958) Argumentation Pattern (TAP). TAP consists of a claim-an assertion, declarative statement or belief about a phenomenon; data-evidential or supportive statements of that assertion; warrants-statements which seek to justify or show a relationship between the data and the claim; backings-implicit or underlying assumptions of the data; qualifier-the contingent conditions on which the claim is based; and rebuttals or contrary statements to the claim. However, several criticisms have been leveled against TAP. One criticism is the inconsistent way in which Toulmin presents the “validity of an argument”. In certain cases he uses the formal logical meaning of “soundness” (i.e., based on modus tollens in logic) while in others he uses the concept for some vague general commonsensical notion of “goodness” or “acceptability” of an argument (Van Eemeren, et al, 1987). Also, none of the constituents of the model can stand alone in that each is not only inextricably linked and/or can be invoked by others, it is impregnated with a variety of meanings depending on the nature of the argument, its level of complexity or the context in question. Besides, there are different types and levels of arguments serving a variety of functions and hence, it is not feasible to use a single model to represent all forms of arguments. The TAP is also criticized for its inconsistency by including a backing, rebuttal and qualifier for the warrant but not the data and so on.

Despite the various objections that have been raised against the TAP, it has served as a tool for rejecting the universality of an argumentation model as well as its usefulness for assessing simple arguments commonly encountered in a classroom discourse. By collapsing the overlapping elements of the model, several researchers have managed to use its modified versions to evaluate classroom arguments. Some studies have shown that there is no common pattern in the way teachers use even the same form arguments in their classrooms, i.e. the use of arguments appears to be teacher dependent (e.g. Erduran, 2006; Erduran, et al, 2004; Jimenez-Aleixandre, et al, 2000; Kelly & Bazeman; Kelly & Takao, 2002; Niaz, et al, 2002; Osborne, et al, 2004; Simon, et al, 2005, 2006 Zohar & Nemet, 2002).

The Argumentation Instructional Model (AIM) used in the study is underpinned by the TAP described above as well as the personal testimonies and reflective comments the pre-service teachers involved in the project. As a dialogical process, AIM creates a learning environment, which enabled the pre-service teachers to discuss ideas and express their viewpoints on various issues, which sometimes are beyond the confines of the science curriculum. It is radically different from traditional teacher-centred expository instruction, which tends to focus mainly on the transmission of scientific facts for examination purposes. Rather AIM attempted to mirror as much as possible scientific discourses in terms of claims and counter-claims and classroom ethos emanating from classroom discourses, which have relevance to learners' life-worlds outside the school.

The AIM workshops involved discussions on the nature of science and IK as espoused by well-known historians, philosophers and sociologists of science, as well as anthropologists, linguists, and experts on traditional African Indigenous cosmologies. It also examined contemporary issues such as policies on intellectual property regarding knowledge derived from Indigenous communities, ethics of using subjects from poorer communities to test HIV/AIDS drugs, and use and abuse Indigenous medicinal plants. The overall goal of AIM workshops was to provide the pre-service teachers with the needed intellectual freedom to clarify their views, clear their doubts and to seek for meaningful connections between their cultural beliefs and that of science (Ogunniyi, 2004, 2006, 2007a & 2011).

2.3 Toulmin Argumentation Theory

In his book, The Uses of Argument, Stephen Toulmin (1958/2003) has argued that arguments need to be analyzed using a richer format than the traditional one of formal logic in which only premises and conclusions are distinguished. He has proposed a scheme for the layout of arguments that in addition to *data* and *claim* distinguishes between *warrant*, *backing*, *rebuttal* and *qualifier*. As an illustration, Toulmin discusses the claim that Harry is a British subject. The *claim* supported by the *evidence* is that Harry was born in Bermuda. There is a connection between *evidence* and *claim* expressed by the warrant that a man born in Bermuda will generally be a British subject. In turn, the warrant supported by the backing is that there are certain statutes and other legal provisions to that effect. The warrant does not have total justifying force, so the claim that Harry is a British subject must be qualified: it follows presumably. Moreover, there are possible rebuttals, for instance, suppose both his parents were aliens and he has become a naturalized American.

2.4 Pedagogy relevant to Science-IK Curriculum

Within the last decade there has been an increased interest in determining the effectiveness or otherwise of argumentation in enhancing teachers' and learners' understanding of the NOS (e.g., Driver et al, 2000; Ebenezer, 1996; Erduran et al, 2004; Jimenez-Aleixandre et al, 2000; Kelly & *Bazeman*, 2003; Kelly & Takao, 2002; Niaz et al, 2002; Osborne et al, 2004; Ogunniyi, 2004, 2006, 2007a & b; Simon et al, 2006; Zohar & Nemet, 2002). Many of these studies have shown the importance of argumentation and dialogue as useful tools for enhancing teachers' and learners' conceptual understanding as well as increasing their awareness of the tentative and material-discursive nature of scientific practices (Barad, 2000). Toulmin's Argumentation Pattern (TAP) has been one of the most frequently used argumentation models by science teachers to enhance teachers' and learners' understanding of the NOS (e.g. Driver et al, 2000; Ebenezer, 1996; Erduran et al, 2004; Jimenez-Aleixandre et al, 2000; Kelly & Bazeman, 2003; Kelly & Takao, 2002; Osborne et al, 2004).

However, the TAP is more applicable to a deductive-inductive classroom discourse than what is required when IK is to be integrated with school science. The Contiguity Argumentation Theory (CAT) on the other hand deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IK. The TAP essentially involves the processing of data, warrants, support, and claims (Toulmin, 1958). It has been applied as a methodological tool for the analysis of a wide range of science curricula and also as a heuristic for the assessment of learner work and of both large and small group learner discussions (Erduran et al, 2004). According to Lawson (2004) effective instruction encourages an atmosphere where ideas may be raised and then contradicted by evidence and by the arguments of others. Since the TAP is well known in the field of science education the rest of the background of this study is devoted to the CAT.

2.5 Contiguity Argumentation Theory (CAT)

Ogunniyi's (2007a & b) Contiguity Argumentation Theory (CAT) draws on the Platonic and Aristotelian notion of resolution of conflicting ideas. CAT asserts that one or two conflicting worldviews such as science and Indigenous Knowledge (IK) tend to readily couple with, or recall each other to create a harmonious worldview. This type of association has sometimes been considered the basic type to which all others are reducible. Philosophers have long recognized the phenomenon of association of ideas. For instance, Plato cites examples of association by contiguity and similarity. In addition, Aristotle in his treatment of memory enumerated similarity, contrast, and contiguity as relations, which mediate recollection.

Ogunniyi (2007a) cites Runes as stating that Locke introduced the phrase "association of ideas" which gave impetus to modern association psychology. Following Locke's notion of association of ideas, various scholars (e.g., Berkeley & Hume) were especially concerned with the relations mediating association. Berkeley enumerated similarity, causality and co-existence or contiguity as critical to recall or learning in general. Hume talked about resemblance and contiguity in time or place and cause or effect. Associationism is therefore a theory of the structure and organization of the mind, which asserts that every mental state is resolvable into simple, discrete components. In addition, mental life is explicable by the combination and recombination of these elemental states in conformity with the laws of association of ideas.

Although CAT regards such elemental ideas not as "concrete referents" but as dynamic organizing conditionals or "frames of reference" that galvanize the process of association or learning in general depending on the context in question. CAT holds that claims and counter-claims on any subject matter within (or across) fields (e.g., science and IK) can only be justified if neither thought system is dominant. There must also be valid grounds for juxtaposing the two distinctive worldviews within a given dialogical space. The role of such a dialogical space is to facilitate the process of re-articulation, appropriation, and/or negotiation of meanings of the different worldviews. Learners must therefore be able to negotiate the meanings across the two distinct thought systems in order to integrate them (Ogunniyi, 2007a).

CAT recognizes five categories that describe the way conceptions can move within a learner's mind. These categories can also describe the movement of conceptions amongst learners involved in dialogues warranting the mobilization of scientific and/or IK-based conceptions. Concepts in the five categories exist in a dynamic state of flux in a person's mind. The five cognitive categories are: (1) dominant conceptions, (2) suppressed conceptions, (3) assimilated conceptions, (4) emergent conceptions, and (5) equipollent conceptions (Ogunniyi, 2007a).

A conception becomes dominant when it is the most adaptable to a given context. However, in another context the same dominant conception can become suppressed by, or assimilated into another more adaptable mental state. An emergent conception arises when an individual has no previous knowledge of a given phenomenon as would be the case with many scientific concepts and theories e.g., atoms, gene, entropy, and theory of relativity. An equipollent conception occurs when two competing ideas or worldviews exert comparably equal intellectual force on an individual. In that case, the ideas or worldviews tend to co-exist in his/her mind without necessarily resulting in a conflict e.g., creation theory and evolution theory. The context of a given discourse plays an important role in the amount or intensity of emotional arousal experienced by the participants in such a discourse (Ogunniyi, 2007b). The importance of context in the learning process is central to the constructivist theory.

2.6 Constructivism

Alongside the challenge from multiculturalists, emerging strategies for teaching science, such as constructivism, emerged in the 1980s in the process of reforming science education. Constructivism questions the realism that characterizes the Western account of science. Constructivist paradigms advance relativist views of scientific knowledge as they suggest that individuals construct worthwhile knowledge individually or socially (Stanley & Brickhouse, 2001). Therefore, engaging the constructivist approach to learning, implicitly or explicitly creates a link to local people's knowledge that comes under play in a child's process of learning science as purported under the constructivist-learning paradigm (Stanley & Brickhouse, 2001).

Constructivism has increasingly influenced the teaching of science (beside other subjects) in modern times. This theory of learning is grounded in theoretical frameworks formulated by Piaget, Vygotsky, and Dewey. All these former theorists of learning articulated the processes that affect learning, which have greatly influenced pedagogical paradigms ever since they came to being. Piaget clearly articulated that learners' development dictates their cognitive processing of knowledge and that their conceptual and psychomotor developments influence their achievement in academic enterprises involving reasoning, problem solving, and acting (Sherman & Sherman, 2004; Woolfolk, 2005). Piaget theorized a hierarchy of skills that are developmentally aligned, which could be attained based on readiness (sensory-motor, preoperational, concrete operational and formal operational skills). One outstanding observation raised by Piaget was the fact that learners come to school with a great deal of knowledge, termed prior knowledge, which determines the reception or processing of information when they undergo school lessons. All theoretical dimensions in Piaget's theory involve the individual learner (Woolfolk, 2005).

Von Glasersfeld found an entry point in Piaget's theory and articulated a theory popularly known as radical constructivism. Radical constructivism stipulates that learning is a result of mental constructs in an individual's mind that materializes from an individual's interpretation of new experiences by drawing from individual's past experiences (e.g. prior knowledge), such that new understandings are a product of an individual's capacity to combine, resolve, and recreate new understandings based on what each individual previously knew upon encountering new experiences. In this way, an individual uses old knowledge and experiences in the process of constructing new knowledge. Hence, the learner cannot be given already made knowledge and be expected to absorb like a sponge, without processing it.

On the other hand, failure to process knowledge from new experiences is attributed to mismatch of new experience with what a learner holds in her/his schema (Von Glasersfeld, 1995). It may be noted that, unlike Piaget's theory of learning, constructivists believe that the schema is not just an additive product (that grows linearly), but it rejects, augments, translates, and comes up with acceptable understandings to an individual that may not necessarily be the same as another learner/individual or dependent on an individual state of development (Sherman & Sherman, 2004; Woolfolk, 2005). Resultantly, those who hold onto behaviorism and rationalism in their theories of learning, criticize the constructivist's theory in that it precludes the value of reality of facts, which is the central focus of science. Hence, people like Phillips (2000) and Matthews (1998) quarrel with the validity of such type of constructivist stance, especially in science where building up of accurate facts is a big agenda.

Dewey, on the other hand, believed in learner-centered approaches that align with constructivism in the sense that the learner is the center of focus and not the teacher. Dewey advocated inquiry just as constructivists believe in allowing; learners to explore (inquire) authentic problems in everyday life. This prepares them for life after school, which is full of problem solving (Hickman, 1992). Vygotsky found some weaknesses in individualistic constructivist learning theories and instead he proposed that learners understand and construct meanings better when they interact with expert elders or peers, especially when they are deficient of certain understandings or skills (Sherman & Sherman, 2004; Woolfolk, 2005). Such deficiencies may be linguistic, experiential, or reasoning capacities. Hence, an optimum learning environment, for Vygotsky, was that which availed a mediator for the learning process. This is the case when teachers and peers facilitate or mediate the learning process of the less experienced learners. When such mediation is available, a child who is less experience is afforded a scaffold to bridge the gap and lift the learner to the next level of understanding, that which the expert intends (e.g. as in the popular zone of proximal development theory). Hence, Vygotsky's theory of constructivism is situated in a social context.

As it may have been noted, there are various types of constructivism, and the latter type (social constructivism proposed by Vygotsky) spotted some weaknesses in former theories. Constructivists, in general, questioned former learning theories that advocated banking theory of learning, which regarded pupils as blank slates that waited to be filled with knowledge. By implication, constructivists uplifted the need to consider a child's prior knowledge that has implications on the learning process.

Another implication, in my view, is that latter theorists were greatly influenced by their prior knowledge of former learning theories. Before delving further into prior knowledge, it must be noted, from the above discussion, that new theories are formulated out of older theories. It is easy to identify weaknesses in an existing theory and build on it to propose a better theory, but it is difficult to start a theory from scratch. This is how we can connect theory formulation processes with knowledge construction processes. New theories are born based on teachers' prior knowledge about theories.

2.7 Why teaching argumentation is important?

We have plenty of evidence that our South African public, private and educational talk rarely, if ever, engages big ideas, important questions, or complicated problems. Popular culture and media are not configured to promote understanding of complex ideas and issues. Rather they promote the reverse by encouraging us to simplify, comfort, or entertain. Likewise, new curriculum statement policies have made minimum competencies and standard methods of evaluating achievement the order of the day, prioritizing testable curriculums and de-emphasizing reasoning. *What are we teaching when we teach arguments?* A persuasive argument is much more than voicing your opinion on a topic. It is not about outshouting others. It is not about being controversial rather; argumentation is the process of setting out a logical series of ideas to persuade others to accept what you believe (Ogunniyi, 2007a). Although each discipline (for example, law, philosophy, or English language arts) has its own definition of argument with different specific requirements, all effective arguments share common elements. The closing argument of a criminal trial or a formal proof in mathematics all require the speaker to take a position, offer compelling data, and explain the underlying assumptions that connect this data to the speaker's position.

An argument begins with taking a stance or a deliberate way of looking and or feeling, toward something for a particular purpose and for specific audience. *What do we mean by stance?* Taking a stance means deciding where to locate yourself in your thinking and valuing of an issue, idea, circumstance or condition that is important to you and to your audience if only they knew. Each of us can and should be able to take many stances about a single subject. An individual can assume multiple stances. People who want to argue effectively first thoughtfully consider where to stand so as to intentionally move to the next step of persuading others of their position. Once they take that stance, they carefully build an argument through reasoning directed at what they assume will convince their audience. To be powerful, reasoning must be based on *evidence* purposefully selected to fit. With stance, purpose, and readers in mind, the argument writer selects the most powerful evidence and *warrants*, or justifies, the stance with it. Writing warrants to explain how evidence justifies the stance of the writer gives the argument its persuasive substance. Arguments are won and lost on well reasoned . . . that is to say, well written warrants. Arguments should always be ethical; they should validly represent the facts of the matter.

Argumentation has become increasingly prevalent as an essential goal for science education in which learners need to support claims using appropriate evidence and reasoning as well as consider and be critical of alternative explanations (Duschl, Schweingruber, & Shouse, 2007). Yet incorporating argumentation into classroom science is challenging and can be a long-term process for both teachers and learners (Osborne, Erduran, & Simon, 2004). My research focuses on the discourse in three urban high school science classrooms in which the pre-service teachers used the same New Science Curriculum. I am interested in whether or not the pre-service teachers engaged learners in argumentative discourse as well as the pre-service teacher's role in supporting that discourse.

Habitually, the discourse in science classrooms has been dominated by teacher talk (Crawford, 2000). The linguistic practices in science classrooms delineate science through the ways that science is spoken and written in different contexts (Kelly, 2007). Regularly, full class discussion follows a triadic model in which the teacher *initiates* discussion by asking a question, a learner *responds* to the question, and the teacher then *evaluates* the learner's response with minimal learner-to-learner interaction. Herrenkohl and her colleagues (1999) talk about the "mistake stigma" in science classrooms where the objective of schooling is to get the correct answer and mistakes viewed as bad. This pattern suggests that the teacher is only looking for correct responses and is the sole knowledge authority in the classroom. Authoritative classroom interactions in which the teacher focuses the discussion on one meaning or one point of view most frequently occur through this pattern (Kelly, 2007).

This traditional pattern of debate in science classrooms places teachers in a position of power in which they control the topic, the direction of the conversation, who participates in the discussion and what contributions count as legitimate (Lemke, 1990). This type of traditional discourse focuses on conveying the correct answer and having learners repeat back to teachers' content they previously learned. Traditional science discourse patterns are not appropriate as the sole discourse pattern in inquiry-oriented classrooms, because they are based on teacher-driven instruction and known answer questions (Lehrer & Schauble, 2006). If the goal is to engage learners in a more open form of instruction with greater learner involvement, a different type of discourse needs to be supported in classroom discussion. Science is a practice that requires the use of both scientific ways of thinking and reasoning as well as conceptual understandings (Lehrer & Schauble, 2006). Thus, viewing science as a practice that learners need to experience and be enculturated into shifts the traditional image of science classrooms.

Learning science means that learners are able to talk science, which requires learners' participation and practice in talking science (Lemke, 1990). This suggests that science classrooms should include opportunities for learners to engage in classroom discussions in which learners practice talking science, challenge each other's ideas, and influence the direction of the discourse. Science education needs to demystify science in a manner that is no longer represented as a static body of facts, but rather a social endeavour where culture and discourse play prominent roles (Duschl et al., 2007). Learners need to participate in and develop an understanding of how knowledge claims are constructed in science.

Science is a social process in which scientists debate knowledge claims and continuously refine and revise knowledge based on evidence (Driver, Newton, & Osborne, 2000). Yet classroom science often portrays science as a static set of facts rather than the social construction of knowledge (Lemke, 1990). To be proficient in science, learners need to be able to generate and evaluate scientific evidence and explanations as well as participate productively in scientific discourse (Duschl et al., 2007). Consequently, it is important not only for learners to actively have a voice in science classrooms, but that their participation enculturated them into essential scientific practices such as argumentation.

Participating in dialogical interaction in which claims and evidence play a dominant role may help shift learners' views of science. Viewing science as alive and changing is important for developing learner epistemologies of science and encouraging learner interest in becoming part of this dynamic process (Herrenkohl et al., 1999). Shifting the type of discussion in classrooms requires examining the roles of the teacher and learners as well as instructional strategies that can be used to alter discourse norms (Kuhn & Reiser, 2006).

2.8 Argumentation in Science Classrooms

Argumentation can play an important role in both the written and oral discourse practices in science classrooms helping to promote learners' scientific reasoning and conceptual understandings (Zohar & Nemet, 2002) as well as support learners enculturation into the practices of scientific culture (Jiménez-Aleixandre & Erduran, 2008). Argumentation is a core practice of science in that scientists construct and justifies knowledge claims, and it is essential for learners to also experience science in this manner (Driver et al., 2000).

Similar to Jiménez-Aleixandre and Erduran (2008), I define argumentation in terms of both an individual or structural meaning and a social or dialogic meaning. The individual or *structural* aspect refers to argument as the justification of knowledge claims through the use of evidence and reasoning, which can occur either internally within one individual or externally in writing or talk. A single individual can construct a scientific argument as he or she weighs evidence and considers relevant scientific theories to form a conclusion about a problem. The key aspect of the structural meaning is the product. The structural definition can be thought of as an argument or product in contrast to argumentation or the process of arguing (Jiménez-Aleixandre & Erduran, 2008).

Sampson and Clark (2008) reviewed the diversity of analytic frameworks that science education researchers use to examine the structure of learners' written and spoken arguments. These analytic frameworks offer different perspectives on learners' arguments such as a focus on the components of the argument (Bell & Linn, 2000), the epistemic levels of the claims (Kelly & Takao, 2002), the coherence of the explanation (Sandoval, 2003), and the rhetorical features of arguments (Kelly, Regev, & Prothero, 2008). The various frameworks have different constraints and affordances offering a range of insights into learners' work (Sampson & Clark, 2008). Similar to a number of other science education researchers (Bell & Linn, 2000; Driver, et al., 2000; Jiménez-Aleixandre, Bugallo Rodríguez, & Duschl, 2000; Erduran, Simon, & Osborne, 2004), I adapted Toulmin's (1958) framework of claim, data, warrant and backings to examine the structure of teachers' and learners' arguments. The data, warrant, and backing are all different ways to justify a claim or conclusion about a problem. An individual can determine the validity of a claim by constructing an argument that considers the data, warrant, and backing both for and against the claim. Both the construction and critique of claims are essential to scientific practice.

Although a lone individual can construct an argument, it can also be constructed and critiqued in a social or dialogic process with other individuals (Jiménez-Aleixandre & Erduran, 2008). The *dialogic* component refers to argumentation as persuasion or the interactions that occur between individuals when they try to persuade or convince an audience about the validity of their knowledge claims.

In science, critique is important because knowledge claims are constructed within a community of scientific peers and individual success is often determined by one's ability to anticipate the potential critiques of the community (Osborne, 2010). Furthermore, rebuttals are a complex and important aspect of argumentation, because they require the examination of multiple perspectives (Osborne et al., 2004). Yet learners often do not see persuasion as a goal of science, but instead can see the goal of science as to know the "right answer". In science classrooms, it is important not only for learners to be able to make sense of data to construct claims, but they also need to be able to consider alternative claims as well as critique the claims and justifications provided by other individuals in the context of dialogic interactions.

The social or dialogic aspect of argumentation focuses on the relationships between individuals and whether or not learners' contributions are linked (either in support or against) to previous ideas contributed by the classroom community. I view both the structural and dialogic aspects of argumentation as essential for classroom practice, because they promote learners' abilities to reason and justify claims as well as interact with their teacher and peers in terms of both building off and critiquing their ideas. Consequently, I examined the patterns in the classroom discourse from both perspectives of argumentation as well as the role of the teacher in supporting both the structural and dialogic aspects of scientific argumentation.

2.9 Teachers' Roles in Supporting Argumentation

A shift in discourse patterns places new demands on teachers that require an understanding of current classroom cultural norms around discussion and utilizing instructional strategies that set up new rules for classroom discourse (Herrenkohl et al., 1999). Teachers take on new roles in argumentation science classrooms including that of guide in which teachers support learners in the learning process yet learners still take an active role in that process (Crawford, 2000). This can be a shift from teachers' traditional roles in that they are not the sole authoritative voice in classroom discourse, rather they guide and support learners to play an active role in the discussion.

Furthermore, a classroom culture needs to be created in which learner-to-learner interactions are not only permitted but also encouraged. Learner-to-learner interactions may require explicit social supports, because this type of interaction is not the norm in most science classrooms (Herrenkohl et al., 1999). Learners may wait for the teacher to evaluate a previous learner's contribution instead of responding directly to that learner. Furthermore, it may be unclear to learners what is considered appropriate in terms of a response to another learner particularly if it involves critique. Teachers also need to take on the role of critiquer in the classroom community in which they model how to question claims and the justifications for those claims in a manner similar to what they are expecting of their learners (Osborne, 2010). Learners may be unfamiliar with analysing scientific argumentation so the teacher can play an important role in modelling those practices.

Consequently, to shift the discourse practices, teachers may need to take on a variety of roles that are unfamiliar to them or not a part of traditional science classrooms. Related to taking on new roles, supporting learners in scientific argumentation may also entail the teachers' use of different instructional strategies. Simon and her colleagues (2006) identified a number of pedagogical practices used by teachers that may help support learners in argumentation discourse. For example, teachers' defined argument, provided examples of arguments, prompted learners to justify their ideas with evidence, encouraged debate and counterarguments, and promoted learner reflection to facilitate argumentation in their science classrooms.

Herrenkohl et al., (1999) found that in studying the discourse practices of one science teacher over 2 years that the teacher's questioning strategies appeared to shift and align with increased learner voice and participation in classroom discussion. At the beginning of the study, the teacher used more closed or factual recall questions while later the teacher used more open questions with multiple potential responses. When the teacher used more open questions, a greater percentage of the discussion consisted of learner voice and argument discourse in which learners provided evidence for claims and offered rebuttals. Other research has investigated teachers' questioning strategies in supporting classroom discourse, though without a particular focus on scientific argumentation. Teacher questions provide an avenue to open up classroom discourse beyond the traditional lecture format of teaching by telling. Questions have the potential to bring learners into the conversation and increase learner talk, but the type of teacher question influences how it affects learner participation.

Traditionally, teachers' questioning strategies have focused on evaluation, but they can serve a very different role in classroom discussion (Chin, 2007). For example, Minstrell, J. & Van Zee, E. (Eds.) (2000) found that when the teacher asked open questions and acknowledged learner contributions in a neutral way, that these questioning strategies encouraged greater learner participation, elicited learner thinking, and supported learner reflection during class discussions. This type of open and reflective environment may be important for encouraging argumentation discourse in which learners engage in dialogical interactions where they support or refute the ideas of their peers. I am interested in how different types of questions impact argumentation discourse in the classroom.

Chin, (2007) developed a system for classifying teacher questions that initially used four categories: open questions, closed questions, rhetorical questions, and managerial questions. *Open questions* ask learners to express their opinions and explain their reasoning. Because of this, the answers to such questions are not easily classified as being right or wrong and there are a large number of acceptable learner answers. *Closed questions*, however, have a limited number of correct answers associated with them. These questions tend to ask that learners recall previous facts or explain concepts within imposed limits established by the teacher and the subject matter. *Rhetorical questions* are asked by the teacher, but no response by the learners is expected or solicited. *Managerial questions* focus on classroom management, and they are not associated with the subject being taught. As I will discuss in more detail in the methods, I adapted Chin's coding scheme to evaluate the types of questions being used in the classroom discourse and the relationship between the question types and the argument structure and dialogic interactions occurring in the classrooms.

2.10 Criticisms of the New Curriculum

Since South Africa's first national democratic elections in 1994, the Government of National Unity has issued several curriculum-related reforms intended to democratise education and eliminate inequalities in the post-apartheid education system (Jansen, 1998). The Ministry of Education has introduced three national curriculum reform initiatives focussed on schools. The first attempt was to purge the apartheid curriculum (school syllabuses) of 'racially offensive and outdated content' (Jansen, 1998), while the second introduced continuous assessment into schools (Lucen & Ramsuran, 1997). The most comprehensive of these reforms has been labelled outcomes-based education (OBE), an approach to education which underpins the new Curriculum 2005. While the anticipated positive effects of the new curriculum have been widely heralded, there has been little criticism of these proposals given the social and educational context of South African schools.

As a way of reviewing literature, this study offers a critical assessment of the claims, assumptions and silences underpinning official policy on OBE. In the process, I intend to demonstrate how the current status of education in South Africa militates against sophisticated curriculum reforms such as OBE and recently CAPS. In concluding, I will argue that it is important to understand the origins and anticipated trajectory of OBE (and indeed other curriculum reforms) as primarily a political response to apartheid schooling, rather than one, which is concerned with the modalities of change at the classroom level. Leading up to this event, schools and their allies had been repeatedly warned by the National Department of Education that January 1998 was an 'absolutely non-negotiable' date for the implementation of what has only recently become known as OBE. Within months, an explosion of curriculum activity thundered across South Africa as committees of departmental officials, curriculum developers, subject specialists, teachers, lecturers, trade union and business representatives and a good representation of foreign 'observers' from Scotland to Australia attempted to translate OBE into workable units of information for teaching and learning which would be ready for first phase implementation in 1998 (Jansen, 1998).

At first glance, there appear to be sound reasons for a curriculum policy modelled on OBE. Outcomes would displace an emphasis on content coverage. Outcomes make explicit what aspects learners should pay attention. Outcomes direct assessment towards specified goals. Outcomes signal what is worth learning in a content-heavy curriculum (Jansen, 1998). These are universal claims associated with OBE in several first-world countries. Yet there are several problems documented regarding the OBE experience in these countries. Do outcomes in fact deliver what they claim? How do outcomes play out in a resource-poor context? OBE does not have any single historical legacy. Some trace its roots to behavioural psychology associated with B.F. Skinner; others to mastery learning as espoused by Benjamin Bloom; some associate OBE with the curriculum objectives of Ralph Tyler; yet another claim is that OBE derives from the competency education models associated with vocational education in the UK (Mahomed, 1996). In South Africa, the immediate origins of OBE are in the competency debates followed in Australia and New Zealand (Jansen, & Christie, (1999).

Curriculum 2005 is a form of outcomes-based education. Outcomes-based education has meant different things to different people in theory and in practice (Hargreaves & Moore, 2000; Harley et al, 2000). As the guiding philosophy of C2005 in 1997 it was, for its initiators, the pedagogical route out of apartheid education. In its emphasis on results and success, on outcomes and their possibility of achievement by all at different paces and times rather than on a subject-bound, content-laden curriculum, it constituted the decisive break with all that was limiting and stultifying in the content and pedagogy of education. OBE and C2005 provided a broad framework for the development of an alternative to apartheid education that was open, non-prescriptive and reliant on teachers creating their own learning programmes and learning support materials (DOE, 1997a, & b).

The Report of the Ministerial Committee established to review the curriculum in 2000 gave a wide-ranging critique of the curriculum. It argued that while there was overwhelming support for the principles of outcomes-based education and Curriculum 2005, which had generated a new focus on teaching and learning, implementation, has been confounded by: A skewed curriculum structure and design; Lack of alignment between curriculum and assessment policy; Inadequate orientation, training and development of teachers; Learning support materials that are variable in quality, often unavailable and not sufficiently used in classrooms; Policy overload and limited transfer of learning into classrooms; Shortages of personnel and resources to implement and support C2005; Inadequate recognition of curriculum as the core business of education departments. (DOE, 1997a, & b).

All these areas were seen as requiring attention. Their weaknesses were underpinned by and required adequate resourcing, manageable time-frames for implementation and regular monitoring and review. In order to address these issues the Review Committee proposed the introduction of a revised curriculum structure supported by changes in teacher orientation and training, learning support materials and the organisation, resourcing and staffing of curriculum structures and functions in national and provincial education departments. Specifically, it recommended a smaller number of learning areas, including the reintroduction of history, the development of a Revised National Curriculum Statement which would promote conceptual coherence, have a clear structure and be written in clear language, and design and promote 'the values of a society striving towards social justice, equity and development through the development of creative, critical and problem-solving individuals' (Chisholm et al, 2000, viii). The Revised National Curriculum Statement was duly produced and became policy early in 2002.

2.11 Spirituality in Indigenous Knowledge versus the Nature of Science

Thomson (2003) briefly mentioned the fact that most foreign ethnographers stress on the negative elements of Indigenous people's knowledge instead of concentrating on clearly aligned Indigenous ideas to school science. This is a very important observation, which I also feel that members of the academy should seriously consider when talking about Indigenous science. In the first place, local people's knowledge is not classified in compartments like those in science or arts. Therefore, the moment we mention local knowledge as scientific, there should be a clear connection between the kind of local practice or knowledge in relation to the scientific body of science. In this way, the choice of examples that are labeled scientific will not invite disparaging remarks from the public.

It is well known and documented that the west has a historical record of spirituality. In fact, the missionaries are tightly linked to that belief system. However, the west does not call spiritual work a science. One wonders why the Indigenous spiritual elements are being featured as local science. It would appear that a normal scientific discourse needs to desist from distorting the image of science by bringing in what has already been delineated from science in the Western world. This will correct the distortions that surface in the course of discussing Indigenous science. On the other hand, it may be a better idea never to talk about Indigenous science. We should be talking about Indigenous knowledge being compatible with the knowledge windows in school science. Therefore, the debate about Indigenous knowledge should be freed from obvious distortions. In this way, no one will have doubts about science and other people's knowledge that fit into the scientific frame of reference.

2.12 Indigenous Knowledge

Understanding aspects of Indigenous knowledge (IK), with respect to its characteristics, production, maintenance, adaptation, transmission and its use, is crucial for one to make coherent relationships between IK and science and indeed in making a sound analysis of all propositions about the need for science teaching to embrace Indigenous knowledge (Maurial, 1999; Mwadime, 1999). Efforts to understand Indigenous knowledge are thwarted by several reasons ranging from ambiguity of terms, obscure forces that act on conception of ideas and processes surrounding Indigenous peoples, socio-cultural lives (power, politics, and socio-economic factors), and lack of background knowledge (among teachers) to identify relevant or irrelevant bodies of knowledge in the process of planning and teaching science that embraces Indigenous knowledge.

For teachers, who largely depend on knowledge that they learned from college, dealing with Indigenous knowledge may look like far out of reach. In other words, ordinary minds do not usually worry about processes that shift the position of things in a society. Therefore, I consider it necessary to clarify some meanings that surround the terms "Indigenous" and "knowledge," and their associated characteristics, sub-branches and also theoretical perspectives that are associated with such conceptions. The term “Indigenous” is loaded with meanings (traditional, local, natural, and primitive), just like the term *knowledge* connotes different things to different people. A combination of the two words (*Indigenous knowledge*) obviously presents a huge task in constructing a single concept. Hence, some people say, “the meaning of Indigenous knowledge is difficult to pin down” (ICSU, 2002, Maurial, 1999). Since we are going to use these terms frequently, it is necessary to discuss aspects of Indigenous knowledge, in general, through which the linkages with science can be discerned. Prior to analysis of “Indigenous knowledge” as a unitary concept, let us put the terms *Indigenous* and *knowledge* in the limelight.

2.13 What does the term Indigenous Stand for?

Semali and Kincheloe (1999) described the term “Indigenous” as ambiguous because it has various meanings. Its former meaning, as construed by colonialists during colonialism rule, is different from the current perception by some of the colonized people in the neo-colonialism era. From colonial masters’ perspectives, the term Indigenous was associated with the primitive, the wild, the ignorant, and the natural. All the descriptors of bearers of the term Indigenous were implicated with condescension from the Western observers (as depicted in most anthropological studies conducted earlier by Western anthropologists): An element that post-colonial theorists reveal to be a causal factor that leads to little appreciation of Indigenous insights and understandings that Indigenous people offered to the colonial masters’ pool of knowledge (Carter, 2006; McKinley, 2005; Semali & Kincheloe, 1999).

All people that westerners labeled as Indigenous were viewed as inadequate and the more the Indigenous people saw themselves in that position; from implicit or explicit experiences the more they accepted their knowledge and capabilities as lower in value (Ogunniyi, 1988). This trend led to attenuation of some forms of practices and knowledge that Indigenous people used for thousands of years prior to the arrival of expansionist Europeans (Ocholla & Onyancha, 2005). However, as Semali and Kincheloe (1999) pointed out, some Indigenous people do not share this subjugated view of their Indigenous knowledge, especially the millions of Indigenous peoples of Africa, Latin America, Asia, and Oceania...some of such Indigenous knowledges have been named native ways of knowing through which elements of local science are highlighted (also see Kawagley, 1995).

A scan across several Indigenous cultures reveals elements of knowledge, practices, artifacts that are closely associated with science and technology, but the colonialists did not often recognize them as worthwhile contributions to the global collection of knowledge and practices. In their study, Ocholla and Onyancha (2005) processed info metrics on Indigenous knowledge which cover a wide range of Indigenous knowledge practices such as agriculture, environment, biodiversity, health and nutrition, just to mention a few. However, the low profile accorded to Indigenous knowledge rendered such contributions valueless and resultantly such knowledge never featured as a commodity. Hence, Indigenous people have reaped nothing out of their contributions. Instead, they suffered some disruptions in their productive practices, since the Western science de-skilled them and immediately after deskilling them they had to re-skill in order to become functional again (Ogunniyi, 1988). It was imperative for Indigenous people to develop new skills under the changed socio-economic demands while living under colonialist governments (Katz, 2004; Maurial, 1999).

The greatest reason for neglecting Indigenous knowledge was power. Since knowledge is power, money, and prestige (McKinley, 2005; Ocholla & Onyancha, 2005; Shizha, 2006), some schools of thought contended that recognition of Indigenous knowledge (on the part of colonialists) would give Indigenous people power to act or agency for identity. Therefore, to maintain power, the colonial masters' knowledge and voice had to remain superior to those of Indigenous people, a clear case in point in the South African context as reported in the De Lange report of 1981 (National Education Conference, 1982). It is through such elements that some post-colonial scholars criticize the universalistic claim that science is the only way of knowing. Thus, such scholars lay pointers to or indeed reassemble the almost obliterated ideas, practices, and artifacts (produced by Indigenous people) that are of scientific relevance (Ogunniyi, 1986; Sundar, 2002) while advancing the claim that Western science is not a unilateral practice for the westerners alone but a universal practice for all people in the world (Ogunniyi, 1986; Sithole, 2005).

To some, this is a paradoxical argument. Instead of thinking about science as universal and of Western origin, post-colonialist and postmodern philosophers feel that the Western view is narrow and short of the credence it claims to bear because it neglects the source of hypotheses and wonderment which mostly come from everyday knowledge like Indigenous knowledge. Additionally, some authors challenge the Western science for claiming that science is value free and yet capitalism is loaded with values (Ogunniyi, 1986; Sithole, 2005). Claiming universality of one set of knowledge is also criticized because all parts of the world have their own local knowledge that changes as it interacts with other forms of knowledge.

Hence, the fluidity of population movements does not allow any set of knowledge to remain purely local, including the knowledge of Indigenous people.

It is from such arguments and assertions that Indigenous knowledge gains the scientific connotations and indeed the emergence of the term Indigenous science. Indigenous knowledge is, however, locked up in spirituality because it "encapsulates the common good-sense ideas and cultural knowledges of local people concerning everyday realities of living", according to Dei (2000). Nevertheless, why call it Indigenous science and not just science? As Carter (2006) would say, this debate arises because there are perceptual borders between the two forms of knowledge, although the margins are leaky. Another reason is that the west has compartmentalized their knowledge, such that spiritual matters are not part of science, while Indigenous knowledge remains holistic (Semali & Kincheloe, 1999). One interesting academic argument indicates that science and religions are not quite separate since they share sections of cosmologies. This brings us to an issue worth pondering on in this debate.

2.14 Emergence of Indigenous Knowledge in the Academia

According to Brokensha, Warren, and Werner (1980), the emergence of Indigenous knowledge in the academe was triggered by ethnographic studies conducted in nation-states that were once colonized by Europeans during their expansionist agenda. Through such studies, it was noted that prior to colonization some local people sustained themselves better when they owned locally developed knowledge than was the case after the colonial rule. The aftermath of colonialism (in the twentieth Century) is thus, viewed as having negatively transformed some of such nations to the extent that they lost vitality of their agricultural and other survival systems (Semali & Kincheloe, 1999, Katz, 2004).

For example, Thomson (2003) mentions the Democratic Republic of Congo (DRC, formerly Zaire) that experienced a downturn in its capacity to produce cereals due to the disruption of colonialism. Resultantly, DRC reached a point where the local people's cereal civilization became almost dysfunctional and people could no longer sustain their food requirements. Through several of such critical anthropological studies it was realized that reverting to the use of some Indigenous knowledge and practices, that sustained people many years before colonization, was a gateway to revamping some colonial country's ailing sustainable living systems among Indigenous people. Through consideration of such examples, and across the continent, the momentum for the Indigenous science/knowledge debate has grown in strength at local, regional and global scales, and scientists have become active participants of this debate (ICSU, 2002; Iseke-Barnes, 2005).

To date, the debate increasingly continues as featured in many institutions and internet websites such as World Bank (under news columns for developing countries), Science and Development Network (SciDev.Net), Indigenous Science network (Australia), Alaska Native Knowledge Network, and India, just to mention a few from the wide range of networks mushrooming in developing countries. At the same time, there is high proliferation of published articles on Indigenous knowledge. In an info metric analysis of Indigenous knowledge, Ocholla and Onyancha (2005) found that there is a growth of literature that is written and published on Indigenous knowledge in years spanning between 1990 and 2005 and such articles have been published in most databases. Almost all the networks mentioned above pursue the issue of legitimizing Indigenous knowledge as a body of oral knowledge that has sustained people who have solely relied on oral transmission of such knowledge for all their survival until they were colonized and introduced to the world of print and education (Ogunniyi, 1997; Kawagley, 1998; Semali & Kincheloe, 1999; Ogunniyi; 2000; Snively & Corsiglia, 2001; Ogunniyi, 2004; McKinley, 2005).

This growing pressure for legitimization of Indigenous knowledge has so far made international organizations such as UNESCO, World Bank and many others to seriously consider using Indigenous knowledge when pursuing development and education support endeavors for some developing nations.

Since Indigenous knowledge is oral by nature and passed on from adults to younger generations, one would expect this kind of knowledge to remain exclusively historical. However, this is not the case. Reynar (1999) in his article, entitled, “Indigenous people’s knowledge and education: Tools for national development?” discusses how Indigenous knowledge has kept evolving and improving to the extent that the past two decades have noted an increase in Indigenous knowledge systems. This is observed through a phenomenal increase of literature (Ocholla & Onyancha, 2005); thereby signifying that Indigenous knowledge has the capacity for adaptation. Although early ethnographers mostly described Indigenous knowledge with negative connotations, time has shown that some of the knowledge is worthwhile.

2.15 Indigenous Science

The definition of Indigenous science is quite difficult to pin down because science itself is a complex learning area. Snively and Corsiglia (2001), quoting Ogawa (1995), stated, we must distinguish between two levels of science: individual or personal science and cultural science or societal science. Ogawa refers to science at the culture or society level as "Indigenous science." He defines Indigenous science as "a culture-dependent collective rational perceiving of reality," where collective means held in sufficiently similar form by many persons to allow effective communication, but independent of any particular mind or set of minds. Although we all participate in Indigenous science, to a greater or lesser degree, long resident, oral culture peoples may be thought of as specialists in local Indigenous science.

Indigenous science, sometimes referred to as ethno science, has been described as: "the study of systems of knowledge developed by a given culture to classify the objects, activities, and events of its given universe…" (Snively & Corsiglia, 2001, p. 10). Indigenous science interprets the local world through a particular cultural perspective. Expressions of science thinking are abundant throughout Indigenous agriculture, astronomy, navigation, mathematics, medical practices, engineering, military science, architecture, and ecology. In addition, processes of science that include rational observation of natural events, classification, and problem solving are woven into all aspects of Indigenous cultures (Snively & Corsiglia, 2001).

As it may be noted from the long quotation, the terms Indigenous science cover a wide ground and many people just prefer to call it holistic science because it has many bodies of knowledge under one umbrella. There are multiple meanings and it should also be noted that the local people do not name Indigenous science as science. Indigenous science is encrusted in Indigenous knowledge which is itself an ambiguous term that connotes many categories of knowledge. Before getting into the multiples of Indigenous terms let us take a quick look at the broader body of knowledge in which Indigenous science is a subset, that is, Indigenous knowledge.

2.16 Indigenous Knowledge as Science

Mwadime (1999), also grappling with the meaning of Indigenous science, cautioned that prior to advocacy of Indigenous knowledge, it is important to have a thorough understanding of terminology. Starting with *knowledge*, he defined it as "the awareness or understanding of a practical or theoretical thing or fact" and further stated that this knowledge "embraces knowledge of tools and techniques for assessment, acquisition, transformation, and utilization of resources in their locality" (p. 247). Mwadime (1999) also noted, "it is Indigenous (local or tacit or practical) because it differs from known forms of formal knowledge (scientific, Western, modern, colonial) in the contextual sense (as IK is deeply rooted in its environment, history, and new experiences) and the epistemological nature of IK is holistic". This kind of knowledge remains the information base for a society, which facilitates communication and decision-making. Mwadime (1999) attempted to isolate Indigenous science from its holistic body of knowledge and a glance at his work reveals that Indigenous knowledge bears both scientific and technological threads but in its creation and use it is simply practical/pragmatic knowledge and not ordinarily identified as a science (Stephens, 2001; Snively & Corsiglia, 2001). Thus, understanding and analysis of Indigenous science tends to be done with reference to the well-established Western Modern Science (WMS), which people are already familiar with.

2.17 The Nature of Science

All teachers, especially at school level, where learners are introduced to scientific approaches, need to have a better understanding of the nature of science (AAAS, 1990). This is important because teachers bear the responsibility to introduce all young people to science. The way learners are introduced to science may either uphold or run down the achievements that the scientific community has realized so far. Therefore, teachers are expected to have not only scientific knowledge, but also the historical aspects of scientific endeavors and the current strides in this field. For example, knowledge about genetics has changed from past to present. At first, people like Gregory Mendel only speculated about inheritance traits, but later developments showed that chromosomes are responsible for genetic changes. Experimental procedures, in relation to genetics, have thus changed as time went by.

This argument is well illustrated by Graves (2005) who showed how Francis Bacon criticized Aristotle's syllogistic reasoning, which depended on reasoning alone in search of scientific ideas. Bacon doubted if a syllogistic approach would help in finding new information in science (although it worked in politics). Instead of syllogism, he advanced the use of senses in search of scientific knowledge, which demands complex ways of knowing beyond mere reasoning. This was the beginning of empirical research in science that translated to elements of *the current scientific approach* (p. 54). Due to such changes, teacher's vision of current practices and understandings in science should be tied to earlier developments that necessitated the transformation of earlier practices and understandings. In this way, teachers will understand why we currently have the forms of practices and knowledge (in science) that should be passed on to learners.

Furthermore, numerous jobs today demand understanding of scientific knowledge or manipulation of technological artifacts. Additionally, the changing environment and way of living makes it imperative for children to be scientifically literate if they are expected to successfully interact with nature and the current world. A mention of scientific literacy raises a fully-fledged discourse, which may not fit into this study. Suffice it to note that there has always ensued a huge debate about science endeavors and forms of knowledge to be passed on to learners, which have evolved based on varying philosophies of science, all the way from the days of Plato, Socrates, Thomas Huxley, Francis Bacon, Albert Einstein and, in more recent times, John Dewey (as stated by Shamos, 1995 and Victor & Lerner, 1971). Science worthy knowledge has evolved in response to the philosophy of science along the time line, together with skills for acquiring such knowledge. Most arguments for ensuring scientific literacy in the citizenry have leaned towards knowing nature and how to utilize knowledge about nature in everyday life experiences. Hence, scientific literacy would be associated with acquisition of facts and the know-how that prepares people (both young and old) for the world of work and survival.

Victor and Lerner (1971) have pointed out that viewing science in terms of knowledge and its use alone falls short of the full meaning of science. Teachers who hold on to such views of science have resultantly taught science wrongly by omitting an important aspect of the nature of science. This brings us back to the need for teachers to understand the nature of science to ensure effective teaching. This need for teachers to understand the nature of science was noticed a long time ago since science got introduced in elementary curriculum as stipulated by Blough, (1958) whose articles were reprinted in Victor and Lerner (1971, p. 520-25). In these articles, it was noted that teaching science in elementary school is not matters of the presentation of the content…instruction that may be shared with children are: proposing problems, defining problems, suggesting methods for solution of problems, relating experiences to the solution of a problem, suggesting observation that may be made, thinking through the problem, assisting in drawing conclusions, assisting with experiments…questioning superstitions, myths and unscientific materials, discarding opinions and recognizing the difference between the solution proposed by the class members and scientific information.

Victor and Lerner, (1971, p. 520) and Blough (1958), also stated that: Through the study of science, learners build concepts and ideas of their world, which they use in interpreting it. It is through the accumulation of concepts that they learn to understand what is happening around them and why it happens: Consequently, they are able to react more intelligently. It is through this process that they become better prepared to live in today's world.

Problem solving in science involves the use of scientific habits and attitudes, which include: careful observation, accurate interpretation of these observations, and skilful recording and communication…" (Victor & Lerner, 1971, p. 521). When commenting on the objectives for teaching science in elementary schools and other levels of education, Victor and Lerner proposed that science instruction should aim at learners' "growth in understanding of science concepts and ability to participate in the process of scientific inquiry" (Victor & Lerner, 1971, p. 525). Most of what was said in the three contributions described above, with respect to the teaching of science, reflects aspects of the nature of science. Such knowledge is expected to help teachers determine the nature of tasks that can be designed for learners in order to develop understandings and skills required in science and also in life as citizens. Realization of science literacy is the prime purpose of the education system in the United States of America (USA), through which it is hoped citizens will be prepared to lead personally fulfilling and responsible lives (American Association for the Advancement of Science [AAAS], 1990).

Interestingly, the constructivist agenda also seeks to realize elements of learning that were raised by Blough, in the three excerpts described above. This trend of thinking progressed and got polished or strengthened after some research work was done on these issues. Hence, the current tenets of the nature of science clearly articulate such aspects and more. Literature is rich with epistemological tenets of science. I hereby give a brief account of the tenets stipulated under the nature of science as viewed by the AAAS (1990): (1) Scientific worldview, (2) Scientific method of inquiry, and (3) Scientific enterprise. Each of these aspects of the nature of science deserves elaboration in order to illustrate their implications for teaching.

2.18 The Scientific Worldview

Under the scientific worldview, four areas are discussed. *First*, the world viewed as understandable. This notion presumes that phenomena in the universe occur in a consistent pattern that if carefully and systematically studied humans can comprehend them using senses and tools. *Second* view is that scientific ideas are subject to change. This way of thinking arises from the assumption that change, in knowledge, is inevitable. Hence, theories are bound to change in response to emergence of new evidence. *Third* perception is that scientific knowledge is durable, as evidenced by most of the scientific ideas that have remained correct and viable for a long time from the time they were discovered by early scientists. *Fourth* and last view held by the scientists, under the worldview, is that science cannot provide complete answers to all questions. This view emerges because there are issues that cannot be usefully examined in scientific ways as they conflict with other beliefs, or indeed cannot be proved (AAAS, 1990). For example, it is very difficult to prove how the world was created using scientific approaches. According to Huitt (2003), scientific ideas are usually found through investigations or inquiry which rely on observable data. It is probably worthwhile to shed light on inquiry, which is also highlighted as the second aspect of the nature of science (AAAS, 1990).

2.19 Science and Culture

Snively and Corsiglia (2001) pointed out that Western modern science is actually a reflection of the Western culture but not the global set of cultures. Snively and Corsiglia (2001) and other post-colonial scientists contended that all other cultures have developed their own ways of understanding the world realities and independently produced solutions to their own problems using their own understandings as echoed by Berger and Luckman (1966). Berger and Luckman (1966) argued that communities in which they live and the language plays a crucial role in meaning making and thus determine all forms of knowledge objectivities. Hence, science heavily relies on social interactions and not unilateral thought.

Alternative ways of developing worldviews (or realities), besides the Western modern science, fall under Indigenous knowledge, which according to Snively and Corsiglia (2001), is claimed to have also produced numerous examples of time-proven, ecologically relevant traditional ecological knowledge (TEK) and cost effective Indigenous science. The only stumbling block with Indigenous knowledge is its high reliance on oral transmission, which at times curtails progression when elders who possess unique knowledge die before passing it on to younger generations. This is so because of heavy reliance on the wisdom of elders (Boyne, 2003), as the sole custodians of knowledge. However, TEK is renowned for maintenance of culturally established structures, which makes it attractive at this point in time when many things are culturally and environmentally going amiss due to human activities.

Due to the oral nature of Indigenous science, there is an inadequacy standard reference about its nature. This is worsened by the fact that most of Indigenous science is done at personal level. Hence, it is difficult to compare Indigenous science with Western science in terms of their tenets because Indigenous knowledge was usually not meant for the academe and also ideas were not assembled to organize this kind of knowledge. The three tenets under the nature of science, given above, condense vast arguments and philosophies that describe aspects of the nature of science provided by the scientific community.

In the first place, it must be noted that science deals with findings about certain forms of 'truth' arising from pragmatic evidence. Inquiry serves as the main tool for realizing data that serve as empirical evidence after being scrutinized by a community of scientists. Accrued truths or ideas endure for a long time unless other types of evidence disapprove them. The allowance for change of scientific ideas in presence of more suitable evidence is normal. The change of ideas, with respect to recently objectified reality (sometimes dependent on culture or situation), is known as 'relativism' according to some theorists of knowledge and how it is realized (Berger & Luckman, 1966; Gergen, 1999). To this end, even the AAAS (1990) agrees that scientific knowledge is tentative. Hence, scientific ideas are not held as absolute. In this respect, scientific ideas are constructed in a similar fashion to those constructed in constructivist theory.

It is probably high time we switched to the Indigenous science discourse, which potentially changes some few areas in the teaching and understanding of the nature of science. As teachers endeavor to include Indigenous knowledge (which has other worldviews), this information will create a dissonance and needs to be resolved by teachers themselves and all other stakeholders because the inclusion of Indigenous knowledge creates a new (and broader) dimension about the nature of science. This brings us back to pedagogy issues in relation to integration of Indigenous knowledge in school science.

2.20 Indigenous Knowledge as Prior Knowledge

Various multicultural science teachers have pointed out that some Indigenous knowledge backgrounds can actually conflict with the Western account of science. Aikenhead, (2001) presents some aboriginal knowledge experiences, which conflict with science, and feels that it would be better to avoid forcing learners to adopt Western accounts, which would distort their worldview. For example, he cites the aboriginal people's belief in thirteen moons, instead of twelve as disconnect of the two cultural accounts, that is, disconnect of the aboriginal conception from the standard scientific account (p. 344). Kawagley (1995) presents a range of Yupiaq worldviews, which differ from the Western account about their beluga whale tracking as well as their fishing techniques (capable of getting specific types and sizes) apart from their traditional medicines.

Another group is the Moken (Nomads in marine life from Thailand) whose ways of thinking emphasize the connection between human beings and spiritual worlds. For example, the Moken ask the spirit of the tree before logging it or indeed sharing the foraged food with ancestors' spirits before humans partake of it (Arunotai, 2006). Interestingly, the food sharing beliefs of the Moken of Thailand were also found among the Lozis of Zambia and many similar cultures of Caprivians in Namibia. Nevertheless, due to the interculturation with Europeans during the colonial rule most of such beliefs have disappeared. Hence, multicultural scientists ponder on the best approaches that would help learners from such backgrounds to learn science or strike a balance in what they believe and what science says (Aikenhead, 2001; Stanley & Brickhouse, 2001). The answers are tricky but one is better off engaging in these understandings and learning how they play out in science teaching. Somehow, some learners may move across the borders to understand science if such considerations are made in science teaching. Crossing borders is particularly important in very traditional populations (Aikenhead, 2001).

However, there are also many examples where Indigenous knowledge serves as helpful prior knowledge. Putsoa's (1999) poem, quoted from Postman and Weingartner, speaks volumes about the need to use contextualized knowledge from the communities where learners come from, as she says, the institution we call *school* is what it is because we made it that way. If it is *irrelevant*, Marshall McLuhan says; if it shields children from *reality*, as Nobert Weiner says; if it educates the *obsolescence*, as John Gardner says; if it does not develop *intelligence*, as Jerome Bruner says, if it is based on *fear*, as John Holt says; if it avoids the promotion of *significant* learning, as Carl Rogers says; if it induces alienation, as Paul Goodman says; if it punishes *creativity* and *independence*, as Edgar Friedenberg says; if, in short, it is not doing what it needs to be done, it can be changed; it must be changed. (Putsoa, 1999, p. 87)

The above poem and all the foregoing accounts on prior knowledge indicate the need for relating learners' learning to their everyday experiences. All curricula that do not respond to the concerns raised in the poem by relating learning to learners' experiences only serve to alienate the learner. The main issue that Putsoa (1999) emphasizes is the need for science teachers to promote development of scientific knowledge and skills that have practical bearing on the welfare of their societies (in developing countries). This follows a big shift in objectives for science teaching, in response to environmental changes that learners need to be aware of and help develop solutions to their environmental problems. Again, Indigenous science and awareness of learners' local environment remains a great starting point for science education.

2.21 Teacher's Knowledge about Indigenous Science

Shumba (1999) carried out a quantitative research study in Zimbabwe, whose objective was to measure the extent to which secondary science teachers are oriented towards traditional culture and how their orientation towards Indigenous culture is related to instructional cultural ideological preferences. Shumba's (1999) study design assumed that teacher's commitment to Indigenous cultural values and beliefs would bear a relationship with their instructional ideology preferences. The study found that secondary school teachers were not strongly traditional but maintained a traditional posture concerning aspects of traditional authority, religion, view of nature, and social change. Additionally, the study revealed that secondary school teachers shifted further off from tradition about sex roles, causality and problem solving. In summary, this study revealed a transformation of secondary school teachers in Zimbabwe (a former British colony known as Southern Rhodesia) that led to loss of some traditional values.

On the point of methodology, Shumba (1999) realized that the instruments for validating cultural tenets need to be improved and that the next study could include observational data collection instead of sole reliance on thematic categories whose occurrence rates determined the prevalence of characters under study. These results were not strange because Michie (2002) also pointed out that teachers, especially in secondary schools, tend to lack knowledge on Indigenous science. This is why teachers are encouraged to conduct research in communities surrounding their schools as a way of upgrading their background knowledge in Indigenous knowledge as also recommended by Gonzales, Moll and Amanti (2005). Michie (2002) further contended that secondary schools might not be a good site for Indigenous knowledge since the content, at that level, is more compartmentalized than holistic. For Michie, the best site for Indigenous knowledge is primary schools, which tend to have integrated curricula.

Thomson (2003) affirmed the foregoing knowledge deficiency concerning secondary school teachers through his personal experience while in Africa. As a young secondary school teacher, he went out in the forest to catch a unique type of moth. He could see the moth flying around the canopy of the tree but it would not come down. An elderly man found him, with his eyes glued in the tree. When he explained his intention to catch the butterfly, the old man told him that the moth would only come down if there was human dung. Using the elder's advice, he caught the scarce moth. This opened up his eyes and thereafter, he looked at Indigenous elders as being loaded with wisdom which secondary school biology teachers, like him, did not have. Through this experience and a few other experiences, with knowledge from elders, he conducted many other studies to search for validation of local people's knowledge as well as their languages.

2.22 Textbooks and Representations of Indigenous Knowledge

Textbooks are the most predominant source of knowledge in science teaching but at times they could also be a source of problems. There has been a general outcry among some teachers that some textbooks are not helpful to Indigenous learners. Some have branded science textbooks as biased to Europeans and that this scenario disadvantages minority learners. A follow up on the issue of textbooks was Ninnes' (2000) study of textbooks that were designed to reflect Indigenous science in Australia. That study was specifically conducted in a bid to overcome ethnocentric, racist, and culturally imperialistic approaches in representation of knowledge. The study was specifically evaluative in nature, influenced by post-colonial theory, essentialism, and the prescription of identities. Hence, that study employed a qualitative research approach that targeted the representation of meanings coming out of the words in the books.

Findings, following evaluation of discourses in the books, revealed that "passive statements" associated with Indigenous knowledge could mean that Indigenous knowledge (IK) is of lower value and probably obsolete. Ninnes (2000) contended that the "past tense representations" were culprits for setting up IK as pieces for antiquities. Hence, although the study revealed that all forms of sciences would be represented by IK (though variedly, with biology being the highest, followed by chemistry and physics), the style of writing suggested some negative elements, which might reinforce hegemonic stereotypes. Among the most outstanding is the use of stories, which do not enhance the image of Indigenous knowledge or people. This takes us to the last aspect, that is, spirituality in Indigenous science. This element of Indigenous knowledge warrants some attention, given its contentious nature in the field of science.

2.23 Summary

In this chapter, I have attempted to trace past events that have shaped science education from its early teaching to present day in an effort to present the context, which ultimately resulted in the Sciences Curricula Policy Statements published by the South African Department of Education (DOE, 2002, 2011). Furthermore, I presented 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 institutionalizing IK. Having made a case for the importance of IK, 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 particular, I have examined the Indigenous Knowledge (IK) component of the Natural Sciences and Life Sciences Curricula Statements. Different meanings of IK, a thought system, and the product of that system namely, Indigenous knowledge (IK) and possible impact that the introduction of the latter into the school curriculum could have on school science are also suggested. Finally, I also examined the pre-service teachers' abilities to use an instructional model to integrate Science-IK curriculum.

I have explained the curriculum reform in South Africa which led to the inclusion of Indigenous knowledge (IK) in Learning Outcome 3 (LO3) which stresses the importance of relating science to socio-cultural environment of learners. There is little research on what science teachers think and do when a curriculum imperative which demands the inclusion of IK in school science. With few exceptions (e.g. Ogunniyi, 2004, 2007a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008) very little has been done to explore the appropriate teaching strategies for enacting such a curriculum in the classroom. This means that there still much to know before teachers can be well equipped to fulfil the mandate of the new curriculum.

The foregoing discussions show that there is more to the thinking about integration of Indigenous knowledge (IK) in science than the eyes can see. To gain a better view of the association between Indigenous knowledge and science, more researchers need to probe some of the many assertions that have been made in many position papers about Indigenous knowledge. So far, the idea of inclusion of IK is accepted by the majority but to make it operational there is a need to have many studies that can show (a) the effects of IK instructional strategies on learners' learning, (b) the kind of content that fits the Indigenous science paradigm, (c) the nature of books that would support inclusion of IK, and (d) whether IK is indeed unique to the Indigenous masses that were formerly colonized or not.

Sutherland (2002) pointed out that science is alien to both westerners and non-westerners, as discerned by independent studies conducted by Ogawa (1995) and Kawagley (2000), although it is more alien to non-Western learners. In fact, BBC reports in early 2010 have indicated that many British youths are shunning science. This is an indicator that failure in science is a result of deeper causes than what is sometimes speculated. Therefore, would we say that the assertions about inclusion of IK are only useful to Indigenous learners or all people? If constructivism will be a bridge between IK and science, studies on how this indeed works need to be designed to determine the extent to which these assertions are true.

I think that the scarcity of primary research under this topic means that there are many untapped areas of research under Indigenous knowledge integration in school science. The more studies that are undertaken, the clearer will be the picture about the role and value of Indigenous knowledge in school science. According to Michie (2002) and Thomson (2003), it is also equally important for studies to compile examples of Indigenous knowledge that are scarce to many teachers. Such knowledge cannot be determined merely by word of mouth but through intensive and well-designed studies. Hence, it was from this position that this study was proposed in order to unravel issues that could emerge from teacher's (and probably learners') first time experiences with having science lessons with Indigenous knowledge slant.

As it may have been noticed from the foregoing discussion, various theoretical frameworks spring up in the indigenization discourses such as argumentation theory, post-colonial theory, multiculturalism, place based learning, situated cognition, and constructivism (just to name a few). I engaged in this study with a strong posture in argumentation theory, to evaluate what effect teachers have in implementing the science-IK curriculum. Hence, my lens in teachers' implementation practices tended to focus on the construction of ideas from the activities that teachers organized under Indigenous science topics. This was done to follow up the development of scientific ideas that would enhance learners' participation in the world's production economy highlighted in the curriculum. Other theoretical frameworks still came up but only to help discern more of the issues that came up from this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 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 and hence these were kept at the forefront. Focusing on the research questions summarily, what currently informs pre-service science teachers about how they conceptualise Science-IK curriculum, how they 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.

Qualitative and quantitative methods were used. Four instruments/techniques to collect data were used: (1) Questionnaires, (2) Focus group interviews, (3) Case studies from teaching practice scenarios and (4) Document analysis. The four questions targeted two major foci for data collection, that is: (1) the teachers' classroom instructional practices and (2) their impressions about the curriculum and curriculum documents. This study involved an in-depth two-year long assessment of the classroom practices and goals of the natural science pre-service teachers. A combination of semi-structured interviews, an open-ended questionnaire, classroom observations and focus group interviews were used to collect data on the teachers' classroom practices.

Researcher's Background

According to Patton (2002), qualitative researchers' capacity to make effective inquiry depends on their proximity to the program and procedures through which they develop opinions as they interact with people or materials. What the researcher deems interesting depends on his perceptions of meanings from the field. Hence, I considered it necessary to talk about my background that influenced my perceptions in this study. Firstly, I am a South African permanent resident and Namibian citizen who spent most of my early life in the rural area of Caprivi, northeast Namibia. My contact with Indigenous knowledge and technologies began from my childhood. Each day of my early life availed me a close connection to Indigenous knowledge and practices.

My paternal grandmother was a Sotho "oa Moshoeshoe" from Lesotho; maternal grandmother hailed from Botswana. Both my paternal and maternal grandfathers (though Namibians themselves) had their ancestral backgrounds from Zambia's Western province inhabited by the Lozi speaking people, a Bantu language much similar to Sesotho, Sepedi and Setswana. In the village, I spent my formative adolescent years with my grandparents, aunties and uncles as both my parents lived in a small town, called Katima Mulilo where my father was working for the Bantu Investment Company (BIC) a subsidiary company from South Africa as South West Africa (Namibia today) was a fifth province of South Africa then, administered from Pretoria.

My maternal grandparents passed on while I was a teenager and were thus, insignificant in shaping my teenage life. My paternal grandfather taught me how to make hoe-handles, mats, granary-stores and snares for catching birds at a tender age. I also recall how local people in the neighbourhood caught fish using simple technologies like fish traps and wooden fish spikes (*Mioono and miso* in Subia-my mother tongue) from the Zambezi river tributaries. As I tracked my grandfather in his everyday masculine chores, I started building knowledge based on Indigenous technologies or some sense Indigenous science (Semali & Kincheloe, 1999; Snively & Corsiglia, 2001). Each school day I passed through a 15-kilometre stretch of thick forest and valleys, which connected me to nature. Through that exposure, I discovered the rhythm of nature and learned the reasons why wild animals make particular sounds in the wilderness. On the other hand, through informal discussions with friends and adults I learned how to trap birds using juice from certain trees in the field. The list of Indigenous knowledge and technologies relevant to science is long and I hope this gives part of my connection with the people's practices in rural Caprivi, Namibia.

As an adult, I became a teacher in combined schools (Grade 1-10) and secondary schools (Grade 8-12) of Namibia. I spent over 12 years of teaching in both combined and secondary schools sector and taught general/physical/life sciences and mathematics each year, beside other subjects. My next five years of teaching were in a teacher training college as a science and mathematics teacher educator. Those years brought me in contact with more knowledge about teaching science and application of scientific ideas in everyday life. While serving as a science teacher educator, I met late Dr Alausa for the first time (May his soul rest in peace).

Dr Alausa, originally from the Hausa clan in northern Nigeria worked as a science curriculum specialist/consultant at the National Institute of Education Development (NIED) in Namibia. Before taking that job, he was my natural science educator during my pre-service training at Katima Mulilo Teacher's Training College (former Caprivi College of Education and now incorporated into the University of Namibia, Katima Mulilo Campus).

Dr Alausa first introduced me to a project known as "Community Science versus School Science" during an annual science week session. As I participated in both curriculum development activities and projects, such as "Community Science versus School Science", my vision of science started changing and its application in everyday life broadened. Curriculum development experiences, at that time, invigorated my desire to bridge science with local knowledge and practices. Dr Alausa taught me how to appreciate Indigenous ways of doing science, the humble man from northern Nigeria who also acknowledged that the neighbouring peoples namely, Kanuri, Fulani, Akan and the Yoruba peoples had an effect in his formative years. He narrated to me the myths among the Hausa tribe that their founder, Bayajidda, came from the east in an effort to escape his father. He eventually came to Gaya, where he employed some blacksmiths to fashion a knife for him. With his knife, he proceeded to Daura where he freed the people from the oppressive nature of a sacred snake who guarded their well and prevented them from getting water six days of the week. Leadership in the early Hausa states was based on ancestry. Those who could trace their relations back to Bayajidda were considered royal. That story is beyond the scope of this study.

However, the climax of my pursuit for this kind of knowledge was when I started reading networks of Indigenous science in 2004 while studying towards my Masters degree in science education at the University of the Western Cape, under the supervision of Professor Meshach Ogunniyi. It was at this point in my life that I realized that there is a great need to make connections between school science and Indigenous people's knowledge. I started thinking about such connections with lots of enthusiasm, especially after seeing the link of such knowledge with Learning Outcome 3 (LO3) of the Revised National Curriculum Statement published by the Department of Education (DOE, 2002). Back home I had been a Science and Mathematics Curriculum panel member for over six years and I participated in the first IK-Science integration curriculum meeting.

Namibia has a long way to go as the Directorate of Research, Science and Technology under the Ministry of Education has just begun to develop the IK policy document. Funding has been sourced from the National Research Foundation (NRF) in South Africa as part of bilateral agreements between the two countries. From the beginning, it was clear that the blueprint would actually be adopted from South Africa. I am at the moment serving on the Bilateral Committee called the Working Group tasked to produce an IK policy that would later pave way for the introduction of IK in the Namibian school curriculum. Both my Director and the Permanent Secretary in the Ministry of Education approved my three-year study leave and scholarship because of its relevance to my job. Hence, my interest to learn more about the application of Indigenous knowledge to the teaching of school science has tremendously grown from that initial exposure in 2004.

Further, my interest in Indigenous knowledge has propelled my desire to search for more and more ways of recovering and discovering local knowledge that is compatible with school science. My view is that such knowledge is likely to be beneficial South African and Namibians students. According to LO3 of the new South African curriculum much of the traditional technologies which reflects the wisdom and experience of Indigenous people has been lost during the 300 years of colonial domination and needs to be rediscovered and used (DOE, 2002). This thrust of this study has been to contribute towards the achievement of that goal.

3.2 Sample

This study took place at the University of the Western Cape (UWC) with a population of approximately 20 000 learners, of which 2000 are in the faculty of education and further into selected Western Cape Schools. The sample comprised of a cohort of the 16 pre-service teachers pursuing a Bachelor of Education course and had specialization in science subjects. However, in line with the suggestion of Patton (1986), the quantitative analysis will summarize findings on the whole group and the qualitative analysis will focus only on a few number of the subjects (vignettes) to permit an in depth account of the outcomes of the study.

The pre-service teachers were exposed to a series of bi-weekly three-hour workshops, underpinned by Toulmin's Argumentation Pattern (TAP) and Ogunniyi's Contiguity Argumentation Theory (CAT) described in chapter 2 for a period of six months. Three of the subjects were non-traditional pre-service teachers, one had received a teaching certificate and two had returned to university studies after a short absence. The oldest was 27. The remaining 13 were traditional pre-service teachers; undergraduates straight from school before they joined the university and their ages ranged between 22 and 26 years old. Of the total, seven (7) pre-service teachers were male and nine (9) were female. The makeup of the class was comparable to other cohorts of the education pre-service teachers at the University. Although the student population may not be representative of the majority of teacher education students, they were enrolled in a highly competitive public institution and their university entrance examination scores and socio-economic status were considerably above the national average.

Choice of Schools and Teachers

Since the pre-service teachers came from the same area in the Western Cape Province, they share similar social characteristics e.g. most of the subjects came from working-class and lower middle-class backgrounds. The pre-service teachers at the time of the study were due for teaching practice. However, before this, I contacted the Teaching Practice Coordinator in the Faculty of Education who allowed me to scout for schools in the area of my choice where I wanted the pre-service teachers to be placed. She also contacted the School Principals who had control over the day-to-day teacher operations of their respective schools. As the lecturer of the module embracing the study I was also the teaching practice supervisor for all the pre-service teachers for the period of July to October 2010 and June to October 2011 respectively. My contacts with Principals of the schools were made in late May 2010 and early June 2011respectively. To ease my visits, I chose schools within the shortest distance from the university within the community where the pre-service teachers lived.

3.3 Research design

This investigation was based on a case study design. According to Patton (1986), case studies are particularly handy where one wants to understand some particular issue in detail and where one can attain rich information from a small number of subjects-small and rich in the sense that a great deal can be learned from a few exemplars of the case in question. Regardless of the units analysis adopted in the study my paramount concern was to describe each unit as detailed as possible to obtain a robust and contextualized data. For the same reason only the information provided by four (4) group leaders will form the core of the qualitative analysis. As will be seen later in the section dealing the transactions, the 16 subjects were divided into four groups with each group having a leader that would present their decisions on the various tasks to the whole class later on. In other words, as advised by qualitative case study experts it is difficult to discuss in detail the contributions made by a large number subjects without compromising the need for an in-depth and a well-nuanced analysis (Bell, 1993; Denzin, & Lincoln, 2003; Patton, 1986) .

A research design is an investigator's overall strategy for answering the research questions. The choice of the design used in this study was underpinned by the assumption that learners' misconceptions are so varied and multi-faceted that no single instructional style is adequate for remedying such misconceptions. According to Fraenkel and Wallen (1993), the rationale for choosing one methodology over the other is connected with the nature of the subject under study and the underlying goals of the research. Different instructional methods have their strengths and weakness. Some are better for answering certain types of questions while others are better for yet other types of questions.

Likewise, the feasibility of an instructional approach could be an important determinant of the type of design chosen. According to Streibel (1995), instructional design theories, such as Gagne's theory, take the cognitivist paradigm one logical step further by claiming that an instructional plan can generate both appropriate environmental stimuli and instructional interactions. These then bring about a change in the cognitive structures and operations of the learner. Gagne investigated the foundations of effective instruction, which he referred to as conditions of learning. The design of any experiment is of utmost importance because it ultimately controls the methodological inquiry adopted for such an experiment. Similarly, Bell (1993) points out that the nature of the research inquiry and the type of information-required influence both the approach the researcher adopts and the methods of data collection used.

A review of the research literature shows that the best approach of a research design is to control for as many confounding variables as much as possible in order to eliminate or reduce errors in the assumptions that will be made. It is also extremely desirable that any threats to internal or external validity be neutralized through a rigorous research design (see Ogunniyi, 1992). In an ideal situation, a sound research design should produce predictable outcomes. However, in the real world, such is not often the case, as human subjects tend to act and react to the various stimuli. Besides, there are constraints of time, space, resources and situations, which often result in a less than perfect condition for gathering data. Many factors influence the choice of a research design. Some of them are resources (time, budget, experts), practicalities, purpose of the research, type of data required for the study, and the researcher's ability to effectively apply and use the methods of the research.

Taking into consideration these factors, the study was based on action research. The scope of action research as a method is impressive. Action research can be used in several settings where a predicament involving people, tasks and procedures cries out for solutions or where some change of feature results in a more desirable outcome. By way of defining action research, Kemmis (1997) suggests that there are several schools of action research. Action research can be used in a variety of areas for example: teaching methods, learning strategies, evaluative procedures, attitudes and values, continuing professional development of teachers, management, control and administration. Conceptions of action research can be revealed in some typical definitions, for example Hopkins (1985: 32) suggests that the combinations of action and research renders that action of form of disciplined inquiry, in which a personal attempt is made to understand, improve and reform practice. Indeed Kemmis and McTaggart (1992:10) argue that 'to do action research is to plan, act, observe and reflect more carefully, more systematically and more rigorously than one usually does in real life'. Cohen and Manion (1994: 186) define it as a small-scale intervention in the functioning of the real world and a close examination of the effects of such an intervention. The research procedure is provided in the following four (4) stages with reference to the questionnaire development.

3.4 Research Procedure

Stage I: Collecting data

The primary data source for this study was a set of case analyses, which the science pre-service teachers completed as part of the requirements for one of their education courses. The course, Science for Teaching in the School of Science and Mathematics Education (SSME), is part of the block of courses the undergraduate pre-service teachers take once they are admitted into the Bachelor of Education (BED) specialising in science and mathematics (the pre-service teachers take this course in their third and fourth year).

Stage II: Developing the Argumentation Instructional Model (AIM)

A technique was used to obtain a consensus from experts in various fields of study. Participant recruitment: the target of this study was to investigate the opinion of an ideal number of experts who had concerns about the effect of an instructional model on the pre-service teachers' ability to implement a Science-IK Curriculum and reinforcement of science learning through local culture. At least five (5) science curriculum developers, five (5) science educators, five (5) national science teachers, and five (5) Indigenous specialists were selected. All the experts' responses were analyzed numerically by calculating an average response in order to determine the degree of agreement between the groups. The results from each step in the process were returned to the experts to collect their revised individual opinions. There were two rounds of the questionnaire and both consisted of a list of Likert-scale items. First round, each expert was to indicate his/her level of agreement with the statement by choosing from four options: strongly agree, agree, disagree, and strongly disagree. Once returned, descriptive statistics for the group ratings were calculated for the median and interquartile range. Second round, the ratings of research statements and rankings of major research categories by the group in the first round were compiled. Participants in this round again ranked the major research categories as they did in the first round. However, this time, information about how the group responded was provided. Participant experts were asked to review each item, consider the group response and then re-rate the items by considering the information.

Stage III: Designing learning activity for Indigenous science instructional model

Data from documentary study and surveys were analyzed. The theories of science curriculum development were studied. Then the researcher explored the theories of lesson plan construction based on an argumentation model approach. The lesson plans were designed by the use of the Revised National Curriculum Statement, paying special attention to Learning Outcome 3: Science, Society and the Environment.

Stage IV: Implementing the Indigenous science instructional model

The SIK Project generated the diagram below to illustrate the trajectory. The pedagogical schema for enacting a dialogical argumentation-based discourse (as shown in Figure 3.1 below) is a descriptive model arising out of the series of workshops and has been piloted successfully based on empirical evidence (e.g. Ogunniyi, 2007a & b). The result of the pedagogical schema was the attainment of some level of cognitive synchronization on the part of the participating pre-service teachers based on convincing evidence and warrants.

During the six-month workshops, the 16 pre-service teachers were group into four randomized groups. Each group was asked to choose a group leader who would present the outcomes of their discursive arguments on the various tasks to the whole class. It is worth noting that each session must choose another leader and rotate their individual roles such as reader of the worksheets containing the instructions, recorder, and manipulator of apparatuses or materials. For the sake of space limitation more details of the procedures followed in the study have already been published elsewhere and would not be repeated here (e.g. Ogunniyi, 2004, 2007a & b; Simasiku & Ogunniyi, 2012).

The pre-service teachers were confronted with tasks to brainstorm individually, in pairs and in smaller groups and design a lesson and then present to the whole class group. The Argumentation-Based Activities (ABA) practical guide was used in the training of the science pre-service teachers in an ongoing research project based at UWC, Cape Town. The training and reinforcement lasted over a 12 weeks period during the last semester of 2010 and first semester of 2011 (August-October 2010 and July-September 2011). The sessions took place as an integral component of the "practice teaching" of Teaching for Science Module offered during the third and fourth year of the four-year BED training program.

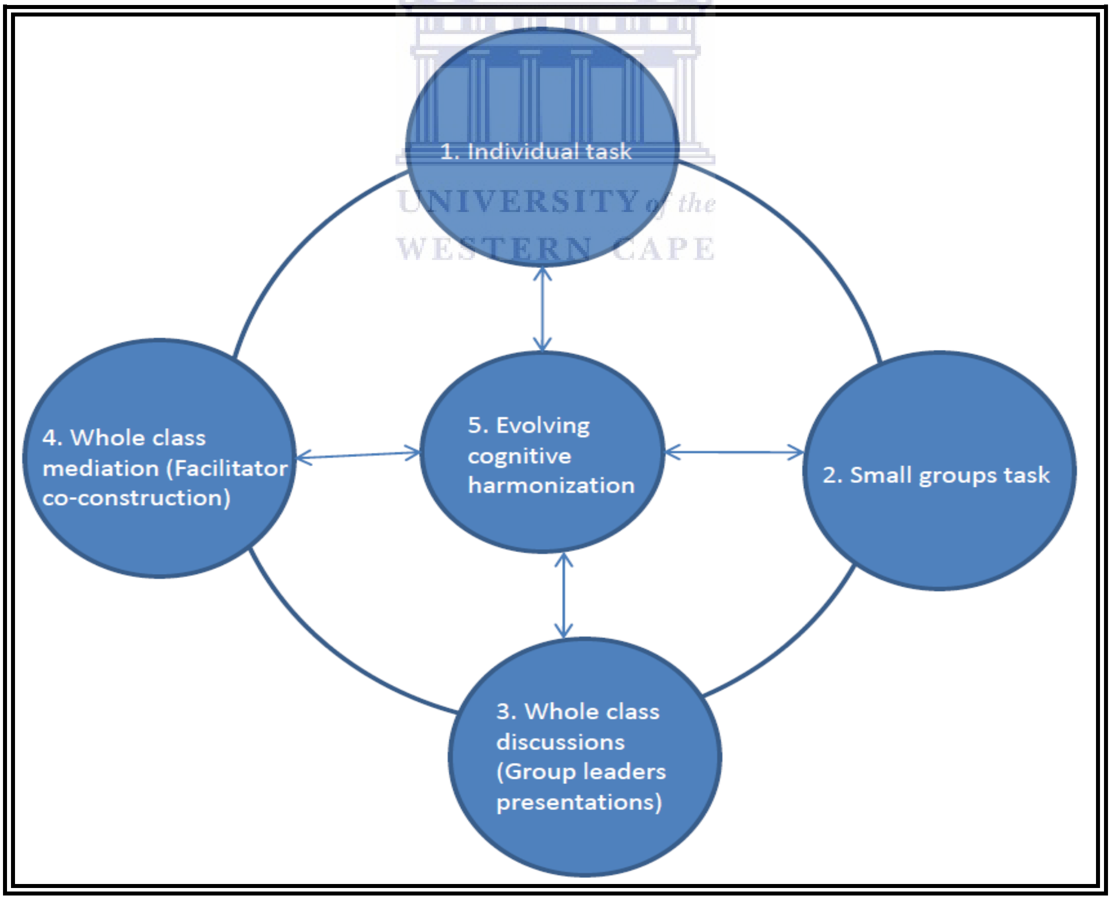

Figure 3.1 A Pedagogical Scheme for Implementing Dialogical Argumentation Instruction
Source: Ogunniyi, MB. (2009). Second National SIKP Workshop, Cape Town

The degree course required the pre-service teachers to plan, revise and teach a minimum of ten science lessons during their field practice of which two should be assessed externally for promotion.

For the purposes of the present study, the pre-service teachers planned and implemented at least two out of the five lessons as an argument lesson derived from the ABA practical guide making four argumentation lessons out of ten lessons. Each training session included a 90-minutes workshop based on the SIK workshop agenda where teacher training included some recommendations for encouraging learners' use of evidence or grounds to support their claims, counter-claims or rebuttals as well as the video exemplars of good practice illustrated in the SIK video (Siseho & Ogunniyi, 2010). The pre-service teachers were further familiarized with Toulmin's Argument Pattern, (TAP) of 1958 (Toulmin, 2003) which is subsequently used to identify the structure of arguments manifested throughout each lesson.

Subsequent to the preparation sessions, the pre-service teachers were given one week to organize an argumentation lesson around a science topic that would agree with the regular school curriculum, in this case following the Curriculum and Assessment Policy Statement for Natural Sciences (CAPS). During the planning phase, the pre-service teachers were expected to use the feedback and suggestions from their lecturer to come up with a lesson plan that used major components of an argumentation lesson.

Table 3.1: Levels of TAP's arguments in classroom discourse

Quality	Characteristics of an argumentation discourse
Level 0	Non-oppositional
Level 1	Argument involves a simple claim versus counterclaim with no grounds or rebuttals.
Level 2	Argument involves claims or counterclaims with grounds but no rebuttals.
Level 3	Argument involves claims or counterclaims with grounds but only a single rebuttal challenging the claim.
Level 4	Argument involves multiple rebuttals challenging the claim but no rebuttal challenging the grounds (data, warrants and backing) supporting the claim.
Level 5	Argument involves multiple rebuttals and at least one rebuttal challenging the grounds
Level 6	Argument involves multiple rebuttals challenging the claim and/or grounds.

Modified after Erduran, Simon & Osborne (2004)

During the three weeks that followed the planning phase, the pre-service teachers implemented their lesson plans in actual classrooms. The next one hour was used for group presentation followed by the whole class discussion and summary. The last 30 minutes of the three-hour block was used to identify the levels of arguments used by the pre-service teachers. To reinforce their argumentation skills the pre-service teachers were then given some assignment for the next workshop. All the ABA sessions were recorded using both audio-video-tapes. The transcribed materials were then analysed in terms of the modified TAP's levels of argument (Table 3.1) as suggested by Simon, Erduran & Osborne (2006).

3.5 Data Collection

I made prior arrangements with the coordinator of the Bachelor of Education module and took a full semester teaching the module myself to the pre-service 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 pre-service 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 questionnaire forms and assignments were then handed to all the pre-service teachers. Different to 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 early 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. The data were collected using various instruments: classroom observation schedule, questionnaire, interviews, and documentary analytic scheme developed for the purpose. Below I will provide a detailed account of how each instrument was used to collect data.

Classroom Observation Schedule

Classroom observations started towards the middle of July 2010 during the soccer world cup festivities. Copies of a syllabus, teacher's guide and learner's book were printed by July 15, 2010. Teachers had about a week of preparations before classroom observations started. Instead of observing two lessons per day, sometimes I had six lessons per day in order to cover the work planned within the limited time. The pre-service teachers planned differently because they had different obligations that varied from one school to the other. Due to these factors, I observed varied numbers of lessons from the four pre-service teachers. Numbers of lesson observations ranged from four to six per day. The pre-service teachers' experiences while planning and teaching and what they displayed during teaching also availed data for this study. Hence, teacher's anxieties, queries, and seeking clarification for or demand for more information were all recorded and turned into field notes as encouraged by Emerson, Fretz, and Shaw (1995).

Participant Observation

In this study, I engaged in more of a naturalistic observation to open possibilities of describing the experience without limitations. The pre-service teachers were free to ask me what they felt did not make sense as they taught. All of the pre-service teachers were told that their insights, struggles and successes were part of the lessons I wanted to learn from the study. As a result, they did not shy away from expressing their experiences and needs. After all, they knew my background as a science teacher educator from their institution. Hence, I participated as an unconcealed participant observer (Fraenkel & Wallen, 2006). I tried hard to suppress the power of my past position as a teacher educator by telling them to do whatever they felt comfortable to do because I was not interested in ideal practices but what they naturally felt comfortable to do. I participated in thinking through some of their problems in planning and teaching whenever they asked for help but also just observed at other times. Hence, I would say I took on the role of a moderate participant observer, whereby I participated only when called upon.

Classroom Observation Procedures

Since I was an unaccompanied researcher, my capacity to collect as much information as possible was facilitated by video recording. Besides video recording, I jotted down notes of key events and these were processed as prototype notes from the lessons. Notes jotted in the classroom and replays of videos turned into lesson vignettes. There were many reflections on each day's observations, written by the end of the class or day. My classroom jottings focused on lesson organization and the flow of ideas between the teacher and learners pertaining to Indigenous knowledge. I was also interested in the assessment of learners and how the pre-service teachers focused on helping learners to acquire knowledge and skills as demanded by the curriculum documents.

To understand what transpired in the classrooms, I checked the pre-service teachers' lesson plans to see why they taught in particular ways. However, it was hard to have their lessons checked every day because sometimes they came in class late and went straight into teaching when time was against them. However, at the end of each lesson, there was a chance to share notes. Learners' responses shaped the classroom dynamics and interesting data about

Indigenous knowledge emerged when learners participated in classroom activities. Learners' participation and the nature of participation also availed valuable data in this study. To keep track of the pre-service teachers' experiences and lessons, each teacher developed a folder in which they wrote the schemes of work and lesson plans. The pre-service teachers were also asked to keep their teaching experiences in that folder. At the end, the profiles were collected as part of data.

Interviews

Beside careful observation, watching, and listening, interviews are a powerful tool for obtaining qualitative research data (McMillan, 2004). Interviews, according to McMillan (2004), are a "more intrusive form of data collection procedure" that involves "asking participants questions, and recording answers." This strategy is very essential to gather data from participants and also on issues that may not be directly observed. In this study, interviews took two forms. First, informal questions posed after the class and secondly, formal semi-structured interviews conducted at the end of the study. To help answer the three main questions in this study, ten questions were used in the interview protocol. I started with seven questions at the beginning of the study but added three more questions in order to learn more from the classroom experiences as shown in (Appendix B). Interviews formed a very rich source of data that confirmed or disconfirmed my speculations during classroom observations.

The pre-service teachers were informed about interviews through a memo and were asked to choose a convenient date for the interviews. However, as in any real world, plans do not always work. One of the pre-service teachers had a funeral, and so I only managed to have a delayed interview with her at a later stage when I had long completed with the others. It was amazing that it worked. All interviews were conducted in quiet places to avoid distortions of recordings and disruptions of the interview process. A digital recorder was used for audio recording, as was the case in 2010 when this study began probing issues of Indigenous knowledge practices relevant to science in South Africa and also the arrival of the CAPS draft document for inputs. Prior to the date of interviews, the pre-service teachers read the questions that were sent together with the notification memo for the interview. The pre-service teachers were also told to ask for clarification if they did not understand the questions, especially those used for probing issues. 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 (1) Teachers' conceptualization of IK (2) Teachers' interpretation of IK and (3) Teachers' implementation of IK.

Science-IK questionnaire

The Science-IK questionnaire presented a brief scenario around six natural phenomena in the new science curriculum that were familiar to both the pre-service teachers and learners. The pre-service teachers were expected to provide explanations for their responses as well as indicate the sources (e.g. science books, media, formal instruction, family, religion and culture) which informed their worldviews about the phenomena in question.

Implementation Phase

The implementation phase is the real, concrete situation where the pre-service teacher is engaged in the real classroom. This phase is usually developed from concepts, ideas and planning obtained during the theoretical phase (Vithal, 2000). The knowledge gained during the theoretical phase is usually exposed and challenged by the real classroom encounters (Ndlalane, 2006). Some aspects of the actual situation are the science pre-service teachers, the learners, the curriculum, the pedagogy, and lesson plans. However, it is not as simple as it seems because in the actual classroom situation, the pre-service teachers are very often required to think on their feet and to constantly adjust their approach to ensure learning progression for their learners. There is often a failure to recognise and acknowledge these day-to-day realities of the classroom, 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 IK in science teaching?

In this phase of the research, my intention was to observe how the interpretation and implementation of the RNCS and NCS policies pertaining to IK played out in the science classroom. In the interest of collecting as objective data as is possible, it is imperative 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 IK in science lessons that I observed.

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

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 the pre-service teachers deploy in IK science teaching.

According to 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 maybe deduced that in essence reflection-on-action in the classroom might mean conducting a post-mortem on lesson plans, teaching strategies, and approaches.

This form of reflection involved the pre-service teachers in careful thought followed by speaking about the details of their classroom practices (Rosenberg, 2004). The pre-service teachers were required to reflect on all the instruments and processes used in the theoretical phase (questionnaires and microteaching lessons) and the actual phase (video recording of the lesson and peer-teaching activities). This type of introspection afforded the pre-service 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 the pre-service teachers to develop reflective competence. Considering 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 collection was informed by Wiersma's (1986) view that, most things cannot be entirely apparent during observation. I decided to revisit the pre-service teachers to get them to reflect on aspects that emerged from the theoretical phase, namely, the questionnaires and tasks 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 playback, the video-recordings of the lessons were viewed together with the pre-service teachers at the university when they are back from schools for the purposes of a reflective interview. This was done by the pre-service teachers reflecting mainly on the video recording of the classroom observation. The pre-service teachers were asked to also reflect on the questionnaire forms, the assignments and interviews. The reflective interview schedule (Appendix 3) was designed to provide answers to all three critical questions of the research. The questions posed in the interviews encouraged the pre-service teacher participants to discuss some of their observations on IK 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 to enhance the emancipation and empowerment of the pre-service teachers. Critical constructivism was therefore an important perspective that underpinned the reflective interviews. The reflective interviews were taped and transcribed. The transcripts were sent back to the interviewees to maximize the validity of interviews as a data collection tool 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 pre-service teachers and self. This relationship was set up at the first meeting and sustained throughout the study. The table below summarises the three phases of the research and the instruments used for data collection during each stage. Although the data collection was categorised in phases, these categories are not exclusive and there is some degree of overlap. For example, in the reflective phase the pre-service teachers also commented on data produced in the theoretical and implementation phases. Below in Table 3.2 is the summary of phases of data collection.

Table 3.2: Summary of Phases of Data Collection

First Phase: Theoretical	**Second Phase: Actual**	**Third Phase: Reflective**
As a university student	**As a pre-service teacher**	**As a pre-service teacher**
✓ Questionnaire	✓ Classroom observation	✓ Questionnaire
✓ Focus group interviews	✓ Video recordings	✓ Focus group interviews
✓ Assignment		✓ Assignment
✓ Video recordings		✓ Video recordings

3.6 Instrumentation

Science-IK questionnaire

The preliminary draft of Science-IK questionnaire consisting of 20 items and a few sub-sections was meticulously examined during a four-day national IK conference by a panel consisting of 6 science teacher educators and 12 experienced science teachers. Based on their and suggestions made in terms of clarity of the items, simplicity of the language, and the ease with which it can be completed within the shortest time possible within a normal primary or secondary school classroom, the final draft questionnaire was further revised. The final draft consisted only seven items each with two subdivisions namely, the scientific and personal worldviews. The term "personal" as used in the study refers to views gained through individual effort or interactions with one's socio-cultural environment. These six items constituting the final draft of the questionnaire were those that fell between 3 and 5 within a Likert scale of 1-5 (i.e., from a very poor item =1 to an excellent item = 5) as judged by the panel. The average two pair-wise correlation based on four randomly selected rankings stood at 0.95 and 0.98 respectively using a modified Spearman Rank Difference formula, thus showing a strong face, content and construct validity (Ogunniyi, 1992) and indirectly, the reliability or more appropriately, the dependability (Lincoln & Guba, 1985) of the questionnaire. The Science-IK questionnaire was later administered to 16 pre-service science teachers undertaking under-graduate studies in university of the Western Cape in South Africa.

Interviews and Classroom Observation Schedules

In addition to the data collected through the Science-IK questionnaire the pre-service teachers were interviewed and observed in their classrooms. This triangulation method was used to obtain a valid and comprehensive picture of the effectiveness or otherwise of the Argumentation Instruction Model (AIM). The development of the focus group interviews and observation schedules used in the study went through a series of revisions based on critical comments of the same panel of experts that helped to validate the Science-IK questionnaire during the SIKP national conference in 2009. The final versions of the instruments (Appendix A) were used to collect a substantial part of the qualitative data. Each session of the interviews ranged between two-three hours depending on the availability of time on the part of the interviewees as these pre-service were busy with teaching practice and preparations for lessons after each school day.

The observational data as well as individual and focus group interviews were video- and audio-taped as well as supplemented with field notes. The recorded interviews were transcribed and codes were used for each subject to maintain anonymity. The verbatim transcriptions were later discussed with each subject to validate the accuracy of the recorded data. The data were then analyzed qualitatively using open coding and the generation of categories using the constant comparative methods (e.g. Strauss & Corbin 1990; Patton, 1987). First, the ideas related to the topic being investigated were identified and then grouped into similar categories under the headings of opportunities and challenges. Although several pre-service were interviewed and observed, space limitation would not allow for a detailed description of the outcomes for all 16 of them. Since IK involve both empirical and metaphysical issues only topics amenable to observable phenomena were explored in the study. But as underscored in the ABA course, the purpose was neither to indoctrinate them nor to censure their alternative worldviews. In other words, the pre-service teachers were free to support their claims with empirical as well as metaphysical grounds they deemed fit for a given context.

Triangulation

Guba and Lincoln (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 discussed attempts of making data for the case studies as rich and trustworthy as possible. Creswell 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.

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 questionnaire 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 would converge on a single proposition (Massey 2004:2). Triangulation also helped on the pre-service teachers' correct understandings of IK by approaching it from several methods.

While the results of the research were applicable to the sample of Bachelor of Education Honours the pre-service teachers, they might be more credible because they were representative of the pre-service teachers from culturally diverse backgrounds and from three of the four historically different types of schools in South Africa. Another concern for the study was the numerous debates and questions about the status of IK, some of which have been discussed in chapter 2 and do not need to be repeated here. Despite this, a concerted effort was made to see to it that the data collected were meaningful enough to add more insight to studies in the area.

3.7 Data Analysis

The *first level* of data analysis, which was presented in this chapter, was done in distinct phases. The questionnaires and focus group interviews addressed primarily the first and second critical questions: namely, (1) what the pre-service teachers said informed the way in which they conceptualized IK and how they interpreted IK and (2) how they thought they would implement IK in the science classroom. In the first part of this chapter, the pre-service teachers' sources of IK were examined by analysis of the questionnaires. The questionnaires data set was supplemented by data from the focus group interviews to provide deeper insights into how the pre-service teachers were thinking about IK and to further illuminate their ideas and meanings.

Document Analysis

I began scrutinizing the amended National Curriculum Statement Grades R - 12: Curriculum and Assessment Policy Statement (CAPS, January 2011) which replaces the National Curriculum Statement Grades R - 9 (2002) and the National Curriculum Statement Grades 10 - 12 (2004). The three documents were analyzed for details of content labelled as Indigenous, and a comparison of details between regular and Indigenous science topics. In my daily journal, I inserted my own comments and made some notes in my research log of each curriculum document that circulated to the pre-service teachers. These notes proved useful during my classroom observations. I was enthusiastic to see how teachers were dealing with a curriculum that was less explicit about scientific facts and how well the Indigenous knowledge was used to teach science.

My reactions to, and analysis of the documents increased as I saw the pre-service teachers struggling while attempting to explore their learners' understanding nutrition and associated Indigenous beliefs and practices. I also picked out "food taboos and beliefs" as a topic of interest, not because the curriculum has labelled it as Indigenous, but because I thought the topic dealt with issues emanating from Indigenous ways of knowing among the 'Coloured' s community known for their ingenuity in cuisines in the catering industry. Hence, instead of only covering Indigenous foods, which clearly bear connections with Indigenous knowledge, I also decided to see how teachers were handling food taboos, especially at a point when Indigenous knowledge they started to recognize what Indigenous knowledge depicted in the new curriculum was all about.

In the second section of this chapter the two assignment tasks they developed for the teacher education programme were analyzed by using a TAP and CAT framework model of Toulmin (1958/2003) and Ogunniyi (1997) respectively to extend the analysis on how the pre-service teachers were thinking about and planning for implementation of IK using argumentation instructional model. As indicated earlier, my study was located in the interpretive paradigm. It used case studies, which was supported by the qualitative methodology. I explained further in the chapter when dealing with case studies. In this study, narratives were used as supplementary data to support the arguments in the study. This section began by examining why the interpretive paradigm was most appropriate for my study.

Analysis of Assignments

In consideration that merely asking the pre-service teachers how they interpreted IK in the RNCS, NCS and CAPS documents might not yield substantial data, I decided to use tasks one and two of the assignments for this information. The assignments required the pre-service 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 pre-service teachers' sources of IK, their interpretations and understandings of IK. My choice is supported by Tellis's (1997) opinion that documents are also useful in making inferences about events (interpretation of IK for the classroom).

The tasks developed during the preliminary theoretical phase fitted my study since the pre-service teachers developed lesson plans to include IK in science lessons. Assignments included Indigenous technologies, Indigenous myths and beliefs. The pre-service teachers were requested to design two lessons in which they integrated IK, one lesson using an Indigenous expertise and the second lesson using a belief or myth. The pre-service teachers were expected to select a topic on nutrition (local foods) from any one of the Life Sciences or Natural Sciences curricula. In the first task, they had to explain how they would use examples of Indigenous equipment in the lesson.

In the second task, the pre-service 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 F). The lecturer provided a framework for the lesson plan. Analyses of these assignments would provide data on how the pre-service teachers interpreted and planned to teach IK in the classroom.

My decision to analyse the data from an interpretive perspective was 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 mirror image-in-action and mirror image-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 Five Step Model was framed on constructivist thinking it could be argued that the model in seeking to bring perspectives and experiences from different contexts into critical reflective dialogue embraced a critical perspective.

3.8 Interviews

The four group leaders were very enthusiastic and volunteered to participate in the interviews. These four pre-service teachers used pseudonyms: Franco, Stein, Zukiswa and Shani were then interviewed face-to-face during the theoretical 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 to be 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 main purpose of this interview was to solicit the views, experiences and practices of the pre-service teachers regarding IK. A further purpose was to gather in-depth responses to the issues raised in the pre-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 featured in the interview process, wherein I attempted to determine whether the science pre-service teachers 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 IK
- Thoughts/feelings/experiences about IK teaching (Appendix 2)

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

Classroom Observation

Classroom observations characterised the implementation 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. In order 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 the pre-service teachers interpret and implement IK in the classroom and why they interpret and implement it in the way they do. Participants Stein, Shani and Franco were observed thrice. However, with Zukiswa only two lessons 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 Shani and Franco taught three lessons each, I chose the ones most related to IK.

Although only one lesson was chosen for the analysis, each lesson was probed deeply and analysed intensively through playback of the video recording of the lesson with the teacher. The purpose of the stimuli-recall was to seek deeper insights into the pre-service teachers' perceptions and practices and for them 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 pre-service teachers the advantage of hindsight and allowed them to share their thoughts and feelings that occurred during the lessons. This reflective phase allowed the pre-service teachers thinking about events, knowledge and methods of the actual phase (DOE, 2002a: 48) in order to analyse them.

3.9 Ethical Consideration

To ensure that other ethical considerations were accommodated throughout my research, I have undertaken to maintain the anonymity of the pre-service teachers and schools involved through using pseudonyms. The following considerations were taken into account to address ethical concerns in this research (Cohen, Manion & 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.

A substantial consideration was given to ethical issues in conducting this study. As defined by May (1997), the word 'ethics' suggests that a set of standards by which a particular group or community decides to regulate its behaviour to distinguish what is legitimate or acceptable in the pursuit of an aim from what is not. This awareness helped me to know how to go about collecting the data for the study. I assured all the participants that there would not be in any way illegitimate use of research findings.

The data collected for this study have not been of a highly sensitive nature, politically, socially, or physically. Regardless of this, it has been of utmost importance for me to maintain an ethical approach to the research process. The most important ethical issues for this study are related to the participants, namely the pre-service teachers, their learners and the schools in which the research was conducted (Brickhouse, 1991). I have highly valued the interactions I had with the participants and the ethical approach that guided this study is outlined below as a set of codes (Punch, 1994).

Institutional Senate Research Committee

This thesis formed part of the larger research study called Science Indigenous Knowledge System Project (SIKP) by the School of Science and Mathematics Education registered by the university. This research project on integrating Indigenous knowledge and school science in South African schools utilising argumentation as a vehicle has been running since 2004. The team leader for that study was Professor Ogunniyi while since its inception I participated first as a student (guinea pig), later as a research assistant, and finally as a novice researcher. That study revealed very little or non-existence of Indigenous knowledge content in science curriculum. The current study came up after the revision of the C2005 that sought to include Indigenous knowledge through amenable instructional practices. Hence, this study attempted to investigate the effects of an argumentation instructional model on the pre-service teachers' abilities to implement the Science-IK curriculum. Given that this was in a similar field and context, the previous OBE was reviewed to continue gathering extra data on ways and means to integrate Indigenous knowledge in science curriculum in South Africa. It is against this background that the Senate Research Committee of the university approved the methodology and ethics of my research project exclusively under my name confirming it as a separate research project (Appendix D).

Confidentiality

Confidentiality was considered important to this study because the participating pre-service teachers' professional status could be at risk if any disclosure was made about their teaching and learning classrooms atmosphere. Confidentiality is something that cannot be ensured because the nature of the descriptive reporting process means that if someone wanted to identify a participant, it is highly possible (Punch, 1994). Regardless of this, I embraced the code of confidentiality so that the pre-service teachers, learners, and participating schools in the research were not immediately identifiable to people who might read any documents pertaining to the study. For example, names that could identify participants were altered or removed to enhance confidentiality. The raw data were kept in a filing cabinet and only my supervisor and me as the researcher had access to it. These strategies helped to protect the privacy of the participants and prevent any bias on the part of the reader/reviewers should they know the teachers, learners or participating schools.

Within the information sheet, I had mentioned that I would keep respondents' answers confidential. Confidentiality meant that I knew who the participants were, but that their identity would not be revealed in any way in the resulting report. The goal of my research project was to facilitate learning and seek understanding how it influenced practice. However, in undertaking my research, I was frequently required to seek information from individuals who were part of the educational process. As the result I was obliged to ensure that no harm occurred to those voluntary participants and that all participants have made the decision to assist me with full information as to what is required and what, if any, potential negative consequences may arise from such participation. Those who choose not to participate were also be given the same information on which to make their decision not to be involved.

Throughout the interviews, the pre-service teachers were informed about confidentiality issues, and were asked to choose and use fictitious names. A few of them were naïve to confidentiality issues, such that they did not worry about their names being reflected as usual. Nonetheless, I informed them that it was important to shield them from exposés that research findings could bear on them. Three of the pre-service teachers gave me their preferred false names. The other pre-service teacher did not mind but all the same, she bears a pseudonym in this thesis and none of the participant can be immediately indentified.

Informed Consent

In some form of research, deception has been justified in that the value of the results of the research outweighs the harm it may cause the participants (Guba & Lincoln, 1989; Punch, 1994). In this study, this has not been the case and a code of informed consent has guided the involvement of the pre-service teachers and schools in the research. The pre-service teachers were invited to participate in the research by me and were fully informed about the nature of the research. Although the direction that a research study would take might not always be entirely predictable, this makes informing the participant about the exact nature of the research questions difficult (Brickhouse, 1991). Despite this, participants were informed as accurately as possible about the purpose of the data collection at that particular time. I maintained a friendly and collegial relationship with the teachers and explained the overall benefit of the study to them. This made them to be enthusiastic in participating in the study.

In order to maintain a code of consent, it was important that the pre-service teachers were able to negotiate with me the extent to which I became involved in the research. These negotiations were upheld throughout the research so that the pre-service teachers could maintain control of the research process within the classroom.

In this study, I elected to audio record or videotape the specific intervention. This was done to ensure that no verbal information is missed in a focus group interview. Alternatively, I also attempted to capture nonverbal information, such as body language. Ethical issues associated with taping of participants were reinforced here as well. When taping participants, I clearly stated in the information sheet and consent form (Appendix E) that I would be doing so. I allowed participants to have some access to edit the tape, and as with all activities, allow participants to withdraw, even during the taping process. I told participants what would happen to the taped material after it has been analysed, and in some cases, it was worthwhile to offer the tape to the participant. In my own case, the tapes were erased after the data has been transcribed. I therefore obtained consent from participants when taping activities. Though participants could withdraw at any time, this still provided some evidence that participants initially agreed to participate.

3.10 Summary

The research methodology described 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 collection was done in three phases, the first phase, which is the theoretical, second phase is the implementation and the third phase, which is the reflective phase. Data collection employed teachers' questionnaires, classroom lesson observation, face-to-face and focus group interviews in the theoretical and actual classroom observation and reflective interviews in the reflective phase. In this chapter, I have explained the theory used to support the research design of this study. Various dimensions encountered during the study influenced the methodologies, for example, during the course of the research, the sampling technique was amended. In addition, after initial analysis of the data I recognized a need to go back into the field for further data collection. This had to be done at the beginning of 2011 because the participants were involved in school examinations in October and November 2010. This could have resulted in some loss of continuity on the part of teachers. Reflective interviews were therefore used to prompt recall.

Since I felt that by simply asking the pre-service 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 the pre-service 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 IK. My decision is supported by Tellis's (1997) opinion that documents are also useful in making inferences about events. The assignments developed during the initial imagined/hypothetical phase fitted my study since the pre-service teachers developed lesson plans to include IK in science lessons. Assignments included both Indigenous myths and beliefs. The pre-service teachers were requested to design two lessons in which they integrated IK, one lesson using an Indigenous foods and the second lesson using a belief or myth. The pre-service 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 pre-service 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 F). In summary here below (Figure 3.2) is research process flow chart taken for this study.

Figure 3.2 Research Process Flow Chart

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Introduction

This chapter described the stages of data presentation, analysis and discussion. The first, second and third aspects of data analysis deal respectively with the theoretical, implementation and reflective phases. The theoretical aspect of the findings was construed in the study as the unknown data that I was interested in gathering from the pre-service teachers. The implementation data dealt with what emerged from the instructional intervention and the reflective aspect was concerned with making sense of what emerged from the study (Vithal, 2000). The central concern of the study was to determine the effect of an Argumentation Instructional Model on the 16 pre-service teachers' ability to implement a science-IK curriculum in a classroom context. As indicated in chapter 3 the quantitative analysis focused as much as possible on all the pre-service teachers or as many of them were willing to express their viewpoints on any issue. However, to permit a detailed account the qualitative analysis focused mainly on the experiences of only a few willing pre-service teachers or vignettes. For ease of reference, the findings were analyzed using the four research questions as subheadings.

4.2. RQ 1: What conceptions of the Science-IK curriculum did the pre-service teachers hold before and after being exposed to an argumentation instructional model?

Determining the sources of the pre-service teachers' Indigenous knowledge was essential for two reasons. The pre-service teachers' sources might have informed the way they modelled the implementation of a science-IK curriculum in the classroom. It emerged from their responses that the sources listed in the questionnaire were well chosen, since for most of the sources of IK listed in the instrument they ticked "Agree" in comparison with "Disagree." In addition, for ease of reference, related sources of IK were combined. Thus, the original ten sources of IK depicted in the questionnaire were combined into only five namely: B.Ed Science for Teaching Module 112; Family and Relatives; RNCS/NCS/CAPS; Traditional Healers and Media/books. Table 4.1 and Figure 4.1 indicate the combined strong agreement-agreement or strong disagreement-disagreement response choices for each source of IK. Figure 4.2 indicates the separate response choices for each source of IK. As shown in Table 4.1 there was a noticeable tendency for the pre-service teachers to indicate similar agreement and disagreement patterns for their sources of IK.

Table 4.1 Pre-Service Science Teachers' Sources of Indigenous Knowledge

Sources of IK	Agree		Disagree	
	Count	%	Count	%
B.Ed Science for Teaching	15	94	1	6
Family and Relatives	15	94	1	6
RNCS/NCS/CAPS	11	69	5	31
Traditional Healers	13	81	3	19
Media and Books	14	88	2	13

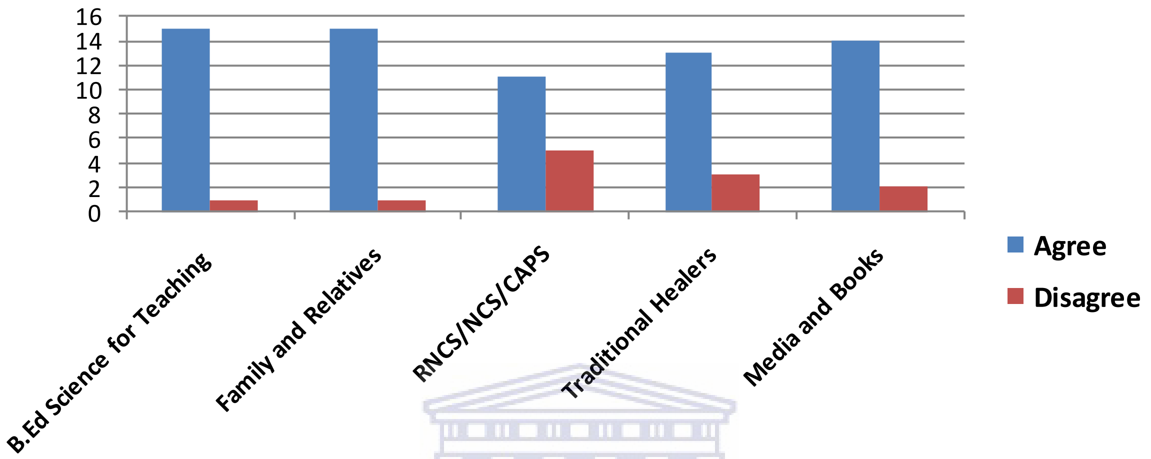

Figure 4.1: Pre-Service Teachers's Sources of Indigenous Knowledge

With the exception of RNCS/NCS/CAPS identified by 11 or 69% of the pre-service teachers as their source of IK 15, 13 and 14 respectively identified relatives and family and the science module, "Science for Teaching", traditional healers, and media and books respectively as their main sources of IK (Figure 4.1).

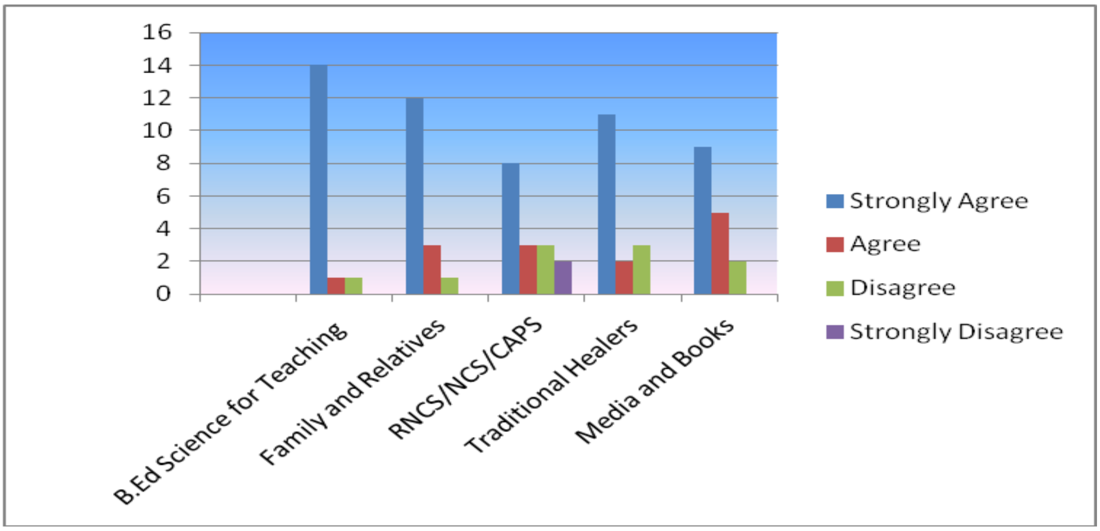

Figure 4.2: Pre-Service Teachers' Separate Response for each Sources of IK

Of the 16 pre-service teachers, all of the pre-service teachers in conformity with the new government policy were Blacks (i.e. formerly 'Coloured', Indians and Africans). However, it is worth noting that despite the new policy many governments' documents still required one to indicate the apartheid-based designations of people groups. In that sense 12 of the subjects were 'Coloured', two (2) were Indians and only one (1) was a Black male from the Xhosa ethnic group and another one (1) was a Black African from West Africa, seven (7) pre-service teachers were male and nine (9) were female. Amazingly, nearly all the pre-service teachers rated the Science for Teaching Module as an important resource, when one would imagine that they might have this information obtainable at home and in their communities.

Clearly, the pre-service teachers may have chosen the module because as part of a university course it is recognized as an institutional knowledge. Another basis could be that almost all the exemplars of IK used as the content of the Science for Teaching Module were examples from African IK and this module then became an important source of IK for them. A third motive connected to the choice of the university module being selected by most of the pre-service teachers could be that the questionnaire was administered on the last week of the coursework for the module. At that particular time, the pre-service teachers would have had a great deal of exposure to the argumentation-based instructional model, discussions and understandings of IK, which might have influenced their choice. The excerpts below are representative:

Franco: *"My understanding came from the Science for Teaching Module but it was something that we practiced in Eastern Cape..." (FK)*

Secondly, the pre-service teachers' supported their choices by alluding to their understandings and awareness of IK as they were growing up. The following comments are representative of the pre-service teachers' sources of IK:

Stein: *"My understanding built up from the university but I knew this while growing up" (SD)*
Zukiswa: *"The university module enlightened my idea of IK but I grew up having some of this ideas" (MZ)*
Shani: *"It came from the university. I had this knowledge but I did not know that it was called Indigenous knowledge systems" (SM)*

These pre-service teachers' comments could perhaps be their interpretation of the notion of "source" as being where the Indigenous knowledge originates. They chose the Science for Teaching Module as their source. With the exception of one pre-service teacher, all the pre-service teachers chose the Science for Teaching Module as an important source for their IK. It is worth noting that the pre-service teacher with a different view came from the Eastern Cape, a highly rural province of South Africa. This pre-service teacher seemed to have prioritized original oral sources of IK. There was an assumption that his sources of IK were important to him because their importance in the rural areas where he grew up before coming into the university in the Western part of the country.

Family and Relatives

Fifteen (93.8%) of the pre-service teachers also indicated that parents, grandparents and senior leaders in the community significantly informed their concepts of IK. However, a critical glance at the data exposed that the only pre-service teacher who indicated that families and relatives in the community had an inconsequential influence in informing her concept of IK was the ‘Coloured’ female who grew up in the United States. She is from a central metropolis area of Cape Town and schooled in an urban private ex-White school. Actually, her father is White but she preferred to classify herself as ‘Coloured’ on the demographic sheet. Her choice was probably influenced by cultural differences and her own ambivalence about how families live.

Semali and Kincheloe (1999) argue that in societies undergoing rapid changes, the extended family system normally give way to the urban style of nuclear families. Nuclear families are perceived as dominant of the White culture in the United States (Eagin & Kadushin, 2005) and this may not be very different for the White South African community. Semali and Kincheloe (1999) further argued 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 be the rationale for the pre-service teacher alluded to in the above paragraph. Her view was that families and relatives in her community played a small role in informing her concept of IK. However, speculating into what might have shaped her personal stance is certainly beyond the scope of the study.

Curriculum-RNCS/NCS/CAPS

Eleven pre-service teachers (68.8%) of the sample indicated that the Revised National Curriculum Statements (RNCS) document greatly informed their concepts of IK. Stein valued the RNCS as a source that linked to the formalising and legitimising of IK in the curriculum as articulated in the following statement:

***Stein**:* “*I am happy now we are having the awareness of what happened in the past and what is still happening in the present. Science is involved when you look at the RNCS.” (SD).*

While some of the pre-service teachers rated RNCS as a source greatly informing their concepts of IK, they gave conflicting statements in the interviews. For example,

Shani: *"RNCS assisted me with the effects of OBE, but not IK. I enquired from my associates and neighbourhood for cases of IK. There is none in RNCS" (SM).*

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

Zukiswa: *"Concerning the RNCS, I'm still perplexed. I cannot connect it (IK) clearly"*

A justification for this incongruity could be that during the real process of lesson preparation, the pre-service teachers noticed that the Revised National Curriculum Statement (RNCS) and National Curriculum Statement (NCS) documents were of little assistance for preparing IK science lessons. This may be connected to the RNCS and NCS being silent on strategies and exemplars of IK for lesson development, and to teachers' expectations of greater guidance. It emerged that the curriculum policy document as a source of IK is a limited source that might assist to engender awareness but is insufficient for the practical purposes of lesson development. Five of them (31%) indicated that the RNCS and NCS were of little help in developing their concept of IK. The five pre-service teachers comprised two males and three females. For instance, Franco who opted for "strongly disagree" option was consistent in his ranking as illustrated in the excerpt below:

Franco: *The NCS document provided very little guidance for the assignment.*

Largely, the report above specifies 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. National Curriculum Statements (NCS) as policy documents did 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 IK.

Traditional Healers

A high percentage (81%) of the pre-service teachers indicated that the practice of herbal remedies greatly informed the way in which they conceptualized IK. These pre-service teachers comprised four males and nine females. The excerpts below drawn from Table 4.1 and the item regular practice of herbal remedies and traditional healers in the questionnaire are representative of similar responses given by the pre-service teachers:

Shani: *In the Hindu culture, we use a special thing called munja (turmeric 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 do not have a fever (SD).*

Franco: *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 (FK).*

Thirteen of the pre-service teachers indicated that traditional healers were a very important source of IK for them. However, not all of the pre-service teachers regarded this as an important source. At least two of them considered traditional healers as a moderate to small source. It is surprising that the three pre-service teachers who disagreed and did not indicate traditional healers as a significant source, though traditional healers are a significant part of African culture, did change their stance during interviews. It emerged later that there were misconceptions on who is a traditional healer, traditional doctor and witchdoctor. From the above statements, it seems that herbal remedies are used universally across cultures but traditional healers belong to the African culture.

Media and Books

The questionnaire established that 14 of the pre-service teachers highly prioritised legends, myths, media and books as a source of their IK i.e. more than three quarters of the subjects. Interestingly, Zukiswa regarded textbooks as an important source as shown below:

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

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

Stein: *"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."*

While Zukiswa made use of available books, Stein contended that the books as reported in earlier studies (e.g. Naidoo, 2002; Ogunniyi, 2004, 2007a) were generally deficient of IK materials and instructional strategies for integrating it with science.

Paradigms of using the CAT to analyze pre-service teachers' scientific/IK-based beliefs

The CAT, rooted in the Contiguity Theory, is a learning theory traceable to the Platonic and Aristotelian era (Ogunniyi, 2007). As highlighted above, the TAP is apposite for probing scientific arguments only. It is weak when meting out matters involving both science and IK discourses dealing with IK-based beliefs or practices e.g. origin of the universe, traditional cosmologies, life and death, and psychosomatic illnesses. The Contiguity Argumentation Theory (CAT) deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IK (Ogunniyi, 2011a). It is in such a setting that the CAT becomes handy. The broad categories of explanations that emerged after a careful inspection of the data were: scientific, dualistic and the IK-based beliefs. The pre-service teachers' scientific explanation came largely from scientific books, while their dualistic explanations derived both scientific and personal beliefs from their religions, family or culture. The IK worldview category depicts explanations that place the religious worldview over above the scientific worldview (Webb, et, 2006).

For ease of reference, the broad categories used for analyzing the teachers' responses to SIK questionnaire are as follows:

- ***Science worldview**: The Science-IK worldview about the scenario was generally acceptable and pre-service teachers' personal belief coincided with either the scientific or IK worldview.*
- ***Dualistic:** The pre-service teacher is able to describe and/or explain a given phenomenon in scientific terms but expresses personal beliefs in IK-based (e.g. religious or cultural) terms or vice versa.*
- ***IK worldview:** The pre-service teacher dismisses the scientific explanation and explains the phenomenon in mystical terms.*

Item 1 of the CIKS questionnaire asserts that: **IT1: Origin of the Universe**

Many scientists believe that the universe occurred by chance, and since then has been undergoing continuous evolution. On the other hand, many people adhere to the religious or cultural view that a supernatural being created and controls the workings of the universe. Express your candid opinion on both worldviews (Scientific understanding {SU} and Personal Understanding {PU}).

Item 2 of the CIKS questionnaire asserts that: **IT2: Modern vs. Traditional Healing**

A girl suffering from severe hysteria (excessive or uncontrollable fear) could not be cured in a modern hospital but was cured within a week by a traditional healer. Express your honest opinion on both worldviews.

Item 4 of the CIKS questionnaire asserts that: **IT3: Occurrence of Rainbow**

Scientists describe the occurrence of the rainbow as a result of the refractive dispersion of sunlight. However, in many traditional beliefs, the rainbow is seen as a good or bad omen. What is your view about the ideas expressed above in terms of your scientific and personal understanding?

Item 7 of the CIKS questionnaire asserts that: **IT4: Conceptual ideas of IK**

What ideas of IK did you hold before and after being exposed to the Science for Teaching Module?

Table 4.2 Pre-conceptions of certain phenomena held by pre-service teachers

Phenomenon of Items	***Scientific Worldview***		***Dualistic***		***IK Worldview***	
	Count	%	Count	%	Count	%
IT1: Origin of the Universe	9	56	1	6	6	38
IT2: Modern vs. Traditional Healing	7	44	1	6	8	50
IT3: Occurrence of Rainbow	8	50	2	12	6	38
IT4: Conceptual ideas of IK	10	63	1	6	5	31
Overall Mean	8.5	53.3	1.5	7.5	6.3	39.3

N=16

Tables 4.2-4.4 provide the summaries of pre-service teachers' conceptions of certain phenomena before they were exposed to argumentation instruction. These pre-conceptions categorized their scientific and personal worldviews depicted in Tables 4.2-4.4.

Tables 4.2- 4.4 showed the pre-post worldviews held by pre-service teachers about certain phenomena and the sources for such worldviews. As in an earlier study by Ogunniyi, (2004) the salient observation made on the analysis of the pre-service teachers' responses to the selected phenomena was that they appeared to hold in an ascending order a pluralistic worldview namely, a dualistic, personal or IK-based and scientific worldview. At the pre-test more than half of the subjects (53%) drew upon their scientific belief about the selected phenomena, 39% on their IK-based beliefs and only 7.5% drew upon a dualistic worldview.

Table 4.3 Post-conceptions of certain phenomena held by pre-service teachers

Phenomenon of Items	***Scientific Worldview***		***Dualistic***		***IK Worldview***	
	Count	%	Count	%	Count	%
IT1: Origin of the Universe	15	94	15	94	15	94
IT2: Modern vs. Traditional Healing	14	88	13	81	14	88
IT3: Occurrence of Rainbow	15	94	15	94	15	94
IT4: Conceptual ideas of IK	10	63	14	88	10	63
Overall average	13.5	84.8	14.3	89.3	13.5	84.8

N=16

However, this pattern of belief changed dramatically after the intervention. At that stage 85% attributed their worldviews equally to their scientific and IK-based beliefs while 89% project a dualistic worldview of the same phenomena (Table 4.3).

Table 4.4 Percentages of pre-service teachers' pre-post conceptions of certain phenomena

Phenomenon of Items	***Scientific Worldview***		***Dualistic***		***IK Worldview***	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
IT1: Origin of the Universe	56%	94%	6%	94%	38%	94%
IT2: Modern vs. Traditional Healing	44%	88%	6%	81%	50%	88%
IT3: Occurrence of Rainbow	50%	94%	12%	94%	38%	94%
IT4: Conceptual ideas of IK	63%	63%	6%	88%	31%	63%
Overall average	53.3	84.8	7.5	89.3	39.3	84.8

N=16

Table 4.4 and Fig. 4.3 indicate the subjects' stances at both the pre- and post-test. This implies that while the pre-service teachers improved their scientific understanding of the phenomena considerably they also showed an increased IK-based understanding as well as dualistic understanding of the same phenomena. What can be inferred from these findings is that the subjects had begun to appreciate both the scientific and the IK-based beliefs of the phenomena in question most probably as a result of the argumentation instruction to which they had been expose. In terms of CAT the subjects must have made cognitive shifts entailing a shift from a dominant scientific stance and a suppressed IK-based stance to an emergent scientific-IK-based stance and finally an equipollent stance; thus corroborating earlier findings in the area (e.g. Diwu & Ogunniyi, 2012; Kwofie & Ogunniyi, 2011; Ogunniyi, 2004, 2007a & b, 2011; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008; Simasiku & Ogunniyi, 2011).

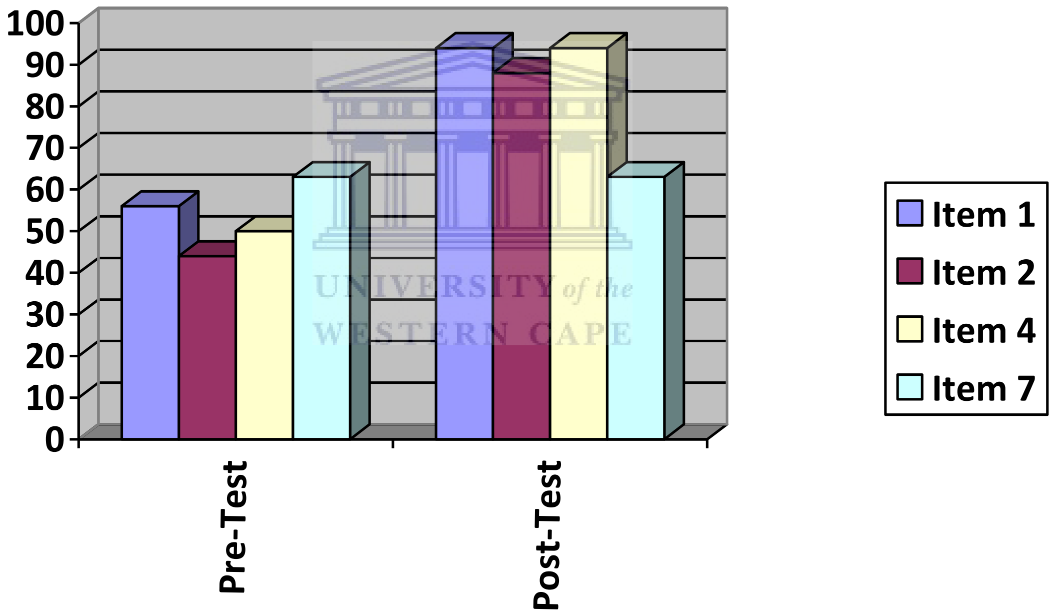

Figure 4.3 Pre-service teachers' pre- and post-test conceptions of certain phenomena

The excerpts below are representative of the sources that had influenced the pre-service teachers' worldview-conceptions of the selected phenomena depicted in Tables 4.2-4.4.

PT1 (SU): *Some scientists believe that the world came into being due to an explosion in the sky that is the Big Bang Theory.* **(Source: Institution)**

PT1 (PU): *Quran speaks of the Big Bang Theory but Allah causes and creates everything.* **(Source: Religious)**

PT2 (SU): *Our universe in 12 to 14 billion years ago was hot dense matter and there were few matters larger, which expended into much cooler cosmos we inhabit.* **(Source: Media)**

PT2 (PU): *The universe did not occur by chance but created by God, as we read in the Bible that nothing created itself but created by God.* **(Source: Religious)**

PT3 (SU): *True. Scientist believe that the universe developed overtime, light came and evolution took place.* **(Source: Books and Media)**

PT3 (PU): *God created everything. He said let there be light, he made man from dust and they produced.* **(Source: Books and Religious)**

PT5 (SU): *There was a massive surge of energy that expanded and scattered around the universe. Over time chemical reactions transformed matter into organic life forms,* **(Source: Books)**

PT5 (PU): *There is a historical trend which shows that civilized beings always believed in a 'higher spiritual being' from the Greeks and Romans to Egyptians and Christianity today…* **(Source: Culture and Religious)**

PT7 (SU): *In science we learn that there is a logical explanation for anything and everything that goes along with…molecules, compounds, matter, and all play a part in the evolution of the universe.* **(Source: Books and Media)**

PT7 (PU): *I believe that the universe was created by the Almighty…all the miraculous things that occur in the universe and all creations that go along with it could not just have happened by chance. If there are scientific explanations, I believe that even then…scientists came to those conclusions by the help of the Almighty.* **(Source: Religious)**

PT9 (SU): *10 billion years ago the world existed through years of raining and storms that's the oceans came about, the continents to plates movements.* **(Source: Books)**

PT9 (PU): *The world was created by a higher power God, Allah and everything in it.* ***(*Source: Religious)**

PT11 (SU): *The big bang theory that a big explosion occurred in the universe. The Earth was created after that and everything else evolved over the centuries.* **(Source: Media)**

PT11 (PU): *God created the Earth and all living things* ***(*Source: Religious)**

PT13 (SU): *It all began with God. He created the universe and all that are in it. I do not doubt any of the religious knowledge I was taught.* **(Source: Media)**

PT13 (PU): *I believe that the universe was created by a supernatural being (God) n that it is him that controls the working of the universe. If it all happened by chance how do scientists that believe so think they got their energy from and ability to reason the way they are. To me there is no doubt that God is alive.* **(Source: Religious)**

PT15 (PU): *It was created by something larger than itself since the first law of thermodynamics says that energy cannot be created; only changed. The universe had to be created by something outside itself, because of the same law. It was begun by chance (or accident); or the answer is not sure.* **(Source: Media)**

PT15 (PU): *The universe was created by the God***. (Source: Religious)**

In terms of the CAT, it is interesting to note that pre-service teachers' stances made cognitive shifts among all three worldview categories (scientific, dualistic and IK worldviews) and that these shifts were not unrelated to the context they found themselves. This corroborates CAT, which stresses that ideas tend to move in the minds of people as the context changes. This in itself as Gunstone and White (2000) have argued is neither good nor bad provided people know when a particular view is the most appropriate. According to Gunstone and White (2000), "The issue now appears to be not one of abandonment and replacement, but one of *addition*, so that the earlier belief and the scientific belief co-exist (p.298). An examination of Table 4.4 and Fig. 4.3 shows biggest shift to a dualistic view (6%-94%) which is an equipollent stance in terms of CAT. Based on the findings above it seemed that the pre-service teachers were more favourable disposed to accepting IK as a potentially legitimate aspect of a science curriculum and more able to distinguish between scientific or IK worldviews as well applying the appropriate context. There was a similarity at post-test stage in response to Item 1: Origin of the Universe and Item 3: Occurrence of Rainbow (94%). Pre-service teachers seemed to prefer a religious worldview to a scientific worldview with respect to the phenomena tested.

What one can conclude from Tables 4.2-4.4 is that the pre-service teachers in consonance with their religious environment were probably dealing with realities beyond the scope of school science. The reality of a dualistic worldview as in earlier studies done in non-Western traditional societies has again been confirmed (e.g. Ogunniyi, 1988, 2000; Ogunniyi et al, 1995; 2008).The implications of this for the teaching and learning of science certainly warrant a closer consideration for classroom practice. Whatever the view or approach adopted, there are sound arguments for raising the awareness of pre-service teachers about the existence of different worldviews, beliefs, and Indigenous knowledge systems in their classrooms Ogunniyi & Ogawa, 2008) . In order to do this meaningfully in the South African context, however, we need to know primarily the teachers' cosmological worldviews and sources for such worldviews.

4.3. RQ 2: How did the pre-service teachers use an Argumentation Instructional Model to enhance their ability to implement the Science-IK curriculum?

The goal of this question was to document the pre-service teachers' abilities and beliefs relative to practicing argumentation instruction as they participated in the methods course. They responded to set tasks both at the beginning and end of the semester (see Appendix A). My reflection on field experience served as the second source of data for my analysis.

Pre-Service Teachers' Perspectives on Argumentation

Pre-teaching Views

Preceding the university class intervention, the pre-service teachers replied to a series of questions (see Appendix A) that revealed some of their ideas relative to the place of argumentation in science. Only three (3) of the 16 pre-service teachers referred to argumentation in response to the question: "What in your view is argumentation science teaching" The quote below was one of these responses by PT1 (Pre-service Teacher 1):

> *"Science teaching is an attempt to investigate, understand, and explain natural phenomena. Although this can be done by a variety of methods, observation and collection of evidence is the primary method…The evidence is analyzed, discussed, and debated in order to draw the best, most accurate conclusions possible". (PT2)*

Similar responses to that of PT1 were given several other pre-service teachers. Many of them acknowledged the role of argumentation in science teaching before the topic emerged as a part of the class; only a few did not make this specific reference. Thirteen (13) discussed the significance of *data* and *evidence*, which are central to argumentation as the construct has been operationalized in this study. For example, the pre-service teacher 5 (PT5) stated:

> "*Science teaching generates explanations that are based on evidence: Science can be tested and observed*." (*PT5)*

Once provoked to reflect on the role of argumentation in science teaching, majority of the pre-service teachers (12) articulated notions similar to that expressed above by PT2. In other words, argumentation was a normal part of the scientific process. The following excerpt exemplifies this pattern:

> *"Argumentation helps generate phenomenon for study…helps widen the approaches to studying a phenomenon…invigorates the scrutiny of evidence and proposed explanations, and…helps push the field of endeavor outwards" (PT3).*

When solicited to go further and consider the place of argumentation in the context of science classrooms, the pre-service teachers cited several ideas, including debates reflecting the true character of science, promoting critical thinking, helping learners develop social skills, and connecting science to everyday lives. Not more than three individuals mentioned any of these themes. The only themes discussed by several of the pre-service teachers (more than 7) related to argumentation as a pedagogical tool for enhancing content understanding and personalized learning. These quotes exemplify these themes:

> *"Discussions and debates that take place in secondary school classrooms should happen as a means to help the learners better understand new concepts" (PT4)*

> *"Conversation can let them (secondary learners) be involved and see that science is not merely a set of facts and figures that they need to recite later" (PT5).*

In response to the question of what argumentation science teaching should look like in a best-case scenario, all the pre-service teachers mentioned learner centered approaches, including dialogue and hands-on activities. Only three (3) of the pre-service teachers suggested that dialogue was fundamental to an ideal science education. The quote below provides an example:

"Learners can work together as scientists and then present their findings to the teacher and other fellow learners. Constructive criticism and dialogue during the classroom activities facilitated by the teacher makes the science education classroom an interactive and engaging opportunity for learning". (PT7)

At the end of the semester, which corresponded with the conclusion of the pre-service teachers' teaching practice experience approximately 12 weeks (three month) long, the pre-service teachers responded to another set of questions. They were asked to reflect on how their ideas about science teaching had changed. Not surprisingly, most of the pre-service teachers focused on the practical issues with which they struggled throughout their practice teaching placements. They talked about classroom management, the difficulty of incorporating argumentation, how busy a teacher's day is, and the complexities of adolescent learners. However, as shown in the excerpt below, one of the pre-service teachers also alluded to value of dialogue in classroom discourse:

"I learnt during the semester the value of dialogue and conversations in the classroom. More often than not, some learners had helpful input on the topic that we were covering in class. Whether it was in the form of a story, question, or remark, the suggestions that they brought up usually helped contribute to the understanding of the subject matter (PT12).

In organizing the inquiry set, I did not anticipate many of the pre-service teachers to discuss argumentation with this general question, so I included a more targeted prompt: "How did you use (or not use) argumentation in your classroom(s)?" Of the 16 pre-service teachers, seven (7) reported having tried one or two lessons focused on argumentation. PT6 briefly describes her experience below:

"I did two activities…that really did a great job of bringing dialogue into the classroom. The first activity was based on cancer. I gave the learners some articles from two newspaper sources…I would say that argumentation *works really well with the right topics and give learners a chance to share their thoughts".* (*PT6)*

Four other pre-service teachers, represented by the excerpt below, reported a more systematic approach to incorporating argumentation:

"I prepared several lessons that were meant to encourage debate and argumentation. One lesson provided information and roles to guide learners in discussion about a variety of large-scale energy production methods…Another activity-involved genetic engineering in agriculture. (PT14)

Several other pre-service teachers also talked about how they had used lesson ideas seen in class from both their peers and me during the sample lesson presentations. Of the three pre-service teachers who reported not using argumentation, two suggested the prescribed content did not lend itself to this approach. At least one of these pre-service teachers, quoted below, came to this conclusion because he perceived argumentation from its conversational use as necessarily oppositional:

> *"I did not incorporate argumentation because I never saw an opportunity to fit it in. Most of the standards I covered were argument free" (PT11).*

PT11, a male pre-service teacher seemed to suggest that because something is not controversial, argumentation cannot be employed, a view that is consistent with most idiomatic accounts of the construct. This perspective ignores the fact that argumentation can involve evidence and claims, and does not necessarily have to be controversial. Another pre-service teacher did not try classroom argumentation because she felt that she did not have the time to develop African (Xhosa in particular) community characteristics necessary for productive argumentation. The final pre-service teacher reported that she felt unprepared to manage this approach:

> *"I do not feel very comfortable about trying something like that [argumentation], and I am not sure how to apply it to my content area [physics]" (PT12).*

Classroom Observations

As a part of their classroom experience, the pre-service teachers were asked to reflect on the nature of learner argumentation throughout their observations during peer teaching (the pre-service teachers were paired during teaching practice). Four of the 16 pre-service teachers chose not to complete this item of the assignment, so the data presented in this section were based on only 12 of the pre-service teachers. A majority of the pre-service teachers (8) reported that the pre-service teachers' argumentation instruction were virtually absent from the classrooms they were observing. The following typifies statements made by all of these pre-service teachers:

> *"There was no discussion in class at all except learners 'illegally' talking to each other and teacher telling them to be quiet" (PT10).*

This result is consistent with classroom surveys focused on the characterization of learner conversation. These studies suggest that teachers account for the overwhelming majority of classroom talk and that learners have few opportunities to engage in argumentation (Driver et al., 2000; Duschl & Osborne, 2002). The two pre-service teachers who did not cite the absence of learner dialogue provided some specific examples of argumentation in action. The quote below provides one such example:

> *"The class sessions dealing with cloning were interwoven with ethical questions. These questions were aimed to address certain aspects of cloning that could be morally/ethically*

unacceptable. During class, the learners were expected to voice their opinions-supported with evidence-about certain concepts of cloning". (PT9)

Despite the fact that most of the pre-service teachers did not observe much in the way of learner dialogue, several (7) discussed opportunities presented in the classrooms that would have been amenable to an argumentation approach. Six of the pre-service teachers, such as the individual quoted below, also discussed their own plans to weave argumentation into their curriculum.

"I would like to make discourse an essential part of my instruction and try to work it in at every opportunity…I would teach students about the format of arguments and allow them to evaluate several sources before asking them to take a position. (PT11)

The final data source providing insights relative to the pre-service teachers perspectives on argumentation were self-reflections based on the micro or mini-lessons that the pre-service teachers presented to their peers. It should be noted that these mini-lesson presentations were one of four such mini-lessons and reflection assignments. All of the mini-lessons were video recorded and the pre-service teachers were asked to analyze their teaching videos and write a reflection. Most of the pre-service teachers focused on the practical logistics of their teaching behaviors throughout their reflections. Common topics included the use (or nonuse) of wait time, patterns of nonverbal communication, nervous habits, learner interest, and other themes that we might expect the pre-service teachers to consider as they practice teaching. However, in some cases, these reflections provided an occasion to further understand the pre-service teachers' perspective on argumentation. Five of the pre-service teachers discussed how the experience focused their attention on key elements of classroom discourse. They mentioned such challenges as the importance of thought-provoking questions, how to best moderate learner discussions, and grouping strategies. The excerpt below provides an example:

"This style of teaching [argumentation] is very new and different for me. As I watched the video, I noticed that I seemed to hold back from the conversation and allow the learners to do more of the talking. I think this can be strength and a weakness at the same time". (PT10)

The reflections of some of the pre-service teachers also demonstrated changes in their perspectives toward argumentation. For instance, they indicated that the opportunity to present dialogical argumentation-based mini-lessons improved their confidence in using this teaching approach as well as prepared them for their future teaching career. PT12 expressed the following:

Before we began this exercise, I was not sure how or if I would ever use discourse and argumentation in my classroom, beyond having students defend their answers. However, I do like this lesson plan and may use it or ones similar to it in my teaching. (PT12)

The pre-service teacher offering this comment had created a hypothetical scenario related to an environmental problem and challenged her audience to assume the roles of various stakeholders. The pre-service teachers were then asked to interpret evidence through the lenses of their roles.

This study described the effect of the Argumentation Instructional Model on the pre-service teachers' abilities to implement the Science-IK Curriculum. It was not the case that argumentation became the exclusive focus of instruction in the study. Argumentation was one of several themes stressed as fundamental issues relevant to high-quality science education. The study also documented the pre-service teachers' perspectives on science-IK curriculum as well as how the pre-service teachers' argumentation skills were manifested as they experienced the course. Though some were rather cautions most of the pre-service teachers agreed with the premise central to the planning of this investigation that argumentation instruction played a fundamental role in the practice of science.

Two of the pre-service teachers indicated more systematic approaches to incorporating argumentation, which may support the view of argumentation as an educational goal in its own right as opposed to a means to another educational end. These two pre-service teachers were exceptions more closely aligned with my own normative expectations than the majority of their peers; but at least a few pre-service teachers represented exceptions of the opposite extreme. Four of the pre-service teachers did not try integrating argumentation in their teaching practices at all, and at least one of these pre-service teachers felt unprepared, even if she had wanted to do so.

The fact that these pre-service teachers did not always succeed in using argumentation in their lessons did not necessarily imply that they did not gain much from the study. Rather, it is that for these second language pre-service teachers it proved to be a challenging task. From hindsight, their struggles in understanding the elements of TAP reflect my own struggles when I participated initially in the Science and Indigenous Knowledge Project (SIKP). Despite their struggles, however, most of them were favourably disposed to using argumentation in their lessons. In fact, most of them realized without this intellectual space for argumentation discourse it would be difficult to integrate science with IK or even reflect the nature of science to their learners. While many of the pre-service teachers indicated the desire to promote classroom discourses through argumentation some were rather cautious, given the practical limitations of a restricted practice-teaching schedule.

Despite the pre-service teachers' positive view about the inclusion of argumentation instruction in their education and professional preparation, they all conceded that they needed more time before getting immersed in this form of instructional practice. The majority (10) reported that science classrooms in the schools they did their practice were devoid of organized opportunities for discourse since the emphasis was the chalk and talk model of teaching (see Duschl & Osborne, 2002). However, it was encouraging to see that the pre-service teachers cited many opportunities to use argumentation strategies, and most reported a willingness to attempt structuring experiences designed to promote learner argumentation.

Overall, about three quarters of the pre-service teachers applied Toulmin's Argument Pattern to a reasonable degree. However, about a quarter made minimal attempts to do so. What this suggests is that a considerable number of the pre-service teachers were not confident enough to use this new teaching approach. As Simon et al (2004) had noted argumentation instruction is a drastically different teaching approach to traditional teaching that most teachers still use. I personally empathize with these pre-service because it took me about two years before developing enough confidence to adopt this new instructional approach. I am not suggesting that science teachers and learners could not fully apply TAP, given appropriate support but from my experience with these second language pre-service teachers more time is needed to get the desired result.

What is obvious to me is that the pre-service teachers' struggles with the various elements of TAP were similar to my own struggle when I was exposed to the SIKP lectures and workshops. In reflecting on my own teaching practice and learner needs, I will need to modify my future instruction by simplifying the terms as much as possible. From hind sight, I might have to stress the connections among TAP elements e.g. the connection between claims and data or adopt the collective term "grounds" to represent evident, warrants, backings and qualifiers (Erduran et al, 2004) or simply call them reasons.

Although argumentation is central to science, it is frequently absent from typical science classrooms. Methods courses for the pre-service teachers represent one possible vehicle for promoting argumentation in science education. The course described in this paper served as a means of raising awareness of the place of argumentation in science and classrooms and promoting argumentation skills. Most of the pre-service teachers did not adopt the socio-cultural perspective on argumentation that served as a basis for the course, but they generally embraced the idea of using argumentation as useful classroom strategies. Given the challenges of being a new teacher (Adams & Krockover, 1997; Luft & Patterson, 2002), it might be unrealistic to expect the pre-service teachers to adopt this transformative view of argumentation and science education within a short period.

4.4. RQ 3: How did the pre-service teachers justify the way they implemented the Science-IK curriculum in their classrooms?

By way of investigating the pre-service teachers' ability to implement the Science-IK curriculum, the focus centred on how the pre-service teachers (a) prepared the learning task for individual and group debates, (b) enquired for supporting evidence and validations, (c) moulded arguments, used presentations and peer review and (d) provided feedback during group discussions. These features were implicit in the training resources. More detailed information about what actually took place in classrooms was obtained from looking at the selected events pre-service teachers had chosen to analyze as part of the reflective workshops. The pre-service teachers described 23 events and 18 of these events sourced from the argumentation-based learning activities. In five other events, pre-service teachers used learning activities that they had developed on their own. These 23 transactions were extremely diverse and rich in information, so that they could have been analysed from multiple perspectives.

Repeated readings indicated that references to learners' reasoning difficulties were a regular matter (Roehrig, & Luft, 2004; Lawrenz, Huffman, & Gravely, 2007; Osborne, 2010). From that perspective, I observed three categories. The results briefly abridged in the three case studies here can be extended to all the other pre-service teachers. There was evidence on all aspects of the teaching strategy investigated that the pre-service teachers were using argumentation techniques in their classrooms. The level of disparity between the pre-service teachers relied on their use of free talk and the quality of the feedback provided to the learners. Here below follows the presentation of the case studies of three of the pre-service teachers in their 20s to illustrate their teaching relative to these criteria. It was assumed that the pre-service teachers' belief systems and the knowledge they gained through methods courses are in relation with their further teaching experiences as the cases (vignettes) below show:

Cases

The first case consisted of events, in which the pre-service teacher (**Shani**) had perceived an obscurity in learners' judgment, and learners had portrayed it but for some reason, Shani did not respond to learners' difficulties. The same cause for not reacting to learners' worries was repeated in five other instances. In these cases, the pre-service teachers judged their own teaching as unsuccessful, as can be seen from the following excerpts from **Shani**'s lesson:

Shani: *Replying to my question, Chandra responded that the percentage of the gas changes {claim} because of the respiration procedure {evidence}. Her answer was incorrect but I {Shani} preferred to go on to the next learner, Erica, who gave the right answer. What I did not like concerning the session was the part where one learner, Thembalethu, had a hard time formulating the problem. He was perplexed between complete amount and percentages {conceptualisations} so that I could not comprehend him...I did not like that part and I had to cut him short and I had not given him a chance to explain himself until I would be able to understand him . . . I did that because I wanted to go ahead with the lesson.*

The need to carry on with the lesson in order to complete the prepared task was advanced as a primary reason preventing a response to learners' worries. The pre-service teachers did lead a class discussion, but they were looking for precisely those learners' responses that would assist them to make progress with the main line of the lesson. When a learner did not hit the planned mark, the pre-service teachers moved on to the next learner with the hope that he/she would be more successful in hitting the target (i.e., say exactly what the teacher had been expecting).

The second case, **Stein** did a lesson on the Periodic Table where he began the lesson with an introduction to the history of the Periodic Table. He used group activities and writing frames to support learners' commitment in argumentation. Another strategy he used was the use of messengers to groups where a representative learner from each group was sent to another group to present results of group discussions. Subsequently all of the groups made presentations and the lesson ended with a summary.

The primary teaching strategies used by Stein are summarized in Table 4.5 below.

Table 4.5: Teaching strategies used by Stein

Teaching strategy	**Example**
Task structure	Competing theories
Questioning	"How do you know? What is your evidence?
Modelling	"If you look at this one, it can't be a metal because…"
Use of presentations	You will swap seats and tell your friends what you have done and how you reached your conclusions."
Establish argumentation norms	I know that you know this by heart but what I want is for you to find out why it is there.

The central task in this lesson was framed in terms of competing theories where learners were asked to place missing elements in the Periodic Table and decide whether it is a metal or a non-metal. Stein outlined the task clearly indicating that “You need to judge the evidence to decide whether this can be a metal or not.” During this lesson, Stein asked many open-ended questions that were included as argument prompts in the training guide. For instance, he asked, “How did you classify this element? Why?”, “How do you know that?” Stein provided much support to the learners by modelling what would be a good argument. For example, he used the statement stems as “If you look at this one, it cannot be a metal because…” Stein made use of presentations by using envoys across groups.

He established the norms of argumentation by highlighting the significance of why it is important to provide justifications for our knowledge. In terms of learners’ outcomes, there is evidence from Stein’s lesson that learners were able to construct a range of arguments. For instance, learners related data to claims (e.g. “It could be aluminium because it dissolves in water.”) as well as more complex argument involving warrants and backings as well (e.g. “We are sure about this one because it has all the properties. It is soft and it is close to these so this one also is…”). The nature of the questions asked by learners tended to be clarification questions (e.g. “Are we considering the rows or the columns?”) while the criteria used for evaluating evidence included the idea of classification (e.g. “We could see if it is a metal, non-metal or semi-metal.”). Learners tended to discount others’ ideas by proposing alternative claims (e.g. “I said this but he said something else.”).

The third case consisted of 12 events in which the pre-service teacher (**Zukiswa**) responded to learners’ difficulties in a successful way. Bringing examples from everyday life is a simple and apparently an efficient teaching strategy. Such examples connect unfamiliar new knowledge to the learner’s prior intuitive knowledge. The next excerpt illustrates an event in which Zukiswa led her learners to generate an example from everyday life to overcome a difficulty that she had diagnosed. Below is a snapshot of the conversation between Zukiswa and two of her learners:

Zukiswa: "*I did not envisage that my learners would not accept the key sentence, “air is a substance that takes up space”...I did not expect that...The way I had chosen to encourage them to think about it was by bringing examples from everyday life. Below is a short segment from the transcript of that lesson. In response to my request to describe incidents from everyday life showing that air takes up space, learners responded”*

Eric: *If you blow up a balloon or a plastic bag {data}, it is true that there is air inside {claim}. It is caught up inside the balloon {evidence}. And that's how the balloon stays blown up {qualifier}. Then when we release it, all the air goes out and then the balloon is no longer blown up {justification}.*

Mary: *As a youngster I used to take a cup with me in the bathtub and I used to hold it like this (upside down).The water stayed out of the cup because there was air in it.*

Similar lesson scenarios were encountered in the lessons of other preservice teachers. In summary, the pre-service teachers' reflective analysis of classroom events, opened a window into what actually took place in their classrooms, allowing us to learn about a variety of successful and unsuccessful strategies they had been using. Once again, the data from the pre-service teachers' reflections on selected events revealed the two scenarios sketched earlier. The events in which the pre-service teachers did not treat learners' difficulties or treated them in an unsuccessful way are related to the first pedagogy because they were centred on transmitting subject matter, rather than on constructing learners' understanding. As opposed to that, the events in which the pre-service teachers had treated learners' difficulties in a successful way were related to the second pedagogy because their focus was on the construction of learners' understanding using argumentation. The extent to which the pre-service teachers expressed a deep, professional satisfaction from these events was striking.

In other instances, (e.g. "Why should I spend more energy in a solid? When you pull out an electron from an atom, the orbit does not disappear, therefore there is no difference in the circumference") the data used might not support the conclusion reached. Such instances suggest that formative feedback in argumentation might be challenging to beginning the pre-service teachers although other advanced skills such as modelling and questioning did not seem to present as much difficulty. These were preliminary results only. However, I was encouraged by the level of engagement by the pre-service teachers, their commitment to the use of some key strategies such as group discussions and presentations, and the outcomes displayed by their learners.

The majority of the pre-service teachers in this study expressed initial apprehension about incorporating dialogical argumentation into their curricula because "the presentation of plural explanatory theories would confuse the learners or lead to the development or strengthening of a belief in scientifically incorrect ideas." These concerns seem understandable for at least two reasons. First, as Osborne, Erduran, Simon, & Monk (2001) suggests, if teachers believed that their job involved presenting carefully crafted and persuasive arguments for the scientific world-view, then presenting alternatives to the scientific explanation would, at first, seem to undermine their efforts and lead to confusion.

Second, as mentioned previously, if participants in a dialogical argument believed that an explanation *is* evidence for a claim, then an unsubstantiated explanation could provide more support for a claim than was warranted, which might enable persuasive learners to lead others astray with unsubstantiated non-normative explanations. Science teachers have developed numerous ways to engage learners in collaborative scientific argumentation over the last decade (see Clark & Sampson, 2006; DeVries et al., 2002; Kelly et al., 1998; Osborne et al., 2004; Sandoval & Reiser, 2004 for examples). There are, however, a number of challenges associated with these types of activities that teachers must overcome in order to be successful, and which have been elaborated in this literature. These challenges could be organized around two broad themes. One theme reflected the various challenges that were associated with the nuances of learners' scientific argumentation and the other theme stems from the additional challenges that learners faced when they engaged in dialogical argumentative work.

Learners encountered numerous challenges when they engaged in argumentation activities that were associated with the nuances of scientific argumentation and the nature of scientific arguments (Simon, Erduran & Osborne, 2006). These challenges often stemmed from how the process and products diverged from the forms of argumentation they encountered in daily life rather than from a lack of skill or natural ability. For example, when learners were asked to generate an explanation for why or how something happens, learners must first make sense of the phenomenon they were studying based on the information available to them. Current research suggests that learners struggle with this process (Sandoval 2003; Roehrig, & Luft, 2004; Lawrenz, Huffman, & Gravely, 2007; Osborne, 2010) and often rely on their personal beliefs or past experiences to do so.

Another challenge that learners faced when engaged in scientific argumentation is the process of generating a sufficient and useful explanation that is consistent with the types of explanations valued in science (Lawson, 2004; Ohlsson, 1992 & Sandoval, 2003). Once learners have generated a suitable explanation, learners also have difficulty justifying their explanation using appropriate evidence and reasoning from a scientific perspective. Research indicates that learners often do not use appropriate evidence, enough evidence, or attempt to justify their choice or use of evidence in the arguments they produce (Bell & Linn, 2000; Erduran, Osborne, & Simon, 2004; Jimenez-Aleixandre et al. 2000; Kuhn & Reiser, 2005; Sadler, 2004 & Sandoval, 2003). Finally, learners often do not evaluate the validity or acceptability of an explanation for a given phenomenon in an appropriate manner.

Given the dilemmas of evaluating the pre-service teachers (a) impartially, (b) consistently, and (c) with regard for acquired skills, knowledge, and attitudes, the SIK Project sought to design an instrument accounting for these problems satisfactorily. The result was the SIK Lesson Observation instrument (not included in this thesis) which used detailed descriptions of 10 general areas of teacher behaviors. The ten areas (preparation for instruction, knowledge of the subject matter, knowledge and understanding of learners, effective use of teaching skills, effectiveness of teacher evaluation of learners, effectiveness of teacher self-evaluation, teacher's ability to make decisions, human relationships and overall effectiveness of pedagogy) were chosen based on their consistent appearance in the literature on generic methods of teaching. These areas were also viewed as encompassing skills that the SIK Project considered appropriate and crucial for the pre-service phase of their candidates on-going program of professional development.

In addition, the SIK Lesson Observation instrument adopted for this study focused on the TAP and CAT instructional practice. Thus, these areas became the major components of the teacher preparation program at UWC. The Likert-type scale employed allowed teacher educators some latitude in their evaluation of the pre-service teachers, and the space for comments directed them to elaborate on the markings they had made. As a result, the pre-service teachers, host teachers, and school district personnel could readily see specific areas of strengths and weaknesses as observed by the evaluators.

Descriptive data analysis revealed that the pre-service teachers' confidence levels with argumentation teaching methods, classroom management, and science content increased with the number of science content courses taken. As the pre-service teachers' content knowledge increased, they became more confident with pedagogical issues (Shulman, 1987). Shulman argued that, when teachers know their subject matter very well, they could apply the necessary pedagogical approaches to increase learners' understanding. In other words, this study suggested that knowing something for oneself and being able to enable others to know it were important aspects of learning and teaching. This study provided additional evidence that shows the importance of science content knowledge for future the pre-service teachers to increase their beliefs about implementation of argumentation teaching methods and classroom management strategies complementary to that method. However, at this point, it would be necessary to indicate the contradictory findings in the literature but because of space that will be reserved for the future publication.

The study reported in this chapter was informed by the work of Simon, Erduran & Osborne (2006) from King's College, London. In 2004, Osborne, Erduran and Simon (2004) reported on a study of the design, implementation and evaluation of a curriculum based on Toulmin's model and designed to enhance the argumentation skills of high school science learners. My study borrowed from that and developed a similar kit called Argumentation Based Activities (ABA) guide. The kit comprised a pre-service training bundle with instructions and resources for six hours pre-service sessions per week. The video contains excerpts of science the pre-service teachers teaching aspects of argumentation in a range of contexts and topics. After providing professional development through the science-teaching module using the ABA materials and teaching resources to a cohort of B.Ed pre-service science teachers at the university, the pre-service teachers subsequently integrated argumentation into their teaching.

In August 2011, one of the pre-service teachers Mr Stein agreed to trial the introduction of argumentation skills with his two grade 11 classes. The argumentation lessons were taught towards the end of the genetics topic after learners had studied inheritance and some uses of gene technology including genetics testing and genetic modification. An instrumental case study approach (Stake, 2000) was the primary research method. It was intended that the findings of this exploratory case study would inform the design of further research and professional development on argumentation. The timing of the argumentation lessons was deliberate, as it had been shown previously that learners of this age displayed better argumentation skills if they have some prior knowledge (Aufschnaiter et al., 2008; Lewis & Leach, 2006).

Extensive field notes were recorded during the professional development session, a pre-lesson, and the lessons on argumentation. Audiotapes of all lessons were transcribed. The transcript sections where Mr. Stein promoted argumentation were coded using the framework developed by Simon et al. (2006). A summary of this analytical framework is shown in Table 4.6 here below.

Table 4.6 A summary of Argumentation analytical framework as espoused by Simon et al. (2006)

Talking and listening	**Knowledge of argument**	**Justifying with evidence**	**Construct arguments**	**Counter-arguing**	**Reflection on argument**
Encourages discussion	Defines argument	Checks evidence	Uses written work	promote counter argument	Encourage reflections
Encourages listening	Exemplifies argument	Provides evidence	Prepares presentations	Encourage debates	Asks about mind-change
		Prompts justification	Give roles equitable		
		Emphasises justification	Encourages arguments		
		Plays devil's advocate			

A sample of 10 learners from Mr Stein's two classes, five learners from each class, was interviewed before studying the five-week genetics topic. Four of these learners were re-interviewed after the topic. The remaining six learners were either absent or not available each time I visited the school. Interviewed learners were asked questions about their understanding of genetics concepts and their decision-making about two genetics dilemmas. Mr Stein, using a purposive sampling method (Patton, 1990) that allowed for a range of academic abilities selected the learners. The classes at this school were not streamed for academic ability and the interviewed learners were identified by the pre-service teacher as being of high, medium and low academic achievement in science. The interviews were transcribed and the post unit transcript sections on learners' perceptions of argumentation were analysed for emergent themes.

The Lessons

Mr Stein's classes were observed prior to the argumentation lessons to ascertain his teaching style. Mr Stein was a very confident pre-service teacher who encouraged independent learning in his learners because he wanted them to take responsibility for their learning. Typically, the learners worked independently in small groups, with Mr Stein calling the class together at intervals to check on progress and provide information. As learners worked, he moved from group to group. There was a whine of noise in the class and learners were largely on task. In order to examine more closely the strategies used by Mr Stein to promote argumentation, the audio-taped lesson transcripts were analysed using the framework developed by Simon et al. (2006) and outlined in the previous section. As described earlier, this framework was developed by scrutinising the types of teaching strategies and dialogue used by the pre-service teachers whose learners subsequently displayed better argumentation skills compared with those pre-service teachers whose learners did not improve their argumentation skills. Table 4.7 provides exemplars from the audio-taped lesson transcripts of the behaviours exhibited by Mr Stein. All behaviours were demonstrated on at least one occasion.

Learners' views

During the argumentation lessons, I observed that the learners were engaged and on task. They appeared to enjoy expressing their views about the two socio-scientific issues. The learners listened to each other and did not tend to talk over or interrupt each other, partly because Mr Stein managed the discussion. Apart from when learners were using the writing frames, there was a constant dialogue of learner–learner and learner–teacher talk about the issues. Most learners recognised the benefits of discussion where evidence was used to support claims (*provides evidence, encourages ideas, emphasises justification*).

Table 4.7 Examples used by Mr Stein while teaching argumentation

Argument process	Teacher facilitation Codes	Example from transcript
Talking and listening	Encourages discussion	P.2 What was your first initial response to the business about the Flavour Savoir tomato? P. 5 So you are saying that everybody on this planet is so ethically and morally perfect nobody will do the wrong thing?
	Encourages listening	P.3 Oh, that is good Vuyo. Yes, so Vuyo is also making that comparison.
Knowledge of argument	Defines argument	P.4 So with the tomato, you have a claim and a counter claim.
	Exemplifies argument	P.6 So it's a bit like saying, man never landed on the moon, or man landed on the moon, and the counter claim is, of course, no he didn't, you look at the flag, there's no way they could have done it. Therefore, we have a claim and a counter claim.
Justifying with evidence	Checks evidence	P.7 They have actually given you that word, Zahra, what is that word? (Zahra—mutation)
	Provides evidence	P.8 The hostess or steward will walk up and down the aisle and they'll say please fill out these quarantine cards and watch the video.
	Prompts justification	P.9 Teacher: Now because it is recessive if you have just one of them, can you get the disease? (A: No) Teacher: No, so we are drawing back on the work we did in genetics.
	Emphasizes justification	P.10 Teacher: What more do I need? (A: Evidence) Teacher: More evidence. So like, I need more data.
	Plays devil's advocate	P.12 What if you were the father, would you want to know?
Constructing arguments	Uses written work, presentations, equitable roles and push arguments	P. 2 I am going to hand out a sheet to you. Have a bit of a read first and as you are reading it be critical.
Counter-arguments	Encourages counter-argument	P.6 We have people who are willing to, and we discussed this one the other day too, you know there is going to be a bit of a rebuttal there also. What are we going to qualify?
	Encourages debate	P11 If you were the genetics counsellor, would you tell both Mr. and Mrs. C the test results? P.13 What if you were the father, would you want to know?
Reflecting on argument	Encourages reflection	P.10 That is a good point. Do you think that is what schools are trying to do with their science programs though? Is there any way that a school with maybe one lesson of science a day, is going to bring you fully up to speed with what is happening in the science world?… Therefore, we are not actually asking you to remember absolutely everything. Perhaps we are asking you to remember certain techniques, as we are doing now. We are talking about how to create a constructive argument.
	Asks about mind-change	P.9 Okay, hand up those people who have changed their mind between the start of the sheet and…. Who heard what somebody else said and maybe changed their mind on it?

Mr Stein also asked questions to draw out backings and qualifiers from learners [*prompts justification*, *encourages further justification, and plays devil's advocate*].

> *He gave us some scenarios and inside the scenario, he would say like, what if this happened? Then what about if you put this and this and then what would happen? (C, 17/08/11)*

Mr Stein also encouraged learners to express a range of views (*claims and counter claims*) [*encourages ideas*]. For example:

> *It was good how we like, yeah, everyone had his or her own input. (B, 17/08/11)*

The learners valued listening to the arguments (*counter claims and rebuttals*) put forward by their peers [*values different positions*, *encourages debate*, *encourages reflection*]. For example:

> *I learnt that like there are lots of different opinions and it's kind of good how everyone has their own input—that's what I liked about it and like yeah, there was lots of different opinions which can twist the way you look at it and some were good and some were bad. (A, 17/08/11)*
>
> *I thought the lesson was good because we all have to discuss, we all like heard different opinions from other people, and we all thought about it. (C, 17/08/11)*

The learners not only listened to, but also were influenced by the evidence put forward by their peers [*encourages listening, encourages positioning, asks about mind change*].

> *Everyone has their own opinions on certain topics and it is kind of changes the way you think about the topic when you hear other people's opinions so you might be for it and when you hear certain things, you might be against it. (D, 17/08/11)*
>
> *We kind of had a light debate about it, like we would all give our own opinion and then he was like it's OK if you change your mind, like if you started off thinking one thing and then changed it, like that's fine but we all like gave our opinions and then we kind of thought outside the box and how they would feel and how the father would feel and… it kind of brought ideas to your head but then you still had yours—you kind of, you're fighting with yourself on which one to choose. (B, 17/08/11)*
>
> *For example: We built off each other's ideas and came up with more ideas than we would have done by ourselves and learnt more about the cystic fibrosis one, DNA testing and with the flavour Savr one all about how it could be different with climate conditions…It left it up to us to think and then by using our ideas and some of the things Mr Stein said and everybody else, we were able to understand more of the different effects and everything. (Ca, 17/8/06)*

4.5. RQ 4: What practical challenges did the pre-service teachers experience as they attempted to implement the science-IK curriculum in their classrooms?

The final data source providing insights relative to the pre-service teachers' perspectives on argumentation discourse were self-reflections based on the lessons presented to their learners. It should be noted however, that these discourse lesson presentations were one of four such lessons and reflection assignments. All of the lessons were video recorded, and the pre-service teachers were asked to analyze their teaching videos and write a reflection. Most of the pre-service teachers focused on the practical logistics of their teaching behaviours throughout their reflections. Common topics included the use (or non-use) of wait time, patterns of nonverbal communication, nervous habits, learner interest, and other themes that we might expect the pre-service teachers to consider as they practice teaching. However, in some cases, these reflections provided an opportunity to understand the pre-service teachers' perspectives on argumentation. Four of the pre-service teachers discussed how the experience focused their attention on key elements of classroom discourse. They mentioned such challenges as the importance of thought-provoking questions, how to best moderate learner discussions, and grouping strategies

The excerpt below provides an example:

Franco: *This method of teaching [argumentation] is very innovative and different for me. As I watched the video, I detected that I appeared to hold back from the dialogue and permit the learners to do more of the talking. I think this can be strength and a weakness at the same time.*

The reflections of four of the pre-service teachers also demonstrated changes in their perspectives toward argumentation. All four of these instances suggested that actually presenting a discourse lesson improved the likelihood that these individuals would attempt this approach in the future. For example, Shani offered the following:

Shani: *Before we began this exercise, I was not sure how or if I would ever use discourse and argumentation in my classroom, beyond having learners defend their answers. However, I did this lesson plan and may use it or one similar to it in my teaching.*

The pre-service teacher offering this comment had created a hypothetical scenario related to an environmental problem and challenged her audience to assume the roles of various stakeholders. Members of her audience were asked to interpret evidence through the lenses of their roles. By the end of the teaching practice, the pre-service teachers provided valuable information on all components of the AIM. Specifically related to claims and qualifiers, the pre-service teachers, who taught classes ranging from eighth grade through eleventh grades, thought that their learners easily understood what claims and qualifiers stood for. One of the pre-service teacher indicated that, as the study progressed, learners were becoming more aware of qualifiers to claims that they found in articles or information outside of classes. However, the pre-service teachers also indicated that some of the qualifiers that learners found (particularly from outside sources) might well fit better as concerns, that is, rebuttals, counter-arguments, or new questions.

4.6. Discussion with reference to argumentation and IK-Science Curriculum

In this study, the biology pre-service teacher (Mr Stein) introduced his grade 11 learners to argumentation skills during a genetics topic as they examined two socio-scientific issues, (1) one on a genetically modified tomato and (2) the other on prenatal genetic testing for cystic fibrosis. When the lesson transcripts were analysed according to the framework developed by Simon, et al. (2006) the researcher identified multiple instances where Mr Stein exhibited the same argumentation processes found in UK teachers who had participated in an extensive professional development program and were effective in improving learners' argumentation skills. An analysis of the classroom observations, audio-taped lesson transcripts and the post instruction interview transcripts suggested that four factors that promoted argumentation in Mr Stein's classroom emerged from the data. These factors included the role of the teacher in facilitating whole class discussion; the use of the writing frames; the context of the socio-scientific issue; and, the role of the learners.

Mr Stein regularly used whole class discussion in his teaching. The researcher observed that Mr Stein used learners' names whenever they responded to, or asked a question. He called on all learners during the lessons. Often he would rephrase or restate a learner's answer so that the whole class could hear the response. He would then build on the learners' responses by providing more evidence, taking an alternative position, or asking for justification. He encouraged learners to answer each other's questions with himself as the intermediary. He used humour and listened actively to learners often asking follow up questions to prompt justification. He exemplified argument by providing examples to illustrate the language of argumentation, reminding learners of the importance of providing evidence, using claims and counter claims. When learners seemed to agree he would play devil's advocate by offering a counter argument. Learners seemed familiar with the rules of whole class discussion with several being reminded that they had reached their quota of asking questions. The whole class discussion was interspersed with periods when learners wrote their answers to questions from the writing frames.

The questions were designed to act as argument prompts to encourage learners to make a decision and to articulate reasons for their decision. The nature of the questions (e.g., 'how would you convince someone who disagreed with you?') encouraged learners to use data, warrants and make explicit the underlying assumptions (backings) that supported their claims. The researcher observed that all the learners wrote answers and Mr Stein used the questions as a starting point for the periods of whole class discussion. Another feature of the lesson was that the teacher selected and used socio-scientific issues that were set in a genetics context so that learners were able to apply their newly acquired knowledge. This is similar to the successful use of bioethical dilemmas to promote argumentation used by Zohar and Nemet (2002). Lewis and Aikenhead, (2000) and Aufschnaiter et al. (2008) both state that learners must have some scientific knowledge if they are to engage in argumentation successfully.

During discussion, Mr Stein was able to draw on his biology background knowledge and awareness of learners' content knowledge. This enabled him to provide further information to prompt learners' when required. The researcher observed that learners used genetic terms in the discussion, writing frames and post unit interviews. The culture and abilities of the learners needs consideration when developing their argumentation skills in science. If learners are unaccustomed to questioning scientific knowledge, evidence, or the teacher, they may be reluctant to engage in argumentation. However, in the classes observed learners seemed very comfortable with providing their point of view and were willing to listen to the teacher and their peers. I observed that the learners seemed interested and motivated by the socio-scientific issues. The post unit interview comments indicated that learners enjoyed the lessons and the activities including the whole class discussion and writing frames. Indeed, as one learner left the class he turned and asked Mr Stein, "Can we do this again next period?"

4.7. Emerging approaches in implementing IK-Science in science lessons

Thus far, the narratives of the three pre-service teachers constructed from the interviews (both face-to-face and reflective) and class observations were presented earlier on and shall not be repeated here. By using empirical evidence from the narratives, the three emerging approaches used by the pre-service teachers in implementing IK in science lessons were illuminated in this 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 pre-service teachers' approaches.

Shani's assimilation approach clarified in the excerpt below:

"I constantly experience a need to unearth whether the IK that learners carry to the class is true. I attempt 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, IK and Western science. As a teacher, maybe I can help the learners reorganize the IK 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"

Stein's segregation approach clearly articulated in the following extract:

"As I come across it I just introduce it (IK) 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 IK teaching for example an electron is an electron and an atom is an atom in pure science"

Zukiswa's integration approach is evident in the following passage:

"Initially my understanding was that since IK is regarded as science it can stand alone and modern science could stand-alone. I now think that by linking IK 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 IK experiences"

The three approaches are analytical categories. None of the pre-service teacher can be described with reference to any one to the exclusion of the other. In certainty, each of the pre-service teacher used aspects of all three approaches. However, for the purposes of analysis it is possible to develop each approach to make it evident and explain the pre-service teacher thinking and action in driving particular theoretical underpinnings of how the pre-service 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.

How the pre-service 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 their approaches, and pedagogical practices have on learner agency are elaborated. Each of the approaches is developed and interrogated by and through the following:

- Pre-service teacher characteristics, memoirs and background
- Didactical practices
- Subject of Indigenous language
- Learner action
- Validation and access to IK
- Approaches to IK in lessons

4.8. Pre-service teacher characteristics, memoirs and background

Shani's own conviction that Western science is the valid science seems to have largely persuaded her in the manner in which she engaged with IK in the classroom. Her view seems to stem from values instilled by the Christian based education during her school experience where Western science was presented as fully epistemologically adequate while subjugating other knowledge systems. Deliberately or not, the “west is best attitude” has persevered in her classroom teaching and has influenced her level of engagement with IK.

By incorporating IK into Western science there appears to be the notion that IK is a subset of Western science and therefore it can be argued that Shani accords Western science a higher status than IK. A second possible reason for taking an assimilationist approach could be attributed to the fact that she only believes the IK imparted by her mother, which she does not question. IK 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 Shani engages with IK seems to lean towards an outsider perspective.

Stein like Shani was also educated in a Christian 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 value and equal opportunities in the curriculum (not specifically in science), which he caters for by using the equal and isolation 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 surviving alongside each other, that is Western science (which is a subculture of the West) and IK. This seems to justify why, distinct to Shani who chose to incorporate IK into Western science he kept both knowledge systems as stand alone, each valued for its own merits.

Zukiswa, like Shani and Stein, was also educated in Christian values and principles during her schooling. Science textbooks used in the classroom depicted only European and American contexts and she went through similar ‘west are best’ instructions as Shani. However, in her approach to IK teaching she does not follow an incorporation practice but an integrationist one. She moves effortlessly between IK 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 IK to negotiate the move between IK and science. Perhaps her personal IK gained from an insider perspective through cultural practices, protocols, and direct transmission of elder knowledge while growing up and which was especially reinforced during rural 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 university experience has been limited to schools consisting of learners and teachers of similar culture (IsiXhosa) and social class. Mono-cultural learners holding similar personal knowledge may have facilitated Zukiswa's attempts to integrate IK and Western science.

4.9. Didactical Practices

Shani's approach of using IK as a stepping stone, as part of building on what learners already know about science concepts is located within the constructivist paradigm with reference to how learners engage with building knowledge. This approach has some meaning 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. Indigenous knowledge may be seen as a didactic device helping learners to appreciate Western science. Shani articulated that her critical goal is to facilitate the empowerment of learners 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 learners of Indigenous cultures...should be to help learners access conventional science. Whether or not the learner accepts the conventional science to the point of making it direct his/her life, is a matter of choice for the learner.

Stein, unlike Shani 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 Stein maybe 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 Stein'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 IK were only used as a springboard for accessing Western science as Shani did, then it would appear as if IK has no value in itself.

This dilemma of competing purposes in the science curricula, are far from resolved. Unlike both Shani and Stein, Zukiswa established an African Indigenous framework at the beginning of the lesson building on what learners already knew about traditional cultural practices of healing and linked it to associated scientific concepts. As diverse concepts in Western science 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. Zukiswa's classroom practice seems to correspond to Lugones (1987) view of teaching science within an eco-cultural paradigm, which aims to empower learners to feel a sense of ease in each culture, for instance, the culture of science and the learner's Indigenous life-world cultures. For Linkson, (1999) the Indigenous perspective should be used to promote differing worldviews in an attempt to facilitate a two-way exchange of knowledge and cultural understanding.

4.10. Subject of Indigenous Language

Given that language is the central medium for the representation and communication of Indigenous knowledge, learning Indigenous peoples' languages and cultural practices by researchers and representation of their 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), the 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 1900s. 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 worldviews 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 (1966) 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 a teacher to translate IK he/she in addition to having knowledge of Indigenous languages 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 learners.

Knowledge of Indigenous languages or lack thereof seems to have largely influenced the manner in which the pre-service teacher participants engaged with IK in the classroom. Although Shani did not understand Indigenous languages, however, she was familiar with some cultural aspects, which were part of her childhood experiences. Stein had an understanding of both the African Indigenous language and an understanding of African cultural experiences and this is probably the reason why he kept the two knowledge systems as stand-alone. Although he valued IK, he did not make adequate attempts to make connections to Western science in his lessons, perhaps because he wanted to maintain them as separate knowledge systems or perhaps did not know how to connect them. Zukiswa has the same linguistic and cultural background as her learners. Her knowledge of African languages allowed her to tap into deeper layers of meaning and understanding. This probably explains why Zukiswa puts a high priority on linking IK 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 IsiXhosa terms. She had both the security of language competence and her personal knowledge of IK to negotiate the move between IK and science.

4.11. Learner action

Learner activity 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 learners in traditional classrooms have little opportunity to develop action. Rather in traditional classrooms, teachers seem to operate with the assumption that their teaching practices control the development of learners 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, IK learning supports learners' sense of action by building authentic experiences into their education that affords an opportunity to engage learners.

Shani relies on learners as a source of IK and maintained that teaching IK in the class allowed for the transfer of responsibility of learning to the child. Shani's accounts indicated that there was more learner participation and enthusiasm in the lessons. Through observation of Shani's classrooms, it has become apparent that using IK in the class made a sizeable impact upon patterns of classroom interactions. She found that learners' level of engagement and enjoyment was lifted by the inclusion of IK in the science classroom. Many researchers have also espoused similar views, for example, Manzini (2000); George (1999b) and Clark and Ramamphele (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 learners had opportunities to speak about their own beliefs in a science lesson. Like Shani, Stein too, used the strategy of building on learners' 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 didactical technique is the recognition of learners' personal knowledge, which can also be thought of as their IK.

The atmosphere in the classroom changed dramatically through the inclusion of IK 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 IK lessons indicative of children as active learners. Learners reacted positively to IK and the emergence of the learner voice during discussions plays a critical role in opening up debates on issues of IK. This created opportunities for learners to be more open and questioning in the classroom, which in turn allowed the pre-service teacher more critical insights into learners' personal beliefs. Similar findings were reported by many researchers, for example Bruner (1986); Cummins and

Swain (1986); Machingura and Mutemeri (2004) who claimed that learners enjoyed a positive learning experience, became motivated to learn, while Clark and Ramamphele (1999) reported that learners became embroiled in lively discussions when IK was included in the classroom.

Stein's approach of compartmentalising science and IK may have restricted border crossing for some learners resulting in delayed or hindered access to science. Nevertheless, the relaxed atmosphere in the class may have created the right conditions for border crossing. Learners' enthusiasm for science and Stein's belief that the teaching of IK was important may have also provided incentives to facilitate crossing borders. Zukiswa's use of activities and instructions that built on learners' personal IK derived from their culture promoted a sudden increase in inputs by learners. Some theorists, for example Gershaw (1989) claim that relevancy helps learners to be more motivated to learn while others (Davison & Miller, 1998; Srikantaiah, 2005) assert that learners need to draw on their prior experiences to make real meaning of the curriculum.

Zukiswa, like Shani and Stein also observed that learners' level of engagement and enjoyment was lifted dramatically by the inclusion of learner's Indigenous experiences in the classroom. However, it seems that Zukiswa's insider perspective makes it easier for her to recognise connections amongst the ideas and experiences that learners bring, and Western science. For Stanley & 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. Zukiswa does so in both tasks one and two of her university assignment and in her teaching of IK in science lessons positioning her as a more effective culture-broker pre-service teacher than Shani.

4.12. Validation and Access to IK

Three pre-service teachers chose to address validation and access to IK in three different ways. There is a mismatch between what Shani says and does in the teaching of IK in science lessons. Although Shani says that IK is science, she does not accept it as usable knowledge for classroom teaching. Firstly, she continually validates IK against Western science in order for IK to fit school science. She then selectively admits to the classroom only that IK that meets the criteria for science and which she can make sense of scientifically. IK, that is not compatible with science, she dismisses from the lesson. Shani's approach of accepting as valuable only the IK that 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 & Sethuraman, 1993).

Contestations thrive in literature (Goonatilake, 1984; Leeuw, 2004; Ntosane, 2005; Onwu & Mosimege, 2004) whether modern science should be the starting point for evaluating IK 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 IK a measure of legitimacy for its inclusion in the science curriculum and how does one do so? Unlike Shani, who validated the IK brought by learners from the community, Stein chose not to validate it suggesting that he intended to retain the integrity of IK by not linking it to science. He regards IK to be equally grounded as Western science and to be able to stand-alone. Acknowledging IK on its own terms seems to reinforce Stein's belief of using IK in the curriculum to address concerns for equity, heritage and nation building. Stein'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 Stein'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 ethno knowledge.

Many researchers such as Mosimege (2005), Ntosane (2005) and Mwadime (1999) are of the opinion that it would be a mistake to subject IK to the same verification or validation processes as one usually does with respect to Western science and that one should not look at IK with the same lens of judgement as one does with Western science. Mosimege (2005) and Ntsoane (2005) further argue that the two systems are different and therefore require different standards for validation. Zukiswa's approach seems to respect the views of the above researchers in that, unlike Shani 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 IK since the local community know and understand their IK better than outsiders and advocates the use of local consultants like elders, teachers, and midwives, religious and traditional leaders. He further maintains that failure of a certain IK to meet one's understanding should not be a reason to render it irrelevant because IK 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 IK before accepting it even if it means using Western science as a verifier. Mosimege (2005) and Ntsoane (2005) oppose Hountondji's (1997) view of using Western science as a verifier of IK 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 Ntsoane's idea further, it may be argued that the standard for authenticating IK should also take the cultural context of IK into account. From the analysis, it may be argued that the pre-service teachers have a limited understanding of the theoretical underpinnings of IK. 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 IK 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 IK 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 IK is measured.

In addition to validation before admitting IK into the classroom Shani restructures IK 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, IK 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' IK experiences suggests that Shani plans to use the methodology and reasoning of Western science, the scientific method, which is not used with other systems of knowledge. Shani seems to privilege Western science in two ways. Firstly, by using it as a yardstick to measure IK, and secondly, by interpreting IK 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 IK meet the criteria set by Western science Shani 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 learners should be encouraged to use this approach in their everyday thinking. To this Tema (2002:137) asserts 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. What Stein 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 analysed 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 IK 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 IK, 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 knowledge system is, accessible 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 IK is becoming an extremely difficult and daunting affair and that teachers too are grappling with both these issues.

4.13. Approaches to IK in Science lessons

Shani's assimilation approach of starting the lesson with Western science and then bringing in IK reflects her own perception that Western science is superior to IK. This style of presentation can also be interpreted as if IK 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 annotation or gesture approach is contrary to the RNCS which portrays IK as a way of knowing, knowledge about the environment (DOE, 2002a: 11) suggesting a role of IK as *content* of science instruction. Clark and Ramamphele (1999) hold an opposite viewpoint to Shani and arguing against the strategy of trying to fit IK 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 learners' worldview and not the other way round which Shani favoured. In assimilating IK into science, Shani would be more inclined to use topics for science lessons that harmonise with learners' beliefs, or alternatively, activities that attend to those beliefs but incorporate authentic aspects of the beliefs into scientific content.

It is clear that Shani treats IK in varying ways. Shani validates IK 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 IK brings with it notions of the superiority of Western science and the inferiority of IK as an ethnoscience. This manner of engaging with IK once more seems to illustrate her own Western bias. If IK is seen as a kind of science, an ethnoscience but not equivalent to Western science it may necessitate a redefinition of science to broaden its meaning to include ethnoscience so that there is no controversy about the nature of IK.

For Stein, it appears that he wishes to maintain the mutual existence of both IK and Western science side-by-side in his lessons in his separatist approach. IK 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 IK can be taught alongside Western science as distinct domains, if they are not entirely dissimilar knowledges. Stein'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 IK, but instead we should actively support a post-colonial 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. Stein's dilemma in terms of preserving what is good in learners' 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 affirms their differences and becomes the basis for meaningful relationships between teachers and learners. Stein's claim of do not destroy the belief, seems to conform to Kyle's (1999) argument that teachers 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 IK and scientific knowledge. Stein did not indicate that answers and explanations given by learners were incorrect. Stein's equal and separatist approach and his argument for IK in the curriculum on political and moral grounds are indicative of his belief that IK was beneficial but more for the purposes of human rights and social justice issues rather than for science teaching. Keeping domains separate, that is, IK and Western science have also been criticized by many theoreticians (Corsiglia & Snively 2000; Stanley & 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.

Zukiswa's integrationist approach illustrates how this may be accomplished. It can also be argued from traditional versus Western worldviews 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. Zukiswa attempts to bring the two systems together in a manner that promotes the integrity of IK while simultaneously embracing the important concepts of Western science. Her lesson was directed towards engaging learners in science activities and discussions that made connections to learners' everyday world. Zukiswa integrated her lesson with IK 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.

4.14. Summary

Several excerpts in this chapter suggested that the pre-service teachers became more argumentative and were eager to articulate their views more cogently than before the AIM intervention. Here below, I made an analysis from excerpts drawn from Item 7a, 7b and 7d.

Item 7a: What ideas of IKS did you hold before being exposed to the Science for Teaching Module 112?

PT5: *"Thought it was about the knowledge of old people and their experiences that they shared with their children and grandchildren".*
PT7: *"That it was only about traditional ways of making food, medicine, shelter,".*
PT9: "*That its methods and ideals were extremely primitive in nature and can't be seen as plausible".*

Item 7b: What ideas of IKS did you hold after being exposed to the Science for Teaching Module 112?

PT5: *"More or less the same, but it also has to do with the cultural beliefs of people and how they live according to this".*
PT7: *"IKS is a broad subject. I also find it very interesting and it has made me aware of the 'other' knowledge that should be taken into account when teaching science in your classroom".*
PT9: *"Majority of modern engineering and medicine is derived from IKS. Like old bush remedies and how to locate water with a stick and anti-venom for a snake bite".*

In other words, the lessons seemed to have provided the opportunity and the dialogical space to convey their viewpoints on issues relating to science and IK. However, in terms of the TAP, pre-service teachers' arguments varied largely between 1, 2 and 3, that is uncomplicated claim versus counterclaim with no grounds or rebuttals and claims or counterclaims with few grounds and limited rebuttals. Even as the pre-service teachers improved their understanding of the argumentation framework, they also became aware of situations where science-IKS curriculum was the most suitable worldview to adopt in dealing with such situations. Findings emerging from this study show that the pre-service teachers had begun to increase their conceptual understanding as well as developed some elementary high-level argumentation. Similarly, the pre-service teachers appeared highly provoked to use dialogical argumentation in their classroom practice. What emerged from this thesis is that pre-service teachers have started appreciating the value of argumentation instructional strategy in an effort to implement the IKS curriculum.

In terms of the CAT, and as shown in Table 4.3, the excerpts below suggest an equipollence stance on the part of the pre-service teachers i.e. science and IKS are seen as complementary.

Item 7d: Based on your knowledge of IKS gained from the Science Module 112, do you think that the IKS worldviews should also be presented alongside the scientific worldview? Express your view.

PT5: *"Yes. It shows how the IKS worldviews and the scientific worldviews come together."*

PT7: *"Yes. These way learners will be able to view their IKS parallel to that of modern day science and will be able to fit it in where they can draw comparisons and similarities to the two perspectives".*

PT9: *Yes and no, IKS could maybe help in the field of modern medicine. Yes, because doctors are now using IKS methods to cure certain ailments. They do this by using maggots to eat dead flesh from a wound which in turn secretes a healing enzyme to heal the wound and they use leeches in some sort of therapy. No, because of the spiritual aspect of IKS. Like I stated earlier in this questionnaire that the power of suggestion and faith is can be a strong healing factor but, it would not do a terminally ill person any good.*

Based on the findings above it seemed that the pre-service teachers were more favourable disposed to accepting IK as a potentially legitimate aspect of a science curriculum and more able to distinguish between scientific or IK worldviews as well applying the appropriate context. My data illustrated a change in the pre-service teachers' perception about IK and its correlation with science, and the opportunity of an integrated science-IK school curriculum. The few selected verbatim quotes exposed changes that I categorized according to Contiguity Argumentation Theory (CAT). As indicated before, this is clearly different to the stance taken by pre-service teachers and also practicing teachers in earlier studies (e.g. Ogunniyi, 2004, 2007, 2011).

The findings from this study are a mixture of positive and not so positive indications. Despite this, even the short-term training of the pre-service teachers resulted in attainment of certain desirable pedagogical and learning goals; thus indicating the potential of argumentation for knowledge and skill development; an encouraging outcome indeed. Methodological considerations illustrate the need to further develop tools that would be sensitive to identifying not only the structure but also the content of arguments. Our work has focused on the process of argumentation not as an ideological preference over content of argument but rather as a pragmatic need to instill in both teachers and students the mechanisms of arguing. Without a sense of the need for providing evidence to justify claims, we wonder how learners could see the need for presenting an argument at all, let alone an argument that has internal consistency in terms of its content. My target is to extent the line of work on argumentation to develop new tools that would be effective in capturing the quality of content as well as the process.

An issue of concern for the researcher, however, was that some of the pre-service teachers were still having trouble in providing clear explanations as to the difference in some evaluative components such as validity and reliability. Overall, the pre-service teachers believed that many learners felt empowered in that they learned to think about a claim and were willing and able to respond to questions about a claim or evidence and to organize their thinking. Thinking about the quality of evidence was particularly useful in that the pre-service teachers thought more about reliability and bias.

The pre-service teachers also raised issues about possible special interests or motivation of authority figures, even if those figures represented respected institutions. In this context, pre-service teachers raised the issue as to whether institutions might have stakes in a claim due to grant support and funding. Relative to the order of reasoning (Toulmin's warrants), input from the pre-service teachers during their pilot of the AIM provided information on their beliefs about their abilities related to higher-order reasoning that could link a claim to the evidence presented in an argument. During the development process, several of the pre-service teachers recommended that the intervention not use the more complex words on the ABA that were taken directly from theorists such as Toulmin. For example, they recommended using "order of reasoning" to represent Toulmin's "warrants" and using "concerns" to represent "rebuttals." Although the researcher accepted these recommendations at the time, this ultimately raised issues regarding the wisdom of substituting some simpler synonyms for complex theoretical terms.

At the end of the study, when the pre-service teachers discussed the order of reasoning, they believed that learners seemed to understand how authority and theory served as appropriate warrants for a claim. However, the pre-service teachers believed that learners had more difficulty with the complex area of logic. Relative to logic, they thought that learners understood and used the term "logic" correctly in a general way, but did not understand various components of logic (as used in the ABA and in the instruction) such as analogy, correlation, causation, and generalization. Relative to rebuttals and counter-arguments, some of the pre-service teachers thought that these terms were difficult for learners to understand, although they could more easily come up with new questions. One of the pre-service teacher thought that the greatest benefit came from learner consideration of the last two components of the ABA: consideration of concerns and new questions, and drawing conclusions about the claims.

Learners, particularly in the upper grades, demonstrated some transfer of learning in that they commented on what they saw or read outside of class that contained claims. This included information found in infomercials, mailings, and various advertisements and articles. One very important issue involves the pre-service teachers' perceptions that learners did not particularly enjoy the argumentation instruction and activities. The researcher questioned whether this perception led some of the pre-service teachers to report that they would not use all the components of the intervention in the future. Learner enjoyment is, indeed, a concern in education, but is only one consideration that must be subjected to more research. In this chapter, a detailed discussion and interpretation of the study take charge.

In this closing section, I zoom in excerpts from the data for each of the three pre-service teachers, to epitomize three different approaches used for IK teaching. The budding image is that although the pre-service 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 pre-service teachers in how they dealt with IK in their teaching. In this chapter, the three diverse approaches to teaching IK used by the teachers were developed, namely: (1) an approach that assimilates IK into science, which exemplifies Shani's approach; (2) an approach that keeps IK and science separate which is indicative of Stein's approach, (3) and an approach that integrates and draws connections between IK and science which represents Zukiswa's approach. Each of the different approaches was interrogated through different themes in an attempt to find out what influenced the pre-service teachers in the way they engaged with IK teaching. Shani's approach may be described as more of an inclusion approach where IK, corresponding to science, was identified and merged with science. Stein developed a separate but equal, stand-alone approach where IK and science were both taught but not really brought together while Zukiswa'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 IK, their IK in science lessons, the relationship between science and IK and conclusions.

How the pre-service 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 their approaches, and pedagogical practices have on learner agency are elaborated. Each of the approaches is developed and interrogated by and through the following: the pre-service teacher characteristics, memoirs and background, Didactical practices, Subject of Indigenous language, Learner action, Validation and access to IK, Approaches to IK in lessons. In the final chapter, the implications of the three different approaches for policy, curriculum issues, teacher education programmes, IK teaching, theories and research are addressed.

This study aimed to investigate the effect of an argumentation instructional model on the pre-service teachers' ability to implement a Science-IK curriculum in four selected South African schools and was guided by four research questions namely; (1) What pre-post conceptions of the Science-IK curriculum did the pre-service teachers hold before and after the argumentation instructional model intervention? (2) How the pre-service teachers practiced Argumentation Instructional Model to enhance their abilities to implement the Science-IK curriculum (3) How did the pre-service teachers justified the way they implemented the Science-IK in their classrooms? (4) What practical challenges do the pre-service teachers experienced as they attempted to implement the science-IK curriculum in their classrooms?

Data from qualitative and quantitative methods were collected using questionnaires, classroom observation schedules, focus group interviews and document analysis. The data analysis offered here was prepared in three separate segments. The first phase is the *theoretical*, the second phase is the *implementation* and the third phase is the *reflective* phase. Furthermore, each section scrutinized the approaches to data analysis and the research instruments employed in each phase.

Issues that have emerged from this study include: poor clarity of the curriculum; limited scope of content in the curriculum; predominant focus on Indigenous knowledge and inexistence of other forms of Indigenous science; poor organization of learning experiences (both from curriculum documents and by the pre-service teachers); lack of literature resources to supplement what is given in the pre-service teacher's guides; and communications problems. As a result, the pre-service teachers involved in the study faced so many problems in teaching the new content on Indigenous knowledge in the new school curriculum. While conceptualizing this study, imbued with the constructivist philosophy, I had the impression that engagement of Indigenous knowledge in the teaching of science presents an opportunity to teach science successfully since Indigenous knowledge would serve as prior knowledge. Indeed, the literature supports the fact that learners do better when they start learning using familiar ideas.

However, it turned out that the teaching of Indigenous knowledge was not that smooth. The pre-service teachers complained that the curriculum document had inadequate information, especially about scientific principles embedded in Indigenous knowledge. Hence, the pre-service teachers struggled to guide learners towards development of the desired scientific principles anticipated by curriculum specialists. To make matters worse, they could not figure out the science principles from the Indigenous knowledge. This resulted into superficial coverage of content perhaps because they did not clearly know what to do.

First, the curriculum design lacked a theoretical foundation, which could guide the specification of desired principles in curriculum document. This was probably due to the fact that curriculum designers seemed to lack adequate or detailed knowledge of what IK entailed. They simply assumed that teachers would find such details for themselves. The teachers were thus confronted with a curriculum that did not convey to them what was actually required to integrate IK with school science. This was exacerbated by the fact there were neither teachers guides nor resource books they could fall upon to give them insight of how to implement the new curriculum. Secondly, teachers lacked the essential knowledge about how Indigenous could be integrated with school science without compromising the quality of the latter. In the absence of well-thought-out hands-on workshops, all the teachers could do was to do what seemed right in their own eyes.

This notion above concurs with Gonzales, Moll and Amanti (2005), who consider community elders as bearers of funds of knowledge. Also, as Stephen (2000) has argued, the factors that could result in the provision of a culturally responsive curriculum in which the community elders or experts take part must be done in a way that such experts' knowledge are not exploited without due compensation either in terms of recognition or in some other equitable way. As South Africa embraces and pursues the indigenization agenda, there will be need to connect with elders and draw from them the knowledge that could soon disappear due to forces of globalization (Katz, 2004). Maintaining cultural knowledge is one of the principal tasks of education. However, South Africa has several micro-cultures that have origins in different tribes. Therefore, successful implementation of Indigenous science will require a systematic way of documenting cultural knowledge. To do that, there will be need to set up a database as well as identify data collectors and the custodians of data and this is what the Science and Indigenous Knowledge Project (SIKP) at my university is presently busy doing.

Opportunities emanating from engaging in indigenizing the science curriculum might include:

- addressing issues of diversity across cultures in South Africa (thereby providing scientific programs that are relevant to both culture and science);
- teaching science by using locally available resources from various places in South Africa;
- training school teachers and teacher-educators to validate and document their self created knowledge which conform the science agenda, and also
- boosting self concept, identity, and self determination among both teachers and learners.

Above all, science would open windows for co-construction of knowledge between teachers and community elders, which would better address place-based learning. In the end, teachers would then ably function as expert elders in the social construction of knowledge in science classrooms, after interaction with elders.

Apart from the legacies of the erstwhile apartheid system of education and its dehumanizing agenda particularly in relation to IK, there are challenges relating to making IK part of the school curriculum (Carter, 2006). The issues to grapple with should, therefore, shift from mere rhetoric and debates about whether IK is compatible with science but how to make the teaching of school science socially and culturally relevant to the learners

The current emphasis in South Africa is quality education for all. This slogan has become a rallying symbol of an educational ideology that signifies a drastically different approach to the process of education. To achieve this goal equity and quality education implies training a calibre of teachers with both the requisite qualification as well as the disciplinary and pedagogical content knowledge that make them to become change agents rather than mere purveyors of decontextualized knowledge. Indeed, in the current multi-cultural South African classroom it would be insensitive for a teacher to assert that his/her business in the classroom is to teach physics or chemistry per se without caring for the varied background of his/her students (learners in South Africa).

The introduction of Indigenous knowledge (IK) into the school curriculum has added another dimension to the challenges teachers face today. When all this is combined with the legacies of colonialism and apartheid past the situation assumes an even more complex setting. Whatever the different stances concerning the introduction of IK there appears to be a convergence of interests both on the part of the policy makers and curriculum developers on the one hand and the teachers, learners, parents and the public on the other about the need for quality and socio-culturally relevant education. Besides, all are irrevocably committed of an education system that produces capable men and women who strive for education not only in terms of goods and services but also who are able to use education as a platform for socio-economic mobility while at the same time are proud of their socio-cultural identity as a people group within a pluralistic society. Against such a background and solid alliances, the responsibilities of science education and science teachers in particular in South Africa and perhaps elsewhere with similar political histories have assumed a new dimension. Based on the findings of this exploratory case study and earlier studies in the area (e.g. Aikenhead & Jegede, 1999; Atwater, 1996; Bryan & Atwater, 2002; Ogunniyi, 2004, 2007a & b, 20011a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008; Suriel & Atwater, 2012), the issue of introducing IK into the science curriculum and preparing teachers to teach such a curriculum seems to be overdue. Hence, the new inclusive science-IK curriculum in not a wild adventure, it is a worthwhile endeavour that value people and what they value

Currently, 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 the pre-service teachers. This task demands a genuine commitment on the part of the pre-service teachers to see to it that the integrating science and IK in their classrooms becomes a reality. However, for that to happen teacher trainers and other stakeholders need to ensure that appropriate levels and types of support for professional development of these would-be teachers is not compromised in any form. Quality education, relevant to the conditions of the present and future generations of learners must come in contact with teachers who are not only knowledgeable in their subjects but are able to make what they teach culturally relevant to the learners they teach. In a way the outcomes of this exploratory case study has in some way shown some promise for future research endeavors in the area.

CHAPTER FIVE

CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This study examined the effect of an argumentation instructional model on pre-service teachers' dispositions towards the new inclusive science-IK curriculum. In Chapter 4, 1 presented the findings on this issue. In view of the findings, the following conclusion and implications for various stakeholders are presented in the sections that follow:

- My involvement in a school-based research in the teaching and learning of argumentation has afforded me the opportunity to equip pre-service teachers with skills that could promote and support their use of argumentation as an instructional strategy in science lessons. However, the outcome was a mixture of positive and not so positive indications.
- While the new curriculum emphasizes classroom activities and discourses the focus seems to be the mastery of content at the expense of useful cultural values. Thus, the introduction of a new instructional strategy such as argumentation seemed to place extra demands on the pre-service teachers involved in the study. If the findings of this study are anything to go by, then the curriculum emphasis on content outcomes is unlikely to afford these teachers ample opportunities to open up the critical discussion space in their classrooms which would allow argumentation to take place.
- Furthermore, without a shift in what gets assessed in terms of teaching and learning performances, it is unlikely that some of the encouraging results observed in this research could be sustainable in the long term.
- Like earlier studies, argumentation instruction requires sufficient exposure of those who want to use it as an instructional approach (e.g. Erduran et al, 2004; Simon et al, 2006; Ogunniyi, 2004, 2007a &b, 20011; Simasiku & Ogunniyi, 2011, 2012).
- While most of the pre-service teachers were positively disposed to using argumentation instruction, the approach posed a great challenge to them. The same applies to the implementation of a science-IK curriculum in the classroom context.
- Science and IK should be allowed to co-exist as two complementing worldviews rather than use the former to replace or denigrate the latter. IK could enrich or complement learners' understanding of natural phenomena from multiple perspectives so long as they know which perspective is appropriate for a given context. Likewise

the integration of science and IK in the classroom could have a positive effect on the pre-service teachers' sense of worth as well as value their Indigenous heritage rather than denigrate it to other ways of knowing or interpreting experience(DOE, 2002, 2011; Ogunniyi, 2007a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008).

5.2 Implications for Policy

In contrast to some researchers (Desai, 1995; Pieterse, 2004 & Miller, 2008) who argue that a disjuncture exists between policy and practice, this research found that both the in-service and the pre-service 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 teachers 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) opens up a space for teachers to contextualize the teaching and choice of content and creates opportunities for dialogue between teachers and learners. On 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 IK 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 learners. 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 IK in the science curriculum and leaving such approaches to the teachers. The assessment standard of LO3 (G11) *recognizes, discusses and compares the scientific value of knowledge claims in Indigenous knowledge systems.* The approach that best fits both these descriptions is the assimilation approach. In (G12) assessment standards learners are expected to…*compare and evaluate scientific and IK 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 assimilation and integration approaches.

The NCS Life Sciences statement, exploring IK *related* to science exposes learners to different worldviews and allows them to compare…explicitly eliminates the segregation approach of keeping IK and science apart but seems to advocate the integration 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 segregation approach would be the most suitable. The policy wavers between the integration and segregation 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 IK in science lessons. The policy also needs to move to the next phase of critically addressing post-colonial discourses of power, social justice, and equity among alternative ways of knowing. This would expose teachers to the debates on IK, which might help teachers to contextualize their thinking and teaching in a broader personal, social and political context. A critique of the policy indicates that only the Life Sciences statement makes clear reference to IK in LO3, whilst in the Natural Sciences and Physical Sciences Statements, IK is addressed only in the assessment standards and illustrative examples.

Glancing references to, or implications of IK in LO3 are not sufficient to ensure that teachers would embrace IK in their lessons. IK needs 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 IK Policy (Mangena, 2005) be critiqued, as the creation of IK policy was a significant milestone and a commitment by the government of South Africa in engaging IK 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 assimilation 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 recognize IK 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.

5.3 Implications for Teachers

In the current setting of curriculum reform, overwhelming attention is being paid to the teachers 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 IK 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 IK 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 IK 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 IK 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 assimilation approach. Teachers with political affiliations may include IK for purposes of social justice and a separate and equal approach would better fit 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 integration approach.

In the teaching of science lessons, the teacher is the knowledgeable expert who has the subject content knowledge and confidence (Shulman, 1987) because he/she knows more than the learners do. These teachers have the qualifications, educational backgrounds and intellectual authority to teach science. In IK, the knowledgeable experts are located in the community and a high value is accorded to this knowledge. However, IK is not packaged as school material is. Therefore, teachers taking either the assimilation or the integration approach must first access the IK, 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, teachers 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), if the interest and belief to include it (IK) are present. This study together with other studies (Jegede, 1995; Garrotte, 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 IK 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 IK 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 IK 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 IK. As teachers begin to teach IK 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 assimilation approach, leaning towards an empirical position may not be able to easily address issues of equity and social justice as the segregation and integration approach.

However, Ng'etich (1996) cautions, against the idea of a single integration 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 learner 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, and cultures. Therefore, many approaches to the teaching of science to include IK curricula would be more suitable. Science teachers 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 teachers 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.

5.4 Implications for Teacher Education

The study has potential value for institutions undergoing curriculum reform in teacher education programmes. The feasibility of implementing IK in science teaching means that teachers need to undergo in-depth changes especially during pre-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. It might also be concluded that the lecturer's perception of IK 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 IK 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 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 in-service teachers is necessary where they understand the critique of Western science that IK scholarship offers and the post-colonial 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 IK knowledge. However, effective practice is not simply a matter of adequate knowledge. Besides the IK 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 questionnaire and from the teachers' stories that the B.Ed module was considered by most teachers to be their most important source of IK. In addition to re-training 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 IK, such as elders and community leaders, who are the primary sources of IK.

Teachers' willingness was found to be critical in implementation of science curricula that include IK because teachers normally teach best what they value. Teachers must want and know before they can act. If teachers do not believe in including IK 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 IK 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 IK issues in Africa and to seek ways to assist teachers to grapple with the socio-cultural aspects in a science classroom (Jegede and Aikenhead, 1999).

5.5 Implications for IK Teaching

IK to Access Western science

In the assimilation approach, particularly, IK 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.

Western science to affirm IK

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 assimilation approach. It seems that although there are those teachers who think that traditional knowledge is beneficial, it is science, they insist on validating IK against. 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, IK is not validated and all IK brought by learners are accepted. This practice of validating IK against Western science implies that science remains the valued knowledge, the useful knowledge, against which other forms of knowledge are measured. Alternatively, does this mean that IK is seen, as being inferior in status to Western science and by constant comparison tends to elevate the status of IK to that of Western science?

IK as Political Transformation

Teachers recognised that engaging in Western science and Indigenous knowledge in the classroom was in itself a transformative act not only for the curriculum per se but for their professional practice as well. Unlike the old curriculum, which encouraged transmission of information and rote learning, the new inclusive curriculum requires a radically different approach. In the latter the teacher and learners become co-constructors of knowledge. In this regard, the role of the teacher shifts from that of an all-knowing expert and purveyor of knowledge to a sensitive, vulnerable knowledge broker (Aikenhead & Jegede, 1999) willing and able to adapt to the new South African multi-cultural classroom where the negotiation and sharing of meaning becomes the order of things. It was in the light of this that this study adopted a discursive and an argumentation-based instruction as a platform for the pre-service teachers to clear their misgivings about the new curriculum as well as prepare them for the task of implementing an inclusive curriculum in their classrooms (Hewson & Ogunniyi, 2011; Ogunniyi, 2011a & b).

Having been included in the new curriculum Indigenous knowledge has gradually gained some respect in classroom discourses. In pursuit of the transformation agenda in post-apartheid South Africa, the teachers' involved in the study believed that including, Indigenous knowledge in the science curriculum was essential and valuable. Some of the reasons provided by these teachers for their choices were: (1) IK being a part of nation building, and fostering tolerance amongst learners of different cultures. (2) Development of morals, values and increasing the self-esteem of learners. (3) The importance is to learn from and respect all people in a multicultural society, namely South Africa.

IK as Science

All three of the pre-service teachers believed IK to be science but two of the teacher's classroom practices show otherwise. In the assimilation approach only that IK that related to science was considered, in the segregation approach it was not linked to science whilst only in the integrationist approach was IK perceived as science and connected to it. Generally, teachers have limited understanding of IK 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.

5.6 Conclusion

In this study, I have presented findings from my work on developing the pre-service teachers' use of argumentation in school science classrooms. The work has made progress on several fronts. First, the series of workshops and lectures meetings gave rise to a set of materials and pedagogic strategies that were structured and focused in a manner that facilitate argumentation in the classroom. The design of these workshops and the successful implementation of our interpretation of argumentation revealed in these meetings afforded a basis for further development in this area. Curriculum materials played a key role in initiating and sustaining change because they are "concrete, tangible vehicles for embodying the essential ideas of a reform" (Powell & Anderson, 2002, p. 112). Working collaboratively with teachers has resulted in the production of materials that they feel empowered to use and own.

Second, the workshops and classroom interventions with the pre-service teachers led to an initial change in practice for two thirds of the group. These findings led me to conclude that it is possible for the science pre-service teachers to adapt and develop their practice in such a way as to bring about a change in the nature of classroom discourse. During the early workshops the pre-service teachers expressed anxiety about presenting alternative theories to learners (i.e., competing explanations for how we see objects) as they thought these may cause confusion to learners and strengthen their belief in scientifically incorrect ideas; but, by the end of the year 2011, these fears had diminished. Discussion with the pre-service teachers in the final workshop showed they had come to recognize that the opportunity for learners to reflect, discuss, and argue how evidence did or did not support a theoretical explanation was beneficial to learners' engagement with scientific ideas.

Third, the two methodological approaches to the analysis of classroom discourse have provided me with new opportunities for helping the pre-service teachers to develop the teaching of ideas and evidence in science. The use of TAP enabled me to identify arguments and assess their quality. Moreover, the features of TAP have offered the pre-service teachers a language for talking about science and for understanding the epistemic nature of their own discipline. My analysis of teachers' oral contributions has enabled me to identify the kinds of teacher talk that may enable learner argumentation to proceed. The pre-service teachers who focus on the importance of talking and listening to others, conveying the meaning of argument through modelling and exemplification, positioning oneself within an argument and justifying that position using evidence, constructing and evaluating arguments, exercising counter-argument and debate, and reflecting upon the nature of argumentation begin to demonstrate implicit goals that value these aspects of argumentation.

Although I have not linked the effects of these the pre-service teachers' oral contributions to learner outcomes, the detailed analysis of the ways in which the pre-service teachers used their talk to emphasize the processes involved in argumentation in the science classroom has informed me of possible ways in which epistemic goals may be fore-grounded by the pre-service teachers. From the TAP profiles generated in this research, I have learned that the pre-service teachers are different but consistent in their practice, with the changes from one year to the next being much smaller than differences between the pre-service teachers. The variations between the pre-service teachers and the consistent pattern of TAP for each of the pre-service teacher demonstrate the uniqueness of pedagogy. In addition, the variations in the degree of change demonstrated by each of the pre-service teacher show that progression in learning is variable. The message here is that the pre-service teachers implement new ideas differently and so there are no homogeneous outcomes reinforces the work of previous studies of professional development (Harland & Kinder, 1997). If professional development is to impact on practice, such differences need to be recognized and taken into account when designing professional development for the pre-service teachers.

Our analysis of the pre-service teachers' oral contributions to facilitate argumentation showed that their initial approach to implementing argumentation was not fundamentally altered, but, rather, refined or extended over the year. Some of the pre-service teachers (e.g., Shani, Stein, and Zukiswa) demonstrated good classroom practices in the teaching of argumentation that were fine-tuned as a result of engagement in the project. It is possible that they had knowledge that is more extensive and understanding of the nature and purpose of the project, which made them more receptive to the teaching of argumentation and ownership of its aims and intentions. Franco and Zukiswa showed a willingness to promote learner discussion and use of evidence and, therefore, devoted lesson time to argumentation activities and supported the process of justification.

However, although the pre-service teachers demonstrated a knowledge and awareness of the epistemic goals of argumentation through their emphasis in their discourse on the importance of evidence and the importance of justifying scientific argument, they appeared not to have a full appreciation of the potential of oppositional discourse. Indeed, their oral contributions even discouraged it. Thus, our data would suggest that it is the pre-service teachers' initial understanding of argumentation that determines their development, particularly in the short term. If so, this would substantiate Leithwood, Janzti, and Steinbach's (1999) argument that the pre-service teachers' basic capacity for change may be dependent on their existing knowledge and understanding.

Hence, to help the pre-service teachers to make progress in their teaching of argumentation, our data would suggest that the focus of professional development should be on the pre-service teachers' existing understanding of the importance of evidence and argument in science and on their implicit goals of teaching and learning science. To this end, the research has helped to identify a tentative hierarchy of learner argumentation processes, reflected within the pre-service teachers' argumentation goals, that I believe will help the pre-service teachers to transform knowledge of the argumentation process into classroom discourse.

Learners need to learn how to listen and talk, justify claims, and so on, before they can debate; likewise, teachers need to value and learn how to implement group discussion and prompt justification before they can orchestrate effective counterargument within their teaching. Finally, we have found that developing the ability to understand and implement argumentation required the important process of reflection on previous experience. This initiates the process of reflection-in-action, or reframing (Munby et al., 2000; Munby &

Russel1, 1992; Schon, 1987) the process that helps the pre-service teachers to construct new pedagogical understanding in this case, of argumentation and its value for learning science.

Drawing on the findings from this study in terms of CAT, it appeared that the pre-service teachers were more positively organized to tolerate IKS as a potentially legitimate aspect of a science-IK curriculum. Furthermore, pre-service teachers were capable of discriminating science and IK. The pre-service teachers were also conscious of the suitable context to use for the scientific or IKS worldviews than was the case before the intervention of the Science for Teaching module. It is beneficial to discern that prior knowledge based on IK or religious worldviews can assist establish to what degree individuals from traditional communities acknowledge the scientific worldview. This is because the scientific worldview is not usually vigorous enough to elucidate the varied experiences to which such persons are exposed in their daily lives.

My data in this study demonstrated a cognitive shift in the pre-service teachers' understanding about how science relates to IK and the possibility of an integrated science-IK school curriculum. The chosen verbatim quotes exposed changes that I categorized according to Contiguity Argumentation Theory (CAT).

5.7 Recommendations

1) To make the teaching of an integrated science-IK curriculum a reality in South African schools I would recommend that training institutions should focus on equipping teachers with pedagogical skills more compatible with cross-disciplinary teaching approaches (including the use of IK experts) that provide ample opportunities for discourse reflection and authentic hands-on learning .The role of the teacher in this regard is that of a facilitator rather than a disseminator of a discontextualized knowledge (Michie, 2002; Ogunniyi, 2007a; Shumba, 1999).

2) Also, if educators are to implement C2005 successfully they should be made aware of alternative worldview perspectives, identify their merits and demerits, the similarities and the differences so that they can use the understandings gained to make wise decisions in their classrooms as well as their daily lives (Ogunniyi, 2011b).

3) Implications for future studies in teacher education include the need to trace the developmental stages in the learning to teach argumentation from apprentice to

professional. What are the learning trajectories for science teachers in getting to know how to teach argumentation? This area of research in argumentation remains relatively uncharted (e.g. Erduran, 2006; Simon, Erduran & Osborne, 2005). The nature of the contribution of argumentation studies to other aspects of science teaching is equally unknown. It will be imperative to situate argumentation in other aspects of science teaching if argumentation is to have systemic validity in professional development. It is when we, as teacher educators, figure out how we can help teachers in their mediation of disagreement with reason that argumentation studies will truly extend the historical precedence of argument embodied for centuries in Plato and Aristotle.

4) To help improve the curriculum and how content is represented, I would recommend the commissioning of research studies on the type of Indigenous knowledge that South Africans feel could boost the image of local people and bridge learners' classroom science experiences with experiences at home. In absence of such research, curriculum developers can only resort to guesswork or intuitive thinking about what they consider as valuable IK to feature in the curriculum.

5) As this curriculum (CAPS) rolls out, it might be necessary to let the pre-service teachers and teachers alike compile data that show their problems and successes in the teaching of Indigenous knowledge using argumentation as a vehicle which might reveal issues to be dealt with during the revision of the curriculum. From curriculum analysis, this study revealed that IK beliefs and taboos are exclusively represented in the negative sense. A compilation of such knowledge will increase access to such information by teachers.

6) The Ministry of Education or Higher Education could encourage research in the classroom by attaching some incentives. For example, a policy might be developed to encourage research among teachers in their classroom practice, of course with clearly stipulated incentives. This approach would enlighten teachers on how to deal with difficult areas or even new ones in science such as Indigenous science.

7) There are many issues that teachers are still not sure about how to approach the teaching about Indigenous knowledge because they probably do not know the origin of such ideas. To clear misunderstandings, I recommend that teachers must make a deliberate effort to explore reliable types of Indigenous ideas from their community. They could also try to find out reasons why their students respond to the Indigenous-knowledge-related content

in the way they observe it happen. Research would thereby illuminate both false and helpful ideas from the Indigenous knowledge pool.

8) In this way, they might be involved in development of clear frameworks about Indigenous science in a more constructivist approach. Being involved in research is likely to equip teachers with the skills that would be passed on to learners. Hence, they might develop some insights on how to engage learners in inquiry, which is one of the major tenets of constructivism. This can only happen if teachers had easy access to literature and are convinced about the benefits for research.

9) It is therefore imperative to find ways of helping the teachers to improve their organization of content in order to give them room for engaging learners in meaningful scientific experiences in schools. Through the experiences learned from my current study which endeavoured to find out issues that the pre-service teachers are likely to grapple with during the implementation of Science-IK curriculum.

10) It is anticipated that the execution of the Argumentation Instructional Model (AIM) course to a larger group of pre-service teachers for a much longer period as a dedicated university module coupled with methodical mentoring would afford a intelligible picture about the effectiveness or otherwise of the course.

11) Affirming South Africa's Commitment to Science-IK Curricula

- South Africa should affirm that Indigenous knowledge is an integral and essential part of the national heritage of South Africans that must be preserved and enhanced for the benefit of current and future generations.

- Government and private sector should work together to ensure that IK is respected and promoted in all funded educational programs an in an appropriate range of documents and contexts.

12) Affirming Traditional Lifestyles and Intergenerational use of IK

- South Africa must recognise and affirm that IK requires the protection of the lifestyles that permit intergenerational use of the lands, traditional ecological practices, and maintenance of cycles of interaction with species and land reforms in a traditional lifestyle of hunting, fishing, trapping, and foraging for foods and medicinal plants

13) Supporting Professional Capacity Building for South African Education

- Whereas decolonising theory and research are required for Africa as a whole, South Africa should identify and target incremental Indigenous graduate student and professional development of PhDs in a target period of time.

- This should be aimed at changing the ‘apex’ and maintaining the usual approach of making change from early childhood up. In this way, educational transformations occur from two directions as the current model of top-bottom approach suggests. These targets of funding and support should be directed to South Africans graduate and professional students who develop a consciousness of developing their credentials to benefit South African people and to contribute to development. This is to produce individuals working with communities, not careerist or remote academics.

14) Affirming a Culturally Responsive Curriculum as Stephens (2001) suggests below:

- It begins with topics of cultural significance and involves local experts.
- It links science instruction to locally identified topics and to science standards.
- It provides substantial blocks of time and provides ample opportunity to students to develop deeper understanding of culturally significant knowledge linked to science.
- It incorporates teaching practices that are both compatible with cultural context, and focus on student understanding and use of knowledge and skills.
- It engages in ongoing authentic assessment that subtly guides instruction and taps cultural and scientific understanding, reasoning and skill development tied to standards.

15) According to Stephens (2001), culturally responsive curriculum bears the following strengths:

- It recognizes and validates what children know and builds upon that knowledge towards a more disciplined and sophisticated understanding from both Indigenous and Western perspectives.
- It taps the often-unrecognized expertise of local people and links their contemporary observation to vast historical database gained from living on land.
- It provides for rich inquiry into different knowledge systems and fosters collaboration, mutual understanding and respect.
- It creates a strong connection between what the students experience in school and their lives out of school.
- It creates content standards from multiple disciplines

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APPENDIX A: INDIGENOUS KNOWLEDGE QUESTIONNAIRE

Characteristics of Indigenous Knowledge Systems Questionnaire

Part A

Gender: **Male ( )**	**Female: ( )**	**Age:**	**ID no:**	
Grade you have taught/are still teaching: ( )		**Years of teaching experience:**		
Religion: Christian ( ) Moslem ( )	**Others:**	**Home Language:**		
Race: African ( ) 'Coloured' ( )	**Indian ( ) White ( ) Others:**			

Indicate your ID for follow-up purposes only. Your anonymity is guaranteed.

Part B

Characteristics of Indigenous Knowledge Systems Questionnaire

One of the aims Learning Outcome 3 (LO3) of the RNCS for the Natural Sciences is that learners should be helped to integrate their traditional worldviews with the scientific worldview they learn at school. This implies that **science teachers themselves are knowledgeable of the nature of both worldviews**. The questions below are intended to explore the status of this knowledge among prospective and practicing teachers and how to help them perform this important task effectively.

Please answer each question as honestly and as fully as you can.

Please indicate the source of your scientific understanding: e.g. arising from books (B), media (M), institutions (I), etc., and the source of your personal explanation: e.g. arising from family (F), religious (R) or cultural (C) beliefs.

Question 1

Many scientists believe that the universe occurred by chance, and since then has been undergoing continuous evolution. On the other hand, many people adhere to the religious or cultural view that a supernatural being created and controls the workings of the universe. Express your candid opinion on both worldviews.

a) Scientific understanding:

____

____

Source: ……………………………………………………………………

b) Personal understanding:

____

____

Source:……………………………………………………………………

Question 2

A girl suffering from severe hysteria (excessive or uncontrollable fear) could not be cured in a modern hospital but was cured within a week by a traditional healer. What is your view in terms of your:

a) Scientific understanding:

____

____

Source: ……………………………………………………………………

b) Personal understanding:

____

____

Source:……………………………………………………………………

Various opinions and explanations have been expressed about 'after life' such as: (a) when a person dies, his/her soul and/or spirit lives; (b) the brain does not stop immediately the heart stops, so 'after life' experience is like a dream stored up in the brain before it stopped working; (c) a person's soul and/or spirit does not die with his/her body; (d) the soul and/or spirit leaves the body at death but may return to the same body if it cannot find a body in the other world.

Indicate the source from which your view has been derived e.g. if your view is based on your religious belief place **R** under Source.

Please complete the following table:

Scientific understanding			
STATEMENT	Agree/Disagree	Reason(s)/Examples:	Source
(a) When a person dies, his/her soul and/or spirit lives.			
(b) The brain does not stop immediately the heart stops so 'after life' experience is like a dream stored up in the brain before it stopped working.			
(c) a person's soul and/or spirit does not die with his/her body			
(d) The soul and/or spirit leave the body at death but may return to the same body if it cannot find a body in the other world.			
Personal understanding			Source
STATEMENT	Agree/Disagree	Reason(s)/Examples	
(a) When a person dies, his/her soul and/or spirit lives			
(b) The brain does not stop immediately the heart stops so 'after life' experience is like a dream stored up in the brain before it stopped working.			
(c) A person's soul and/or spirit does not die with his/her body			
(d) The soul and/or spirit leaves the body at death but may return to the same body if it cannot find a body in the other world.			

Question 4

Scientists describe the occurrence of the rainbow as a result of the refractive dispersion of sunlight. However, in many traditional beliefs, the rainbow is seen as a good or bad omen. What is your view in terms of your:

a) Scientific understanding:

Source: …………………………………………………………………………

b) Personal understanding:

Source:…………………………………………………………………………

Question 5

Lightning is an electric discharge in the atmosphere. The very large and sudden flow of the charge that occurs in lightning has enough energy to kill people or do serious damage to buildings or infrastructures. In many traditional beliefs lightning can come from other sources. What are your views in terms of your:

a) Scientific understanding:

____

____

Source: ……………………………………………………………………………

b) Personal understanding:

____

____

Source:……………………………………………………………………………

Question 6

A learner asked her classmate, "How did the world come about?" Her classmate replied, "Science states that it probably occurred by chance or due to the force of a big bang or something like that." The first learner then asked further, "Where did the force that produced the bang come from?" Her classmate retorted, "I don't know, ask the science teacher."

What is your view about the ideas expressed above in terms of your:
a) Scientific understanding:

____

____

Source:……………………………………………………………………………
b) Personal understanding:

____

____

Source:……………………………………………………………………………
Do you or your learners ask similar questions? Yes/No
c) If yes, please give an example, if no, please try to explain why you think this is so:

____

____

d) How would you deal with such questions if they were asked in your class?

____

____

Question 7
What ideas of IK do you hold at the beginning of Science for Teaching 112 module?

(a) Ideas about IK before the module:

____

____

(b) Ideas about IK after the module: [To be completed at the end of the course]

____

____

(c) How has the knowledge of IK gained from the module influenced (or will influence) your instructional practice?

____

____

(d) Based on your knowledge of IK gained from the module, do you think that the IK worldviews should also be presented alongside the scientific worldview? Express your view.

____

____

(e) From what you gained from the workshops, do you think that the content of the workshops should be of part of the training needed by science teachers to implement LO3 dealing with IK? Explain:

____

____

(f) Do you have other suggestions on how higher institutions can prepare science teachers adequately for the implementation of C2005 dealing with IK?

____

____

APPENDIX B: TEACHER INTERVIEW NOTIFICATION
Teacher Interview Notification Memo

From: Mr. Simasiku Siseho, PhD Student: School of Science and Mathematics Education
University of the Western Cape

To: BEd Pre-Service Teachers (3rd Year 2010 and 4th Year 2011)

Date: Wednesday, 21 July 2010.

Subject: Notification and scheduling for interviews.

Dear participant:

This is to notify you that I will be conducting interviews with you after going through all classroom observations. This is in line with your earlier agreement (in May 2010) to participate in this study as stipulated in the verbal consent, which included acceptance to be interviewed. I am ready to conduct the interview with you beginning from Wednesday, 28 July 2010 to 25 August 2010. Feel free to choose a date for the interview and time within the range of days that I have indicated. When you are decided, indicate the date and time that you feel will be convenient for the interview and indicate your name and signature in the space provided below:

Date: ______________________________ Time: __________________________

Name: _____________________________ Signature: __________________________

APPENDIX C: LESSON OBSERVATION SCHEDULE

SIKS LESSON OBSERVATION INSTRUMENT

Name of Observer: ____

Educator Being Observed: ____

Name of Educator's School: ____

Date of Observation: ____

Topic of Lesson (describe in detail):

____

____

Consent by Educator:

I consent to having my lesson observed today. I understand that this is part of a research project under the direction of Professor M.B. Ogunniyi at the University of the Western Cape. The Observer explained the basic point of the research project to me. I understand that there are no implications (positive or negative) for my school, the learners, or myself as classroom instructor.

Instructor Signature:
Date:

The Rating Scales

The 5-point rating scale shows the frequency of actions taking place. It is not a judgment of the quality of these actions. The meanings of the numbers are:

1 – **Not at all**
2 – **Occasionally**
3 – **Some of the time**
4 – **A lot of the time**
5– **Frequently**

Please note: Some of these items are intentionally constructed negatively.

TOULMIN'S ARGUMENTATION PATTERN (TAP)-BASED SCIENCE LESSON	RATINGS (circle)				
The educator:	*N*	*O*	*S*	*A*	*F*
1.1 Demonstrates he/she is acquainted with TAP	1	2	3	4	5
1.2 Confidently uses TAP as an instructional framework in this class	1	2	3	4	5
1.3 Promotes an "argumentation space" in his/her opening preamble	1	2	3	4	5
1.4 Gives learners specific roles e.g., prepare an appropriate argument for/against the claim	1	2	3	4	5
1.5 Encourages learners to bring supportive materials as backup for/against the claim	1	2	3	4	5
1.6 Assists learners in seeing, accepting, and correcting the mistakes in their arguments	1	2	3	4	5
1.7 Uses tact and good humor when critiquing a student	1	2	3	4	5
1.8 Exemplifies a scientific argument in the lesson	1	2	3	4	5
1.9 Invites learners to take a position and argue for or against it, resulting in claims	1	2	3	4	5
1.10 Encourages learners to justify their claims with evidence e.g., "how do you know?"	1	2	3	4	5
1.11 Plays devil's advocate (e.g. posing provocative questions) in the argument with learners	1	2	3	4	5
1.12 Continually evaluates the quality or validity of learners' arguments	1	2	3	4	5
1.13 Gives learners feedback about their arguments	1	2	3	4	5
1.14 Encourages learners to reflect on their argumentation process	1	2	3	4	5
1.15 Encourages learners to refine their arguments and argumentation skills	1	2	3	4	5
1.16 Asks probing or higher-order questions (analysis, synthesis, evaluation, etc.)	1	2	3	4	5
1.17 Identify the types of argumentation that occurred in this lesson (check all that occurred and the frequency of occurrence), using the following TAP levels:	1	2	3	4	5
[ ] only claims/counter-claims	1	2	3	4	5
[ ] claims/counter claim with data, warrants, &/or backup	1	2	3	4	5
[ ] claims/counterclaims with data, warrants, &/or backup plus occasional rebuttal	1	2	3	4	5
[ ] claims with rebuttals	1	2	3	4	5
[ ] extended arguments with more than one rebuttal	1	2	3	4	5

Please add further description about this educator's ability and willingness to use TAP:

…………………………………………………………………………………………….

…………………………………………………………………………………………….

……………………………………………………………………………………………..

CONTIGUITY ARGUMENTATION THEORY (CAT)-BASED SCIENCE/IK LESSON	RATINGS (circle)
The educator:	*N O S A F*
2.1 Uses the CAT to facilitate the integration or a fair comparison of science and IK	1 2 3 4 5
2.2 Is aware of the prevalent IK of his/her learners	1 2 3 4 5
2.3 Is sensitive to the IK of the learners	1 2 3 4 5
2.4 Creates an argumentation space that incorporates the IK of individuals or groups	1 2 3 4 5
2.5 Includes IK valued in the learners' communities in his/her lesson preparation	1 2 3 4 5
2.6 Clearly values learners' espoused IK	1 2 3 4 5
2.7 Exemplifies IK-based arguments (e.g., religious beliefs) in a science class	1 2 3 4 5
2.8 Allows learners' IK to influence their stances regarding a scientific claim	1 2 3 4 5
2.9 Allows learners' IK to influence their counter-claims or rebuttals	1 2 3 4 5
2.10 Prevents learners from justifying their claims on the basis of the IK in their communities	1 2 3 4 5
2.11 Portrays learners' IK as nonsensical, silly, or irrational	1 2 3 4 5
2.12 Calls learners' attention to instances where IK and scientific arguments agree/disagree	1 2 3 4 5
2.13 Clarifies for learners where IK-based arguments are/are not appropriate	1 2 3 4 5
2.14 Uses IK information in counter-arguing or debating If so, how? ………………………………………………………………………………………………….. ………………………………………………………………………………………………….	1 2 3 4 5
2.15 Makes learners aware of how their personal IK influenced their argumentation skills (Describe)... ……………………………………………………………………………………………… ………………………………………………………………………………………………	1 2 3 4 5
2.16 Uses the following CAT categories during the lesson (check those that apply) and rate the frequency these categories occurred during the lesson:	
[ ] Dominant conceptions	1 2 3 4 5
[ ] Suppressed conceptions	1 2 3 4 5
[ ] Assimilated conceptions	1 2 3 4 5
[ ] Emergent conceptions	1 2 3 4 5
[ ] Equipollent conceptions	1 2 3 4 5
Please add further description about this educator's ability and willingness to use CAT: ………………………………………………………………………………………………… …..	

APPENDIX D: ETHICAL CLEARANCE
Institutional Senate Research Committee Approval

OFFICE OF THE DEAN
DEPARTMENT OF RESEARCH DEVELOPMENT

Private Bag X17, Bellville 7535
South Africa
Telegraph: UNIBELL
Telephone: +27 21 959-2948/2949
Fax: +27 21 959-3170
Website: www.uwc.ac.za

21 June 2011

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape has approved the methodology and ethics of the following research project by: Mr SC Siseho (School of Science and Mathematics Education)

Research Project:	The effect of an argumentation instructional model on teachers' ability to implement a science-IKS curriculum
Registration no:	10/8/25

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

UNIVERSITY of the WESTERN CAPE
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APPENDIX E: PARTICPANT CONSENT LETTER
Consent for Teachers

Researcher: Mr. Simasiku Siseho, PhD Student

Institution: School of Science and Mathematics Education: University of the Western Cape

This statement will be read to the pre-service teacher participant and audio-recorded. Pre-service teachers will have an opportunity to agree or not to participate in the study. I am conducting a study to learn how Indigenous science topics will be taught in the new curriculum using argumentation instruction model during its implementation in South Africa. I would like to observe you teach and interview you after you have taught all the work that you will plan from the new curriculum, to learn how you teach about Indigenous knowledge and you are at liberty to choose any science topic that is included in the new curriculum. I would also like to read your planned work and your personal evaluations, after teaching your lessons, on the two topics, after using the new learning materials (i.e. Syllabus, teacher's guide and learners' book).

The interview, to be conducted at the very end of your teaching will last about 35 minutes and classroom observations will be video recorded. The images on the video of teachers and children may be shown at professional meetings for educational purposes. I may also use the information collected to publish the reports in professional journals. You will have an opportunity to review any papers from this research project before they are submitted for publication. I will not identify you by your actual name in papers or videotapes of your teaching, unless you request that I do. This research will help me understand the issues that are likely to emerge when integrating science and Indigenous knowledge in the newly reformed curriculum in South Africa. You may choose to participate in this study by agreeing to the following statements:

- Do you agree to participate in the study? ___________________________________
- Would you prefer to use you real name in published reports or in videotapes of your teaching? ___________________________________
- You may choose not to participate in this study at anytime by notifying your principal.

Name of Participant:___________________________________

Researcher Signature:__________________________________

Witness Signature:____________________________________

Date:____

APPENDIX F: ENQUIRY SETS

Inquiry Sets (Start-of-semester questions)

1. What in your view is argumentation science teaching?
2. What makes argumentation instruction in science different from other disciplines of inquiry (e.g., religion or philosophy)?
3. What do you want your learners to "carry away" from their learning experiences?
4. What role should discourse (conversation or argumentation) play in secondary school science classrooms?
5. In a best case scenario, what should argumentation science teaching "look like?" What should be the roles of learners and teachers in the science classroom?
6. Select one of the scientific theories below; briefly describe the theory and justify its acceptance. Answer this question as if you were trying to establish the legitimacy of the theory to someone who was unfamiliar with the theory.
   a) Atomic structure
   b) Evolution
   c) Plate tectonics
   d) Relativity

Inquiry Sets (End-of-semester questions)

1. How have your ideas about argumentation science teaching changed throughout your experiences this semester?
2. How did you use (or not use) argumentation in your student teaching classroom(s)?
3. If you incorporated argumentation, describe how you did this (providing specific examples of what you did) and discuss how well it worked or did not work.
4. If you did not incorporate argumentation, discuss why you opted not to use argumentation.
5. Make an argument for one of the positions below. (Select one side of the argument to defend).
   a) Nuclear power should/should not be used for the generation of municipal electricity.
   b) New lines of embryonic stem cells should/should not be harvested for medical research.

APPENDIX G: IKS INTERVIEW PROTOCOL A

IKS Interview Protocol A

Question 1

Many scientists believe that the universe occurred by chance, and since then has been undergoing continuous evolution. On the other hand, many people adhere to the religious or cultural view that a supernatural being created and controls the workings of the universe. Express your candid opinion on both worldviews:

Question 2

A girl suffering from severe hysteria (excessive or uncontrollable fear) could not be cured in a modern hospital but was cured within a week by a traditional healer. What is your view?

Question 3

Various opinions and explanations have been expressed about 'after life' such as: (a) when a person dies, his/her soul and/or spirit lives; (b) the brain does not stop immediately the heart stops, so 'after life' experience is like a dream stored up in the brain before it stopped working; (c) a person's soul and/or spirit does not die with his/her body; (d) the soul and/or spirit leaves the body at death but may return to the same body if it cannot find a body in the other world.

Question 4

Scientists describe the occurrence of the rainbow as a result of the refractive dispersion of sunlight. However, in many traditional beliefs, the rainbow is seen as a good or bad omen. What is your view in terms of your:

Question 5

Lightning is an electric discharge in the atmosphere. The very large and sudden flow of the charge that occurs in lightning has enough energy to kill people or do serious damage to buildings or infrastructures. In many traditional beliefs, lightning can come from other sources. What are your views in terms of your:

Question 6

A learner asked her classmate, "How did the world come about?" Her classmate replied, "Science states that it probably occurred by chance or due to the force of a big bang or something like that." The first learner then asked further, "Where did the force that produced the bang come from?" Her classmate retorted, "I don't know, ask the science teachers."

a) What is your view about the ideas expressed above in terms of your:

b) Do you or your learners ask similar questions? Yes/No

If yes, please give an example, if no, please try to explain why you think this is so:

c) How would you deal with such questions if they were asked in your class?: