Social and Cultural relevance of aspects of Indigenous knowledge systems (IKS), Meteorological Literacy and Meteorological Science Conceptions

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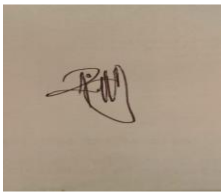
Key Words

Indigenous Knowledge Systems (IKS), Meteorological Literacy, Meteorological Science, Conceptions, Weather Patterns, Social and Cultural Factors, Dialogical Argumentation Instructional Model (DAIM), Weather prediction, Attitudes to Weather, Weather Forecast

DECLARATION

I declare that **Social and Cultural relevance of aspects of Indigenous Knowledge Systems (IKS), Meteorological Literacy and Meteorological Science Conceptions** is my own work, that all the sources I have used or quoted have been indicated and acknowledged by means of complete references, and that this work has not been submitted previously in its entirety, or in any part, at any other higher education institution for degree purposes.

…………………………………….

ALVIN DANIEL RIFFEL APRIL 2020

DEDICATION

For my children Alley, Riley and Brady-Ambrose

This work is all possible by the Almighty Lord. I thank Him for all His mercies and blessings He has bestowed upon me – this research work would not have been possible without His spiritual guidance and protection. To my thesis supervisor Dr Melanie Bernadette Luckay, I thank you sincerely for your guidance and constant support – I really value your academic support and advice throughout this long journey without giving up on my dreams. A BIG thank you to Emeritus Professor Meshach B. Ogunniyi, whom believed in me since the day he took me under his wings – your *spirit of Ubuntu* is the Mastery art of Wisdom – thank you for your "Baptism of Fire" upon me, and make me understand that "all humanity is connected through a universal bond of sharing".

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Editor's Letter

16 Chaucer Road
Claremont
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10 December 2018

<u>To whom it may concern</u>

In 2018 I edited Alvin Daniel Riffel's PhD thesis:

'Social and Cultural relevance of aspects of Indigenous Knowledge Systems (IKS), Meteorological Literacy, and Meteorological Science Concepts'.

The editing process included proofreading, style improvement formatting and referencing as set out in the *University of the Western Cape Thesis Guide* and the APA referencing guide.

I have 13 years professional academic editing experience, six of those full-time and am a full member of the Professional Editors Guild. I am also on the UCT vending list.

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ABSTRACT

This research study examines those aspects of Indigenous Knowledge (IK) that could be socially and culturally relevant in the Western Cape Province, South Africa, for teaching meteorological science concepts in a grade 9 Social Science (Geography) classroom using dialogical argumentation as an instructional model (DAIM). The literature reviewed in this study explains the use of argumentation as an instructional method of classroom teaching in particular dialogical argumentation, combined with IKS (Indigenous Knowledge Systems), which in this study is seen as a powerful tool both in enhancing learners' views and positively identifying indigenous knowledge systems within their own cultures and communities, and as tool that facilitates the learning of (meteorological) literacy and science concepts. With the development of the *New Curriculum Statements* (NCS) and the *Curriculum and Assessment Policy Statements* (CAPS) for schools, the Department of Basic Education (DBE) of South Africa acknowledges a strong drive towards recognising and affirming the critical role of IK, especially with respect to science and technology education. The policy suggests that the Department of Education take steps to begin the phased integration of IK into curricula and relevant accreditation frameworks.

Using a quasi-experimental research design model, the study employed both quantitative and qualitative methods (mixed-methods) to collect data in two public secondary schools in Cape Town, in the Western Cape Province, South Africa. A survey questionnaire on attitudes towards, and perceptions of high school, of a group of grade 9 learners, as well as their conceptions of weather, was administered before the main study to give the researcher baseline information and to develop pilot instruments to use in the main study. An experimental group *(E-group)* of learners were exposed to an intervention - the results were recorded against a control group *(C-group)* that were exposed to no intervention. Both the *E-group* and *C-group* were exposed to a Meteorological Literacy Test (MLT) evaluation before and after the DAIM intervention. The results from the two groups were then compared and analysed according to the two theoretical frameworks underpinning the study, namely, Toulmin's Argumentation Pattern - TAP (Toulmin, 1958) and Contiguity Argumentation Theory - CAT (Ogunniyi, 1997).

The findings of this study revealed that: Firstly, the socio-cultural background of learners has an influence on their conceptions of weather prediction and there was a significant difference between boy's and girls' pre-test conceptions about the existence of indigenous knowledge systems within the *community* they live in. For instance, from the learners' excerpts, it emerged that the girls presented predominantly rural experiences as opposed to those of the boys which

were predominantly from urban settings. Secondly, those *E-group* learners exposed to the DAIM intervention shifted from being predominantly equipollent to the school science to emergent stances and they found a way of connecting their IK to the school science. The DAIM model which allowed argumentation to occur amongst learners seemed to have enhanced their understanding of the relevance of IK and how its underlying scientific claims relate to that of school science. Thirdly, the argumentation-based instructional model was found to be effective to a certain extent in equipping the in-service teachers with the necessary argumentation skills that could enable them to take part in a meaningful discourse.

The study drew on the personal experiences and encounters from a variety of sources. These included storytelling-and sharing, academic talks with local community members recorded during the research journey, formal round table discussion and talks at international and local conferences, conference presentations, informal interviews, indigenous chats at social event-meetings, and shared experiences at IKS training workshops as a facilitator. These encounters lead to the formulation of the research study and occurred throughout the country in various parts of the Southern African continent including: Namibia, Zimbabwe, Malawi, Botswana, Tanzania and Mozambique.

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DEFINITION OF TERMS

Assessment - A means of evaluating students' understanding or knowledge using a form of achievement test, questionnaires or interviewing process.

Conception - A mental idea or one's perception about the nature of a given subject matter.

Cognitive Synchronization - May be defined as a cognitive process that allows an effective spatial orientation due to the continuous synchronization between two kinds of representation

Environmental Education (EE) - Is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, Tbilisi Declaration, 1978).

Glocalization - The practice of conducting business according to both local and global considerations.

Indigenous Knowledge Systems (IKS) - A system of thought peculiar to people of a local geographic location or socio-cultural environment (Ogunniyi, 2008: 6)

Meteorology (Earth Sciences / Physical Geography) - A study of the earth's atmosphere, especially of weather-forming processes and weather forecasting

Nature of Science (NOS) - All explicit or implicit underlying assumptions underpinning the epistemology of science.

Nature of Indigenous Knowledge Systems (NOIKS) - All explicit or implicit underlying assumptions underpinning the epistemologies of indigenous knowledge systems.

Revised National Curriculum Statement - A policy document setting guidelines for curriculum implementation in the General Education and Training band of the education system in South Africa

Science/IKS curriculum - This term refers to the new South African school science curriculum especially Outcome 3 which calls on teachers to integrate IKS with school science school science.

Socio-cultural Critical Constructivism - Constructivism that takes cognizance of learners' socio-cultural environment.

Worldview - To Kearney (cited by Ogunniyi, et al, 1995) "A world is a culturally organized macro-thought: those dynamically interrelated assumptions of a people that determine much of their behavior and decision making, as well as organizing much of their body of symbolic creations…and ethno-philosophy in general" (p. 818).

ABBREVIATIONS

AASIKS: African Association for the Study of Indigenous Knowledge Systems

ANA: Annual National Assessments

C2005: Curriculum 2005

CAPS: Curriculum and Assessment Policy Statements

CAT: Contiguity Argumentation Theory

CoW: Conceptions of Weather

DAIM: Dialogical Argumentation Instructional Model

DOE: Department of Education

DST: Department of Science and Technology

ELRC: Education Labour Relations Council

FET: Further Education and Training

GET: General Education and Training

IK: Indigenous Knowledge

IKS: Indigenous Knowledge Systems

ITK: Indigenous Technology Knowledge

MOE: Ministry of Education

NARST: National Association for Research in Science Teaching

NCS: National Curriculum Statements

NDOE: National Department of Education

NIKS: Nature of Indigenous Knowledge Systems

NOIKS: Nature of Indigenous Knowledge Systems

NOS: Nature of Science

NOSNIKS: Nature of science and nature of Indigenous Knowledge Systems

NOVM: Nature of Visual Modelling

NRF: National Research Foundation

NSES: National Science and Education Standards

MLT: Meteorological Literacy Test

OBE: Outcomes Based Education

PGCE: Post Graduate Certificate of Education

RNCS: Revised National Curriculum Statements

RPL: Recognition of Prior Learning

SACMEQ: Southern African Consortium for Monitoring Education Quality

SAARMSTE: Southern African Association for Research in Mathematics, Science and Technology Education

SCIKQ: Social and Cultural Indigenous Knowledge Questionnaire

SIKSP: Science and Indigenous Knowledge Systems Project

SK: Science Knowledge

SSME: School of Science and Mathematics Education

TAP: Toulmin's Argumentation Pattern

TEK: Technology Environmental Knowledge

TIMSS: Trends in International Mathematics and Science Study

VIKQ: Views of Indigenous Knowledge Questionnaire

UNESCO: United Nations Educational, Scientific and Cultural Organisation

CHAPTER 1 - ORIENTATION OF THE STUDY

1.1 Introduction

The South African education system is shaped by the values informed by the constitution, which aims to lay a foundation for a unified, equal and democratic society (Department of Basic Education, CAPS 2011; Jansen & Tyler, 2003). Since 1994 the school curricula have evolved to provide a curriculum framework to be both appropriate for, and inclusive of all learners at all levels. The approach to classroom teaching is to promote learner-centred education (CAPS, 2011). This approach have been interpreted differently across subject areas, having a direct impact on teachers and their classroom pedagogy. The current study explored indigenous knowledge systems (IKS) as a new and different pedagogical tool to direct Science teachers' classroom teaching to support their pedagogical practices. The research methodology will also extend its investigation with 16 high school teachers' on how to adapt current classroom science teaching into an IK-planned science lesson. Thus, such an approach would provide for a more relevant inclusion of knowledge that would cater for all learners from all cultural groupings in the diverse South African society. The chapter gives a background to the development of post-apartheid science education policy in South Africa and describes how the first democratically elected government construed the education system as a way to acknowledge and develop all the cultural groups in South Africa.

1.2 Background and Rationale

Internationally curriculum changes occur as a means of addressing flaws experienced with implementation, there are also various external influences that lead to the change of a curriculum. *Globalisation* of Education had a big impact on the education policies of South Africa—our education system needs to adhere to global demands and standards within education. With reference to Christie (2008), globalisation can be seen as a new period in time where working organisations mainly operate through technology and demands workers to have knowledge and expertise on how to use technology. It is because of the demand for individuals to be part of this universal technological world that schooling has been impacted. Globalisation demands schools to teach certain curricula preparing learners for the world of work—schools need to teach learners how to use technology if they want to be part of the global economic world or earn a decent family income. Organisations such as; *International Monetary Fund* (IMF), *World Trade*

Organisation (WTO) and the *World Bank* (WB) sets and monitors the rules of the global economy including education. These organisations have the biggest influence on global education as they set the benchmark for the standard and quality of education (Christie, 2008). Another organisation who was at the forefront of the changes on the global education system— is the *United Nations Educational, Science and Culture Organisation* (UNESCO). In 1994 at the UNESCO World conference—global education system took a turn where inclusive education was introduced. This was done in view to ensure that every education system globally, will be globally acceptable and recognised.

Given these trends, the role of inclusivity featured prominently in the development of the South African curricula since 1994. The history of the changes in the school curriculum after 1994 included the abolition of the separate racially categorised education departments and the formation of one national department in the process of reversing the Apartheid legislated segregated education system. It also described the effects of the Bantu Education Act of 1953, and how these continue to be felt in an unequal South African education system, one which continues to effectively exclude the majority of black people from participation in the economic, political and social domains of South Africa (Christie & Collins, 1982; Jansen & Tylor, 2003; Giliomee, 2005).

But as the curricula evolved through the critiques of stakeholders that shaped its implementation. For instance, in 1998, critiques of outcomes-based education (OBE) were for instance, excessive workloads and administrative duties, the absence of proper guidelines, and a lack of resource materials. Difficulties also arose over implementing group work in classes of learners with mixed abilities (Schwarz & Canvener, 2000). Jansen and Christie (1999) expressed doubts about the ineffectiveness of group work as a teaching strategy in terms of giving a true reflection of each learner's competence. In the early 2002's, in response to these critiques, a more streamlined curriculum the *Revised National Curriculum Statement* (RNCS) was tabled. The changes, while based on the same principles as those of OBE and entailing many of the core concepts of OBE, provide more guidance to teachers on the times spent on teaching per week for each learning area and specify fewer outcomes, making it easier for teachers to determine what they wish to achieve at the end of the learning programme.

In 2002, the *National Curriculum Statement* (NCS) (DoE, 2002) and the most recent curriculum policy document, CAPS (2011), from the Department of Basic Education in South Africa, included IKS in the curriculum and assessment practices, with the apparent purpose of enhancing learners' understanding of the Nature of Science (NOS), as well as developing their ability to make a positive connection to cultural knowledge that will help them acquire an awareness of the diversity of cultural beliefs and knowledge of diverse groups in their diverse society and country to empower learners towards meaningful citizenship.

The RNCS (2002) describes *the kind of teacher it envisages* for the country to be able to achieve its goal of the transformation of education with the new curriculum. The Department of Education (2002) stipulates the following:

> *All teachers and other educators are key contributors to the transformation of education in South Africa. This Revised National Curriculum Statement Grades R-9 (Schools) envisions teachers who are qualified, competent, dedicated and caring. They will be able to fulfil the various roles outlined in the Norms and Standards for Educators. These include being mediators of learning, interpreters and designers of Learning Programmes and materials, leaders, administrators and managers, scholars, researchers and lifelong learners, community members, citizens and pastors, assessors and Learning Area or Phase specialists* (Department of Education, 2002, p. 9).

This description fits the profile of a capable professional who is able to demonstrate the values and pedagogy informing the current study: in other words, through dialogical argumentation-based instruction learners should be able to develop meaningful dialogue, and group interaction that can foster and create new knowledge in learners that is of lasting value to them, both in their education and in their lives.

However, I argue that teachers need better guidance in their pedagogical practices. Of great concern is the vague explanation provided by the Department of Basic Education ostensibly guiding teachers in interpreting and implementing this section and sketchy indications of assessment strategies to be employed by teachers in using IKS in the classroom in *Specific Outcome 3.2* of the Natural Sciences Learning Area:

> ***3.2 Relationship of Indigenous Knowledge to Natural Sciences***
> *Examples that are selected (and that should, as far as possible, reflect different South African cultural groupings) will also link directly to specific areas in the Natural Sciences subject content* (Department of Education, 2002, p. 5).

Furthermore, I argue that teachers implementing these aims struggle to translate them to classroom practice. The lack of clear guidance in the curriculum results in a vague plan for implementation likely to result in varied and subjective interpretations by teachers. Moreover, this is likely to have direct pedagogical implications for the Natural Science curriculum in the majority of South African schools, many of which do not have the space, frameworks or resources to develop IKS properly.

Notwithstanding, the introduction of IKS into various Learning Areas in the National Curriculum has opened up a debate amongst IKS-researchers, curriculum developers, academics and education specialists. These would be arguments based on the premise that IKS is an integral part of any culture or society and cannot be ignored simply in the interests of creating a smoother assessment curriculum policy statement (Riffel, 2012). I would argue that, particularly in the context of calls for 'decolonisation' of the curriculum, and our diverse society, IKS forms the basis of every learning area, whether Natural Science, Life and Living Skills, or Social Sciences, and should be regarded at school level by education researchers, policy makers and practitioners as a point of departure for learning and for both acquiring and creating new knowledge (according to the Constructivist perspective underpinning the curriculum), as well as generating healthy argumentation in the classroom and amongst learners of all ages and cultures.

By the time students reach Grade 9 level, they would have an informed attitude and perception toward IKS. They might have been exposed through schooling and their home environment within varying socio-economic (SES) influences. Beets and Le Grange (2005, p. 1201) argue that in Africa "schools are the sites where most learners first experience the interaction between African and Western worldviews". They thus argue that teachers working in these contexts need to be alert, especially in a South African science teaching context, to "this type of interaction and understand the way it could complicate the learning process" (Beets & Le Grange, 2005, p.1201). Much literature has been produced over the years (see Ngcoza, 2019; Chikunda & Ngcoza, 2017; Ogawa, 1986; Koopman, 2017; Ogunniyi, 1987, 1988; Jegede, 1989; Jegede & Okebukola, 1989; Fraser, 1990) detailing the experiences of African and South African learners' learning science in the classroom. Despite this volume of literature, and the "fact that indigenous knowledge systems reside among the majority of South Africans, the topic has not been given the attention in educational curriculum development policies it deserves", resulting in a lack of attention to indigenous knowledge "in the discursive terrains of all learning areas/subjects" (Le Grange, 2007, p. 581).

Teachers are pivotal to enhance learners' IKS. Research shows that only if argumentation is specifically and explicitly addressed in the curriculum will students have the opportunity to explore its use in social science (Kuhn, 1991). However, teachers have varying experiences of IKS pedagogical implementation in their classrooms. Indeed, because science education focuses on learners' understanding of science concepts, teachers often adopt methods like transmission learning, which do not draw on reasoning, only the delivery of science facts. Using teaching methods that use argumentation with appropriate activities and teaching strategies in the social science class can provide a means of achieving a wider range of goals, including social skills, reasoning skills and the skills required to construct argument using evidence (Osborne, Erduran, & Simon 2004a). So, in order to emphasise that teachers need argumentation during teaching social science, they (teachers) need to adapt their teaching styles to more dialogical approaches (Alexander, 2005) that will involve students in class and lesson discussions, and use teaching methods to interact with students to foster argumentation skills. Then the role of 'such dialogical space' is to enhance and promote the 'process of re-articulation, appropriation and/or negotiation of meaning of the different world-views' (Ogunniyi, 2007).

The current study offers to make teachers more aware of an IKS argumentation-based type of pedagogy to facilitate and engage more with learners for better understanding of the value of cultural or indigenous knowledge. This study specifically focused on the perceptions of Grade 9 high school learners and the views they hold of world scientific knowledge and the Nature of Science (NOS) in relation to meteorological concepts, given that at this age their views are likely to be well-developed. An in-depth examination on curriculum and assessment practices to enhance learners' understanding of the Nature of Science (NOS) and IKS to enhance the ability to make a positive connection to cultural knowledge that supports IKS. The high school learners' perceptions and attitudes on the topic climate change, global warming, education, weather predictions and its cultural values within the community is highlighted. The learners' understanding of current weather prediction and in particular, prediction of local weather conditions will be the topic to be linked with IKS.

1.4 Research Problem

The *Revised National Curriculum Statement* (RNCS) (DOE, 2002) and the *Curriculum and Assessment Policy Statement* (CAPS, 2011) both suggest the need to relate knowledge in the Natural and Social Sciences to IK as a way for learners to close the gap between the knowledge they develop at home and within their communities, and what they learn at school, as well as, and related to the former, to develop a holistic understanding of their bio-physical and socio-cultural environment. In this regard the *Revised National Curriculum Statement* (RNCS) carries the expectation that learners are to be enabled to develop the 'science process skills' (RNCS, 2002, p. 4) that they need to solve the problems they encounter in their daily lives 'in the community and in the workplace' (RNCS, 2002, p. 4) later in life.

These science process skills call for the mobilization of critical thinking skills in classroom discourse. However this presupposes that learners have the freedom and opportunity for self-expression in the classroom. This form of classroom interaction, where learners are able to express their views without feeling intimidated or inferior, comes under the general umbrella of 'argumentation instruction', an approach that has been receiving increased attention in both local and international literature since the turn of the century. IKS remains on the outskirts when it comes to inclusion into educational curriculum development. Teachers fail to accept IKS as a different means to teach science education and this failure is a result of teachers not being exposed to this type of teaching themselves since they were trained in so-called "Western Science" (Ogunniyi, 2007a). Consequently, the teacher education curriculum was implemented in a top-down approach with little or no accompanying training in IK (Ogunniyi, 2007a; Onwu & Stoffels, 2005), and thus there is a lack of instructional methods and pedagogical content knowledge (Mothwa, 2011).

1.4.1 Research Questions

The study focuses on the following research questions and seeks answers with regard to the Western Cape Provence:

1. What Indigenous Knowledge Systems (IKS) do the Grade 9 learners' in the sample currently hold, if so, is this connection related to their age, social class or gender?

2. What are these learners' ideas and attitudes towards integrating indigenous knowledge system (IKS) into meteorological science?

3. What are the challenges teachers encounter in IKS-and-Science integrated Science classroom?

1.4.2 Aims of the study

The main aim of the present study is to investigate what kind of IK in the Western Cape, South Africa specifically is or could be socially and culturally relevant in teaching meteorological science concepts to Grade 9 learners, using a dialogical argumentation-based instructional model (DIAM) in a CAPS related classroom.

Emphasis is placed in the current study on how a group of learners relate socially and culturally to selected meteorological concepts and how they interpret them in the context of the current South African school curriculum. The study also aims to show how awareness among these learners about the importance of certain weather concepts is created and developed, especially in terms of how their interpretation of such concepts is developed.

1.4.3 Significance of study

After completing a research study such as the current one, one should be able to identify two major outcomes that could contribute to building national science education quality, depth, and standards in school-communities/organizations in the context of promoting indigenous knowledge systems, meteorological literacy and environmental education at any public school.

The two possible major outcomes of the study are:

- That indigenous knowledge systems education at school has the potential to promote an important public discourse concerning vital issues involving science and technology.
- That learners' exposed to indigenous knowledge (IK) become aware and share a special kind of excitement and commitment to caring about their natural world with respect to the natural environment and its related social and cultural values.

In support of the view, Ogunsola-Bandele (2009) stated that science and IKS should be allowed to co-exist. Some studies concerned with blending formal and informal knowledges have come to the conclusion that it is possible to blend formal science and informal science. However, Finley has asked another probing question relating the co-existence of the two worldview systems, that is, "how could we tell when the intersections are productive and when they are valid or not?" (Finley, 2009). In the light of the questions asked by Finley, Onwu (2009) relating to the issue of which aspects of IKS are to be incorporated in the school curriculum as well as Gunstone and White's (2000) conclusions based on the extant literature, Ogunsola-Bandele (2009), has added that, "African science educators have the challenge of searching and providing scientific explanations for traditional African culture, beliefs and superstitions" (p. 56). I concur with Ogunsola-Bandele (2009), because if areas of commonalities can be identified, there might no longer be any concerns about the quality of a Science and IKS-based curriculum.

1.5 Conceptual and Theoretical Framework

The study is underpinned by an Argumentation Framework based on Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT). In the context of classroom teaching and learning, the two theories align with and complement Vygotsky's notion of constructivism according to which an individual learns or acquires new experiences from his/her interactions with his/her physical or socio-cultural environment. While the TAP construes learning as a product of self- or cross-conversation and reflection, CAT deals with both logical and scientifically valid arguments in either explaining or clarifying scientific reasoning. This study explores the application of both TAP and CAT in the context of classroom discourse that is engaging with selected meteorological concepts.

The study used TAP and CAT theoretical frameworks because of their amenability to classroom discourse dealing with phenomena about which learners may be holding different and/or conflicting worldviews. These frameworks provide the necessary context for inductive, deductive and analogical reasoning on the part of me as researcher and learners in a classroom situation using argumentation as a learning tool. The frameworks and argumentation accord with the Piagetian and Vygotskian notion of constructivism: that knowledge is constructed as a child makes sense of the world around him/her. This type of reasoning can be used as both an instructional and learning tool for learners who constantly interact with their natural environment and with their social and cultural surroundings. Interactions with all aspects of their environment result in experiences gained in the course of which individuals come to relate to that environment in a holistic, sensitive and responsible manner. The context of a given discourse plays an important role in the amount or intensity of awareness experienced and developed by the participants in such a discourse (Ogunniyi, 2007 a & b; 2008).

1.6 Research methodology

The study falls under the umbrella of a mixed-methods research design – where both quantitative and qualitative research methods are equally important paradigms to consider towards a value-bound outcome for the totality of the study. For more than a century, debates have continued amongst advocates of social and scientific research concerning the relative validity of the two methods. The debates have purists emerging from both sides of the argument (cf. Campbell & Stanley, 1963; Lincoln & Guba, 1985).

Advocates of quantitative research such as, Ayer (1959), Popper (1959), Maxwell and Delaney (2004), and Schrag (1992) articulate the assumption that this kind of research is underpinned by 'positivist philosophy'—and that social observations should be treated as entities in much the same way that physical scientists treat physical phenomena (Johnson & Onwuegbuzie, 2004). They further contend that the observer is separate from the entities or phenomena that are subject to observation. They also maintain that social science enquiry should be objective, that 'time- and context-free generalization' (Nagel, 1986) is desirable and possible, and real causes of social scientific outcomes can be determined accurately, reliably and have total validity. According to this school of thought, educational researchers should eliminate their biases, remain emotionally detached and uninvolved with the objects of study, and test, or empirically justify, their stated hypothesis (Johnson & Onwuegbuzie, 2004). Researchers based in the quantitative approach have 'traditionally called for rhetorical neutrally, involving a formal writing style using the impersonal passive voice and technical terminology, in which establishing and describing social laws is major focus' (Tashakorri & Teddlie, 1998, p. 183).

Qualitative researchers (also called constructivist and interpretivists) reject what they call positivism. They argue and ground their research based on what they see as the superiority of constructivism, idealism, relativism, humanism, hermeneutics, and sometimes, or more recently, postmodernism (Guba & Lincoln, 1989; Lincoln & Guba, 2000; Schwandt, 2000; Smith, 1983, 1984). Those researchers following the qualitative school of thought contend that multiple-constructed realities abound, that 'time- and context-free generalizations are neither desirable nor possible, that research is value-bound, that it is impossible to differentiate fully causes and effects, and that logic flows from the specific to general. In other words, explanations are generated inductively from data, and that the knower and known cannot be separated because the subjective knower is the only source of reality (Guba, 1990). Qualitative researchers also dislike a detached/impersonal and passive style of writing; they prefer, instead to give an account of a detailed, rich and thick (empathic) description of the phenomena they are investigating, and one recorded/written directly, and often informally.

Both quantitative and qualitative researchers view their paradigms as ideal and valid, and essential to the completion of the research process; implicitly if not explicitly, they advocate the incompatibility thesis (Howe, 1988) with their associated methods, and contend that these cannot be mixed (Johnson & Onwuegbuzie, 2004). These dominant research paradigms have resulted in two research cultures. Guba (1990) argued that “accommodation between paradigms is impossible... we are led to vastly diverse, disparate, and totally antithetical ends” (Guba, 1990, p. 81). A disturbing feature of this kind of binary research paradigm is that the two dominant research approaches have resulted in a paradigm war “one professing the superiority of deep, rich observational data’ and the other the virtues of ‘hard, generalizable’ ...data” (Sieber, 1973, p. 1335).

1.7 Quality measures and ethical considerations

A research application letter was issued to the Western Cape Educational Department (WCED) to ask for permission to perform the research study at the selected schools.

A letter of consent was also addressed to the School’s Governing Body (SGB) informing them of the research aims and process, and the obligations of the study where the survey and research were to be conducted. A meeting with senior school management of the participating school was held to inform them of all pre-post intervention sessions to be conducted. A detailed timetable with schedules for classroom observation and group intervention sessions was submitted to the principal’s office.

The letter stated that all participating schools were to be entitled to a summary of the research study that was conducted for future organizational and curriculum planning. All participating learners would also be informed of the implications and value of the study and how the data were to be analyzed and interpreted, and for what purposes. A letter of consent was signed by parents of all the underage participants in the research study. All students were also informed of their rights and obligations within the research process.

The following ethical checklist was followed to ensure that the study conformed to the ethical standards laid down by the Senate Research Committee of the University of the Western Cape:

- The principals' permission letters from the two schools was sought.
- Permission to conduct the study was sought from the research department of the Western Cape Education Department (WCED) - (see Appendix B)
- The purpose and value of the study was explained both orally and in writing to all participants involved in the study.
- Teachers and learners consent was also sought.

- All interviews were strictly confidential, and a confidentiality letter was written to the schools concerned.
- Learner questionnaires were to be anonymous and confidential.
- Names of schools would be kept anonymous and no information about the schools or learners would be divulged to any person.
- At the end of the study the school principal concerned received a summary report of the findings of the study conducted in his/her school.
- Informed Consent Letter - A copy of the consent letter (see Appendix H)

The final reports on this study will be made available to the Western Cape Education Department, participants and their schools and a copy will be available at the University of the Western Cape (UWC), Bellville, South Africa. The study results will only be used for the purpose that they are being conducted for: academic purposes. Data were secured through password protected safe storage to ensure that no unauthorised persons could gain access to any information in ways that may compromise the integrity of the participants.

1.8 Limitations of the study

The researcher recognizes a number of limitations to this study. These limitations include that the subject matter used in the empirical component of the study, while under the broad banner of Social Science under the RNCS, differs for Grade 9 learners from the normal Geography subject and meteorological concepts dealt with in the old curriculum from C2000. Inevitably, teaching styles and pedagogy in the implementation of the new curriculum approach (C2005) vary across different teachers. Such a limitation may influence the end results and findings of the study. As with any classroom-based research, the ability to control the teacher implementation and curricula issue is limited. Thus, data collection process is mainly confined to observation.

Language was a second factor which limited the research process; the participating school in the research study had Afrikaans as the language of instruction, and yet all the research materials were printed in English. The researcher clearly explained concepts and was able to guide learners through any misunderstandings. The questionnaires and MLT-test were conducted in Afrikaans. All data collected had to be transcribed, translated and interpreted into English before it could be coded and sent for statistical analysis. This placed a considerable amount of time pressure on the study itself.

The use of the previous OBE philosophy language e.g. *competence*, towards the current CAPS related language uses e.g. *pass or fail*, was problematic and time-consuming to explain to the older teaching staff that were part of the study. The same goes for, *outcomes* rather than *aim and objects*, and *assessment* criteria. The study also called on a teaching and learning space and experience which is different to what teachers were used to — e.g. the *pupil-centred* education that replaces the *teacher-led* class room engagement. It goes beyond getting learners more active in the learning process of an indigenous-argumentative methodology classroom space. The selection of materials, the use of exemplars, the learners' backgrounds are considered in the planning process to provide learners with a learning experience that is relevant, meaningful and which the learner can identify with.

1.9 Definition of Terms

The following operational definitions are used throughout the report of this study.

Toulmins' Argumentation Pattern (TAP)

TAP is an analytical tool used to rate positivistic science consisting of claims, evidence, warrants, qualifiers, counter-claims and rebuttals. It can be used to rate the rigour of an argument involving controversial socio-scientific issues (Toulmin, 1958).

Contiguity Argumentation Theory (CAT)

Contiguity Argumentation Theory consists of five cognitive-mental states that are constantly in flux and this theory is used as an analytical tool or lens to analyse conceptions, perceptions and worldviews of people of a qualitative nature (Ogunniyi, 2000).

Dialogical Argumentation Instructional Model (DAIM)

The Dialogical Argumentation Instructional Model is a pedagogical instructional framework or model developed to assist teachers to scaffold learning spaces (thinking space, sharing space, argumentation space, contiguous space, and so on) for dialogical argumentation to take place with the objective of reaching cognitive harmonisation around controversial/contestable socio-scientific-cultural topics (Langenhoven, et al., 2015).

Indigenous Knowledge Systems (IKS)

IKS can be defined as a system of thought peculiar to people of a local geographic location or socio-cultural environment (Ogunniyi & Hewson, 2008; Ogunniyi, 2008: 6; Fasokun et al., 2005).

Indigenous Knowledge (IK)

IK stems from Indigenous Knowledge Systems perspectives and is regarded as a product of that thought system. IK is used extensively in communities to sustain livelihoods (Khine, 2012).

Nature of Indigenous Knowledge Systems (NOIKS)

NOIKS refers to all explicit or implicit underlying assumptions underpinning the epistemologies of indigenous knowledge systems.

Nature of Science (NOS)

NOS refers to all explicit or implicit/underlying assumptions underpinning the epistemology of school science.

Views on Indigenous Knowledge Questionnaire (VIKQ)

A questionnaire was designed to gather views, beliefs and perceptions on IKS from the learners who participated in the research. In conjunction with individual interviews this aimed to provide meaningful assessments of learners' Indigenous Knowledge and Nature of Science (IKNOS) views.

Science-Indigenous Knowledge Systems curriculum

A Science-Indigenous Knowledge Systems curriculum refers specifically to Specific Aim Three of the South African Curriculum and Assessment Policy Statements (CAPS) that calls on teachers to integrate indigenous knowledge with school science (Department of Education, 2011a, b & c).

Western Cape Province Classrooms

Western Cape Province classrooms in the context of this current study refers to science classes in schools in the Western Cape Province of South Africa. The classes referred to in this study are located at the General Education and Training (GET) phase, grades 7 – 9 and the Further Education and Training (FET) phase, grades 10-12 (Department Of Education, 2011a, b & c). The classes are multi-cultural with a mix of English, Afrikaans and isiXhosa first language speaking learners. The language of instruction is dependent on the language preference of those living in the geographic area in which the school is located and is decided upon by the staff and School Governing Body of the school, in consultation with parents, according to the Language in Education Policy of 1997 (Department Of Education, 2011a, b & c).

Spirit of *Ubuntu*

Ubuntu (/ʊˈbuːntʊ/ uu-boon-tuu; Zulu pronunciation: [ùɓúnt'ú]) is a Nguni Bantu/person. It is an idea from the Southern African region which means literally "human-ness", and is often translated as "humanity towards or because of others". Ubuntu is used in a philosophical sense to mean "all humanity is connected through a universal bond of sharing" (Official Ubuntu Documentation Canonical, Retrieved 5 January 2013)

1.10 Summary of Chapter One

Chapter one, highlights the social perceptions of, and the cultural beliefs and attitudes towards indigenous knowledge systems (IKS) of a particular group of high school learners, and the relationship these beliefs and perceptions share with meteorological education, weather predictions and the cultural-religious values contained in these knowledge systems. The research study also focuses specifically on the perceptions of this group of high school learners and their views and understandings of cultural knowledge, world scientific knowledge, and the Nature of Science (NOS) in relation to meteorological literacy and concepts. The learners in the study were purposefully selected according to their socio-economic, cultural ― even linguistic status. Most of the learners came from the same area within the local community and speak Afrikaans as a mother tongue language. During the pre-group selection stage and interview sessions it was concluded that many of their parents and family members moved to the area due to retrenchment of farm workers on the surrounding farms. The large reduction of staff housing supplied to farm workers on the local farms also led to relocation of many families into the sampled population area with the same socio-economical status. A further aim of this study is to determine the views of these high school learners on indigenous knowledge systems as a form of instruction in the classroom and/or as part of curriculum content.

CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature focussing on theoretical and practical issues related to the perceptions and beliefs of a group of grade 9 learners regarding IKS and how these relate to meteorological literacy and meteorological (Western) science concepts. The theoretical issues arise out of the literature based on the views expressed, and theories formulated, by theoretically well-informed scholars on knowledge (Western and 'indigenous') and education/curriculum, and the relationships between these, while the practical issues deal with studies done in the area of teaching and learning related to science IKS. This study investigates both the conceptions and perceptions (social and cultural) of a group of grade 9 high school learners have of the notion of IKS. It looks at whether, and the various ways in which, they see it as being of value in their communities and/or cultures. The study also investigates the ways in which IKS could be used to explain certain meteorological concepts, or to assist learners in acquiring, developing and applying these concepts in the classroom. Such conceptions may include both scientifically valid (Western science) ideas, as well as what is defined and regarded in the current study as indigenous knowledge/IK (specifically IK based conceptions about weather conditions and/or environmental factors). The sections that follow explore literature pertinent to learners' and teachers' conceptions, perspectives and practices during integration of IK-curriculum reform implementation from international and national perspectives. A brief history of curriculum changes in post-1994 South Africa is also discussed including challenges and dynamics of the previous experiences during the implementation of Curriculum 2005 and the previous National Curriculum Statements (NCS). The chapter reports, critically examines and evaluates claims and methodological approaches used in recent studies. Knowledge gaps are identified and areas for further research to expand knowledge horizons in IK-curriculum implementation are suggested.

2.2 South African Educational Curriculum: Changes since 1994

Prior to 1994, in 1948, the Nationalist Government of Dr. D.F. Malan came into power. According to Christie and Collins (1982) this historical event formed one of the keystones of the apartheid policy, forcing segregation upon white and black South Africans. Apartheid within education was built on this ideology. During this time a total of 19 Different Education Departments were set up, divided according to race, ethnicity and religion (Jansen & Tylor, 2003). According to Giliomee (2005), the Minister of Native Affairs, Dr H.F. Verwoerd, introduced

Bantu Education in 1953, and this was the most influential education policy during the apartheid era. The Bantu Education Act of 1953 linked the value and quality of education according to 'race', referring to one's skin colour. This legislation was designed and motivated to ensure that 'white' South Africans were to be schooled effectively to participate in and dominate the economic, political and social domains of South Africa. Whereas the 'black' South African was to be schooled to become a menial, semi or unskilled labourer/worker, ensuring that the 'black' South African was relegated to an inferior position and was prevented from participating in, or gaining directly from, the economic domains of South Africa or globally (Carrim, 2007). This was but one of the educational inequalities requiring immediate change after 1994.

According to Jansen and Taylor (2003), curriculum change occurred immediately after the 1994 elections with the explicit aim to promote democracy by transforming the education system into a single education department that represented all South Africans. The national curricula changes since 1994 have been informed by and built on the values of our Constitution of 1996, aiming to heal the division that apartheid had imposed on society, and to improve the quality of education for all, laying a foundation for a democratic society and building unity (Department of Basic Education, CAPS 2011). Lifelong Learning through a National Curriculum Framework document of 1996 was the first important curriculum change to occur after South Africa became a democratic country. This document was based on the principles of the White Paper (1995) on education and training. The emphasis was to shift the education system from a traditional approach of aims and objectives to a more Outcomes-Based Education approach (RNCS 2002). These principles led to the introduction of the more streamlined and more easily accessible to teachers Curriculum 2005 (C2005). In 1997 this approach to education had been defined and it become known and referred to as Outcomes-Based Education (OBE) in 1998.

Outcomes-Based Education (OBE)

The C2005 was the introduction of OBE and aimed to be fully implemented by 2005. OBE was implemented to overcome the curriculum divisions of the past, and aimed to provide education equality and quality and to develop learners' critical thinking and problem-solving abilities in order for them to be active participants within society (CAPS 2011). OBE was initiated to provide opportunities for all people to develop to their full potential, making education more learner-centred to ensure that the needs of individuals were being met and their potential developed. According to Mtshali (2004) the "outcomes" concept in OBE is regarded as the core concept as it focuses on the desired end results of each learning process and the instruction and learning processes that will guide learners to these end results. OBE in the original Curriculum described 66 specific outcomes which were linked to 8 learning areas. OBE had three main focus areas namely, *what a learner should know and can demonstrate*; *integration of content with the learner's context*; and *continuous assessment* to determine a learner's level of competence (Mtshali, 2004).

The OBE system was widely criticised after its implementation in 1998 and these critiques were part of the reasons for the change into a more acceptable curriculum in terms of accessibility and practical implementation. The initial negative critique from most educators who had be attempting to teach the OBE curriculum was that the workload and the time they had to devote to administrative duties was too much and unrealistic. Critics pointed out that the OBE curriculum could not provide guidelines and resource materials towards subject content: it only prescribed teachers a subject syllabus to complete and they were to decide what content they would use and at what pace they wanted to teach this. This resulted in confusion over the different grades and across schools all over the country because every school and grade focused on different content at different times. There was no subject and content uniformity when one looked at the syllabus of the schools in South Africa. Teachers also had to spend huge amounts of their own time, often, attending workshops, which many felt was of no assistance or value to them. This resulted in teachers feeling powerless and unable to even explain the new terminology to parents or to their colleagues. Many teachers found it frustrating to implement group work in classes with mixed abilities (Schwarz & Canvener 2000). Jansen and Christie (1999) argued at the time that group work was not necessarily an effective way of teaching as it does not give a true reflection of each learner's competence – which OBE required teachers to measure and assesses. Then the lack of resources at schools played a considerable role in the effective of implementation of the OBE curriculum. Many schools were under-resourced as a result of the unequal Apartheid education system and, because change within the recently transformed and restructured education system had to occur at such a fast rate, the government had insufficient time and money to address this need for adequate resources. This, in addition to the problems with the new curriculum, resulted in poor quality of education in the majority of schools in the country. These are just a few of the critiques that OBE had been battling with, but it led to the DOE (Department of Education as it was then) revising the policy and making some amendments resulting in a new revised curriculum in 2002: the *Revised National Curriculum Statement (RNCS)*

Revised National Curriculum Statement

The 2002 *Revised National Curriculum Statement* (RNCS) was implemented in 2004 with the aim of streamlining and strengthening OBE by improving training, learning support, materials and resources. The RNCS was based on the same principles as those of OBE and retained many of the core concepts of OBE. The RNCS policy document gave more guidance to teachers on the time spent on teaching per week for each learning area. It also had fewer outcomes than the original OBE curriculum. This was intended to make it easier for a teacher to determine what she/he wanted to achieve at the end of the learning programme. The RNCS also divided grades into three phases, namely, foundation phase (grades R-3), intermediate phase (grades 4-6), and the senior phase (grades 7-12). It also gave specific indications on what learning areas were to be compulsory in the foundation and intermediate phases. Although it gave these guidelines, teachers were still in control of deciding the content to be taught for each learning area and at what pace. RNCS set learning outcomes for each learning area and each learning outcome had an assessment standard to determine the 'depth' of a learner's competence (RNCS 2002). Ramrathan (2015) argues that assessment was the focus of the RNCS aim to monitor the learner's progress and to 'facilitate' learning. The RNCS implemented in 2004 became known as the NCS and was implemented in 2007 and is one of the series of amended documents designed to address the shortcomings of OBE.

Overview of NCS

A general *overview* of the NCS *(National Curriculum Statement Grade R-12 (January 2012)* is that it "represents a policy statement for learning and teaching in South African schools" and comprises the following (CAPS, 2011):

(i) National Curriculum and Assessment Policy Statement for each approved school subject;

(ii) The policy document, *National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grade R-12; and*

(iii) The policy document, *National Protocol for Assessment Grades R-12 (January 2012)*

We also have to note that the *National Curriculum Statement Grades R-12 (January 2012)* replaces the two national curricula statements, namely:

(i) *Revised National Curriculum Statement Grades R-9, Government Gazette No. 23406 of* 31 May 2002, and

(ii) *National Curriculum Statement Grades 10-12, Government Gazette, No 25545 of 6 October 2003* and *No. 27594* of 17 May 2005. (CAPS, 2011)

Curriculum changes in South Africa

Curriculum revision in South Africa began immediately after the 1994 election. It has proceeded in three main waves. In the immediate aftermath of the election, syllabi were 'cleansed' of their most offensive racist language and purged of their most controversial and outdated content (Jansen, 1999a). In 1997, the new national Department of Education (DoE) launched Curriculum 2005, informed by the principles of outcomes-based education, as the foundation of the post-apartheid schools' curriculum. Three years later, in 2000, Curriculum 2005 (up to grade 9) (C2005) was reviewed and revised (Chisholm, 2000; DoE, 2001a). Following consultations with unions, public hearings in 2001, presentations within the main organs of government, and further refinement in the light of these public processes, the *Revised National Curriculum Statement* (DoE, 2002a), as the 'streamlined' C2005 was named, became official policy in April 2002. It was scheduled for implementation from 2004.

Global Educational demands

Although curriculum changes occur as a means of addressing flaws experienced with implementation, there are also various external influences that lead to curriculum changes. *Globalisation* of Education had a big impact on the education policies of South Africa in the mid 1990s. It became clear that our education system need to adhere to global demands and standards within education. With reference to Christie (2008), globalisation can be seen as a new period in time where business and other organisations are now highly dependent on technology and demand that employees possess a high level of technological knowledge and expertise and are able to apply it (Christie, 2008). It is because of this global demand for individuals to be part of this universal technological world that schooling has been impacted in various ways. Globalisation demands that schools teach certain curricula that prepare learners for the world of work and for the job market. Schools thus need to teach learners how to use technology if they want to be part of the global economic world or earn a decent family income. Organisations such as *International Monetary Fund* (IMF), *World Trade Organisation* (WTO) and the *World Bank* (WB) set and monitor the rules of the global economy and its demands, including education. These organisations have a significant and powerful influence on global education as they set the benchmark for the standard and quality of education (Christie, 2008). Another organisation at the forefront of changes in the global education system is the *United Nations Educational, Science and Culture Organisation* (UNESCO). In 1994 at the UNESCO World conference the global education system made a significant shift in education reform with the introduction of inclusive education. This was done in an ambitious attempt to ensure that every education system globally would be acceptable and recognised world-wide.

2.3 Integration of IKS into Natural Science: Challenges

Since the turn of the 21st century there has been concerted effort in many developing countries including South Africa to include IK within the mainstream school curriculum. But other than the usual rhetoric on the subject, not much has been done to know or create teachers' or learners' of what IK stands for and how to integrate or introduce it into the school curriculum. Although most of the recent science and physical geography textbooks acknowledge the fact that learners do bring their own ideas about how the world works into the classroom and that school learning science should relate to the context of real life worlds of learners not much progress has been made in this regard. The extant literature has revealed that in countries where attempts have been made to integrate science and indigenous knowledge all that has been done was to sprinkle or flavour the standard account of science with certain extraneous accounts of IK e.g. the curriculum programmes designed for the North American Indians or the Aboriginals of Australia. While many of these programmes have been useful in addressing the issue of the learning styles, social patterns, the commonality of knowledge, the communal life styles and the mode of inquiry of indigenous peoples and how these enrich instructional practices have hardly been considered. This is because of the general assumption that learners from indigenous cultures come into the classroom like a blank slate so to speak (Ogunniyi, 2004, 2007a & b). It was against this setting that the study was embarked upon.

2.4 Indigenous Knowledge Systems

Much of IKS is preserved in the memories of elders and thus this knowledge is gradually disappearing due to memory lapses and death. The oral tradition and empirical learning are the principal ways of transmitting knowledge. Nevertheless, access to IK (indigenous knowledge) is fragmented in the local communities due to various factors, including social dimensions such as age, gender, status, wealth and political influence (Wall, 2006) and attitudes, perceptions, norms, values and belief systems inherent to indigenous people (Meyer, 2009). Other factors are related to the safety mechanisms used by local people to protect their own intellectual property, and to formal education which has excluded IK. There is therefore a need for developing countries to recognise the importance of managing IK, as much of the knowledge required for agricultural development and environmental management already exists with farmers and traditional practitioners. Most of the knowledge were not written down or even archived in any form of literature, books, memo's or novels for future engagement with the knowing that it could be lost forever if not protected, preserved or archived for future generations – it was seen as uncommon to publicly engage in any form (written or general talk) with the traditional knowledge (that are normally used at traditional ceremonies and cultural gatherings) kept away or kept sacred from the young members in fear they would leave the community and join other cultures and share those guarded secrets with non-members. Young members were not allowed to ask and challenge any form of cultural sayings, dances, and rituals within the culture. They were only allowed performing and engaged with it (dances, songs, rituals) on request and at special events within the cultural group on instruction by the elders. These traditional ways of doing were not allowed to be performed or staged anywhere outside the boundaries of the culture. This included a variety of traditional ways of doing: rain dances, prayer meetings, initiation ceremonies that keep on for weeks or even months when requested to do so. It was seen as unethical towards the ancestors to act against the request from the elders, to keep traditional knowledge safe. The fear of losing their cultural identity grew when Western cultures came with colonialism to African countries, the community leaders felt that all existing knowledge should be kept alive in the minds of the elders, as a token of respect towards their ancestors. As a result of this kind of behaviour between 300-400 years of the cultural knowledge was lost and buried with the elders of those earlier communities (Riffel, 2011).

According to Vygotsky (1978), the main aim is to develop, which is the result of social learning through internalization of cultural and social relationships. Vygotsky stressed that a society is the carrier of the cultural heritage without which the "development of mind" is difficult. The Vygotskian social-cultural theory (Scott, 2004) brings together community and personal perspective, sharing "ground with constructive perspectives that a learner cannot be a passive recipient of knowledge and instruction" (Scott, 2004, p. 92) (Govender, 2012).

Some characteristics of IKS according to Hunn (1993, p. 13) are:

1. IKS is local: it is rooted to a particular set of experiences related to geographical place, and generated by people living in those places. The corollary of this is that transferring that knowledge to other places runs the risk of dislocating it from its context.
2. IKS is orally-transmitted, or transmitted through imitation and demonstration. The corollary is that writing it down changes some of its fundamental properties. Writing, of course, also makes it more portable, reinforcing the dislocation referred to above.

3. IKS is the consequence of practical engagement in everyday life, and is constantly reinforced by experience and trial and error. This experience is characteristically the product of many generations of intelligent reasoning, and since its failure has immediate consequences for the lives of its practitioners its success is very often a good measure of Darwinian fitness. It is, as Hunn (1993, p. 13) neatly puts it, `tested in the rigorous laboratory of survival' (Hunn, 1993).

So, the question that comes to mind is: What is scientific reasoning? It is the type of reasoning a learner uses by means of scientific knowledge gathered throughout any school science curriculum and traditional engagement in their culture of origin. This will include scientific knowledge that derived from IKS (Indigenous Knowledge Systems) and Western science. The Curriculum Corporation (1994) is cited by Fleer (1999) in Diwu (2010, p. 18) to assert that:

> *Scientific knowledge has been expanded by cumulative efforts of generations of scientists from all over the world. It has been enriched by the pooling of understanding from different cultures – western, eastern and indigenous cultures including those of Aboriginal peoples and Torres Strait Islands – and has become a truly international activity (p. 128).*

Furthermore, Fleer (1999) raises a concern that, there seems to be an implicit assumption namely, that all other knowledge systems had come to support the one worldview which is 'Western science' (Diwu, 2010, p. 18).

2.5 Teaching using IKS and Dialogical Argumentation

Dialogical argumentation occurs when different perspectives are expressed on a subject with the hope of ultimately reaching consensus. The purpose of argumentation is to persuade others of the validity of your claim through well-reasoned or well-grounded arguments. Through dialogical argumentation learners articulate their "reasons for supporting a particular claim and then strive to persuade or convince" others about the truthfulness of such a claim (Ogunniyi & Hewson, 2008, p.161). Dialogical argumentation provides the critical "environment for learners to externalize their doubts, clear their misgivings or misconceptions, reflect on their own ideas and those of their peers in order to arrive at clearer and more robust understanding of a given topic than would have otherwise been the case" (Ogunniyi & Hewson, 2008, p. 161).

Classroom talk can also take the form of argumentation. According to Qhobela and Moru (2011), argumentation can be said to take place in a classroom setting, mostly between students, if a viewpoint is tabled and justified or if others demand justification (Qhobela & Moru, 2001). This means learners in a science classroom setting need to use the available data to make sense of a specific claim (Riffel, 2011). To complete the process, *warrants* and *backings* are given by participants in the argument to support the original claim, and *rebuttals* are given as counter-claims, showing non-compliances with the original claim. The use by teachers and learners of argumentation as a way of learning science derives its strength from the nature of Western science and the nature of scientific enquiry. Qhobela and Moru (2011) see 'scientific knowledge' as a product of intense and robust discussion within the community of scientists. Thus a scientist must convince other members of the community that a finding amounts to a new, acceptable and important contribution to knowledge (Ford & Forman, 2006).

Of central importance to the current study, and the focus of one of its aims, is that the learning outcomes of the National Curriculum Statements are intended to promote the same values that this research study seeks to determine and advocate: to promote enquiry skills in learners for them to be able to investigate key concepts and processes; for learners to acquire knowledge and understanding of the interrelationships between people, resources and the environment, and for them to develop and use critical analysis of development issues on a local, national and global scale (Department of Education, 2002).

To emanate a central understanding towards the current study the researcher has zoomed into the perceptions of and attitudes of high school learners' towards indigenous knowledge systems (IKS), and the relationship it shares with climate change, global warming, education, weather predictions and its cultural values within the community. This study focussed on the perceptions of high school learners and the views they hold of world scientific knowledge and the Nature of Science (NOS) in relation to meteorological concepts. A further aim of this study was to examine learners' understanding of current weather prediction and prediction of local weather conditions. The study examines curriculum and assessment practises to enhance learners' understanding of the Nature of Science (NOS) and IKS, and the means to enhance the ability to make a positive connection to cultural knowledge that supports IKS. This study offers to make teachers more aware of an IKS argumentation-based type of pedagogy to facilitate and engage more with learners' for a better understanding of the value of cultural or indigenous knowledge.

Research shows that only if argumentation is specifically and explicitly addressed in the curriculum will students have the opportunity to explore its use in social science (Kuhn, 1991). Because science education focuses on learners' understanding of science concepts, it often adopts methods like transmission learning, which do not draw on reasoning, only the delivery of science facts. Using teaching methods that use argumentation through the use of appropriate activities and teaching strategies in the social science class can provide a means of achieving a wider range of goals, including social skills, reasoning skills and the skills required to construct argument using evidence (Osborne, Erduran, & Simon 2004a; Ngcoza, Sewry, Chikunda, & Kahenge, 2016). So, in order to emphasise that teachers need argumentation during teaching social science, they (teachers) need to adapt their teaching styles to more dialogical approaches (Alexander, 2005). This approach should involve students in class and lesson discussions, and use teaching methods, science expo's (competitive science competition among learner representatives from different schools) to interact with students to foster scientific processes, argumentation skills to develop and empower learners to identify local problems and hence find solutions (Ngcoza, et al., 2016). Then the role of 'such dialogical space' is to enhance and promote the 'process of re-articulation, appropriation and/or negotiation of meaning of the different world-views' (Ogunniyi, 2007).

Dialogical Argumentation in the South African School curriculum

Education and training plays a vital role in realizing these aims of the constitution. The *Revised National Curriculum Statements* (RNCS) (2002) seeks to incorporate these values in the *kind of learner that is envisaged*:

> *'The promotion of values is important not only for the sake of personal development, but also to ensure that a national South African identity is built on values very different from those that underpinned apartheid education. The kind of learner that is envisaged is one who will be inspired by these values, and who will act in the interests of a society based on respect for democracy, equality, human dignity, life and social justice. The curriculum seeks to create a lifelong learner who is confident and independent, literate, numerate, multi-skilled, compassionate,* ***with a respect for the environment*** *and the ability to participate in society as a critical and active citizen'.* (Department of Education, 2002, p. 12).

2.6 Toulmin's Argumentation Pattern (TAP)

Toulmin's Argumentation Pattern framework has been widely used by science educators to explain scientific reasoning and argumentation among learners. This methodological definition of argumentation has been applied as a tool into assessing argumentation of small and large group discussions in the Nature of Science (NOS) education (e.g., Jimenez-Aleixandre, Rodrıguez & Duschl, 2000; Zohar & Nemet, 2002). In order to participate in a scientific community, students and novices need to know "how to construct substantive arguments to support their" position. Toulmin (1958) develop the Toulmin's Argumentation Pattern, that can be used "as a basis for characterizing argumentations in science lessons" (Pedemonte, 2007, p. 27). Toulmin (1958) also suggested that a substantive argument requires providing supporting data to a claim. Three elements make up the Toulmin's basic model of an argument, which are:

C (claim): the statement of the speaker,

D (data): data justifying the claim C,

W (warrant): the inference rule, which allows data to be connected to the claim.

In any argument, the first step is expressed by a standpoint (an assertion, an opinion), or in Toulmin's terminology, a claim. The second step consists of the production of data supporting the claim. The warrant provides the justification for using the data conceived as a support for the data–claim relationships. The warrant, which can be expressed by a principle or a rule, acts as a bridge between the data and the claim.

More specifically, in Toulmin's definition:

> *A claim (C) is an assertion put forward publicly for general acceptance. Data (D) are the facts which provide the basis for the claim. Warrant(s) (W) are proposition(s) that are offered to justify the link between the data and claim. Backings (B) are generalizations making explicit the body of experience relied on to establish the trustworthiness of the ways of arguing applied in any particular case. Rebuttals (R) are the extraordinary or exceptional circumstances that might undermine the force of the supporting arguments.*
>
> *Toulmin further considers the role of qualifiers (Q) as phrases that show what kind of degree of reliance is to be placed on the conclusions, given the arguments available to support them.* (Erduran et al., 2004, p. 918 as sited by Ghebru, 2014)

In this research study this model will be used to compare and analyse the understanding of grade 9 learners conceptions of selected meteorological concepts from a cognitive point of view.
The basic structure of an argument is presented in Figure 1 below.

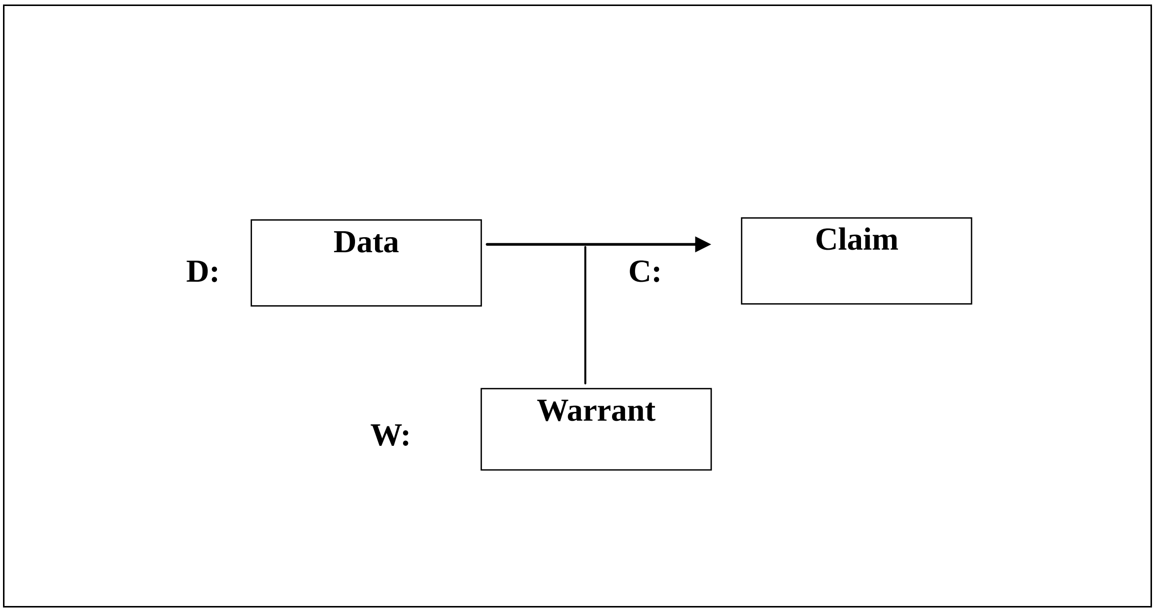

Figure 1 Toulmin's basic model

Toulmin's argumentation model (Figure 2) below can be used to compare and analyse the understanding of grade 9 learners' conceptions of selected meteorological concepts in this study. In Figure 2, the three elements to describe an argument are displayed as a qualifier, a rebuttal, and a backing (Toulmin 1993).

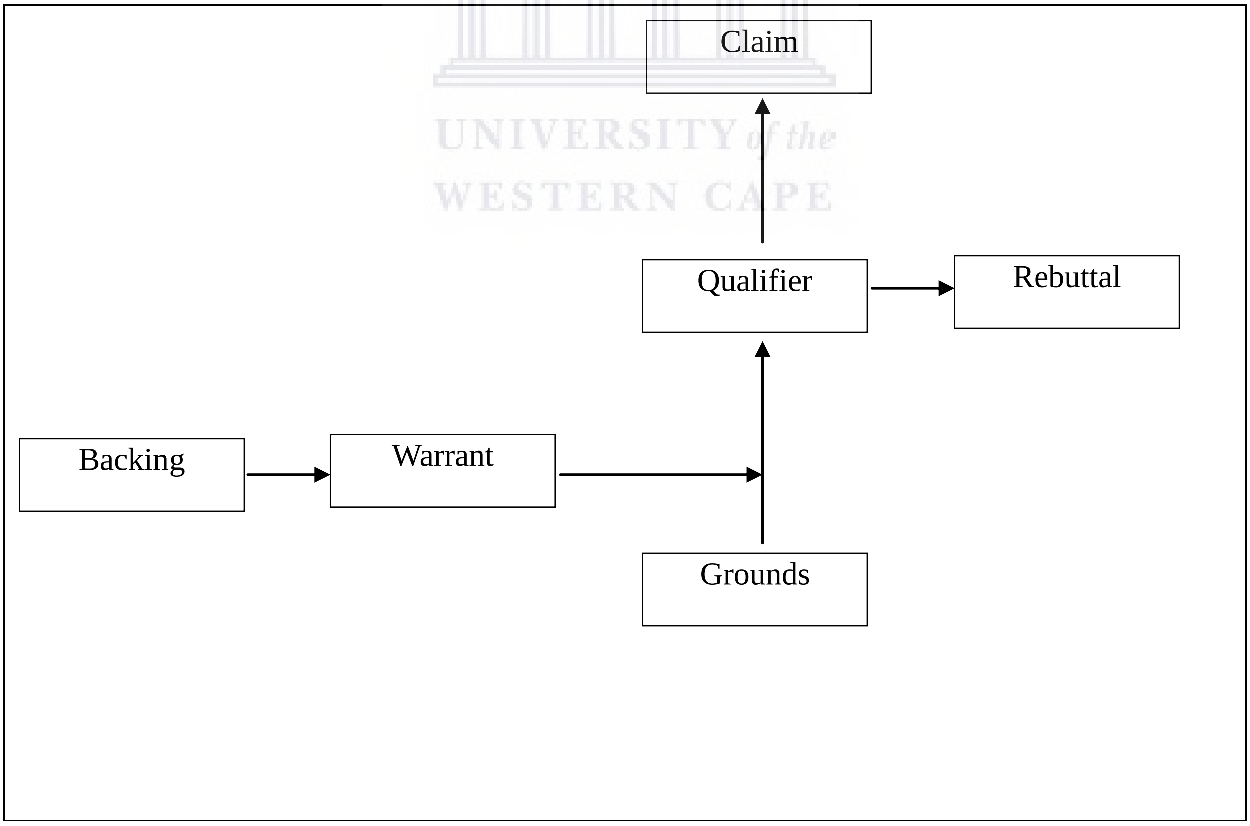

Figure 2 Toulmin's Argumentation Model – TAP (Toulmin, 1958)

Features of Toulmin's (1958) analysis of argumentation include the extent to which learners and teachers make use of data, claims, warrants, backings, qualifiers and rebuttals, and the extent to which they engage in claiming, justifying and opposing the arguments of each other. The Toulmin (1958) framework can therefore be used by teachers to conceptualise and evaluate argumentation. To provide learners with tasks that require discussion and debate, teachers can support learners in the construction of arguments through the process of argumentation, as represented in Table 1 below.

Table 1 Tabulated representation of TAP

Components	**Code**	**Definition**	***Example***	**Scaffold**
Claim	C	**Statement or belief** about a phenomenon whose merits are in question **Statement** whose validity is in question **Conclusion** whose merits are sought to establish **Hypothesis** based on available evidence **Premise** based on deductions **Belief** based on dogma	…there is a battery in the box	I think/ believe that…
Counter-claim	CC	**A challenge:** a specific type of claim, one which question the validity of another claim	…there could be something else in the box	No I think/ believe that…
Data	D	**The facts** (observed or believed) used as evidence to support a claim. **Evidence** appealed to as foundations for the claim	…the bulb is lit	…because
Warrant	W	**Statements** used to establish or justify the relationship between the data and the claim. Statements that act to show that the move from data to claim is valid. The warrant links the data to the claim and indicates the relevance of the claim to data.	…a circuit must be complete for the bulb to light up	…since
Backing	B	**Facts or assumption** which establishes a warrant. Backings for warrants may be expressed as categorical statements of facts, just as data are appealed to in direct support of a claim/ A backing may be the implicit assumptions underpinning the claim. Underlying assumptions that are not often made explicit.	…because adding bulbs to the circuit slows the electricity down	…on account of/ because
Qualifier	Q	**Special conditions** under which the claim holds true i.e. the conditioning governing the claim	…and so there must be a battery in the box – a battery provides the power in the circuit	…and so
Rebuttal	R	**Statements** which show that the claim is invalid. Statements that contradict either the data, warrants, backing or qualifier of an argument	There is no battery in the box	…because

Source: Stone, 2009

Arguments which include a backing for the warrant are termed analytic if the backing implicitly or explicitly contains information communicated in the claim itself. If this information is not communicated in the claim, the argument is termed substantial. This study adapted a modified form of TAP to evaluate the quality of arguments originated from small-group and whole-classroom discussions. I will allude to this later.

However, many science educators such as, Erduran (2008) asserts that despite its use as a framework for defining argument, the application of TAP to the analysis of small and whole class discussion was found to be difficult. The idea is consistent with the view of Simon, Osborne, and Erduran (2003) who indicated that nearly all researchers have found the application of Toulmin's schema problematic, as his criteria do not assist the ready resolution of data from warrants, nor warrants from backing resulting in poor reliability (Duschl, Ellenbogen, & Erduran, 1999; Kelly & Takao, 2002). In response to these difficulties, scholars have modified TAP analytical framework to obtain more robust units of analysis of classroom interactions (e.g., Clark & Sampson, 2008; Erduran, Simon, & Osborne 2004; Ogunniyi, 2004).

Erduran et al. (2004) have combined Toulmin's elements of argumentation namely, data, warrants and baking into a single category called grounds to sidestep many of the reliability and validity issues associated with Toulmin's framework. They have also outlined two methodological approaches that extend the use of Toulmin's model for tracing argumentation discourse in science classrooms. Both methodological tools measure the qualitative and quantitative outcomes of teaching and learning argumentation in whole class and small group discussion in science classrooms. In the first methodological tool Erduran et al. (2004) adapted TAP for the purpose of coding data that originate from the whole class conversation where successive implementations of lessons can be traced for their improved quality of argumentation. In the second methodological approach they developed a scheme and assessed argumentation in terms of levels of the quality of oppositions or rebuttals in the student's discussion in a small group setting. Table 2 below displays the analytical framework used by Erduran et al. (2004) to assess the quality of argumentation.

Table 2:Analytical framework used for assessing the quality of argumentation (Erduran et al., 2004)

Different levels	Argumentation description and quality
Level 1	Argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim
Level 2	Argumentation has arguments consisting of claim versus a claim with either data, warrants, or backing but do not contain any rebuttals
Level 3	Argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backing with the occasional weak rebuttals
Level 4	Argumentation shows arguments with a claim with a clear identification rebuttal. Such an argument may have several claims and counter claims
Level 5	Argumentation displays an extended argument with more than one rebuttal

Level 1 argument is the simplest, usually comprising a claim or an unjustified counter-claim in response to the claim under discussion. This is considered the lowest level of sophistication required in an argument in that it indicates learners with the lowest level of argumentation skills. On the other hand, level 5 is the most complex type comprising all of Toulmin's requirements for an argument-an extended argument with more than one rebuttal.

Other science educators (e.g., Clark & Sampson, 2008; Ogunniyi, 2007a & b) have further modified Erduran et al.'s (2004) framework (TAPping model) by classifying classroom discourse in terms of the complexity of the arguments involved such as: non-oppositional; arguments with claims or counterclaims with grounds but no rebuttals; arguments with claim or counterclaim with grounds but only single rebuttal, arguments with multiple rebuttals challenging the claim but no rebuttal; etc. Their framework characterizes the amount of conflict or level of opposition that takes place within an episode as outlined in the Table 3 below.

Table 3: Levels of argumentation (modified after Erduran, Simon & Osborne, 2004)

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.

The framework above defines high-quality argumentation (oppositional level 5) as a discourse that emphasises the use of multiple rebuttals that challenge the interpretation of a phenomena and the validity of the grounds that are used to support this interpretation. On the other hand, low-quality argumentation is either non-oppositional (oppositional level 0) or consists of claims and counterclaims that do not attempt to challenge the validity of the other participants' interpretation of the phenomena (oppositional level 1).

2.7 Contiguity Argumentation Theory (CAT)

While there are many places where learners can acquire environmental literacy, the most effective locations perhaps are schools. The school plays a vital role in the process of helping children to acquire environmental literacy and awareness. A study done by Barraza (2004) shows that the school is the place where children most commonly report they learn environmental literacy. School science classes are the contexts in which learners are exposed to activities that enhance their knowledge and awareness of their environment. According to Ogunniyi (2001), the CAT assumes that when different ideas interact they tend (through a sort of dialogical process) to find areas of commonality i.e., areas where their subsumed elements are compatible and this ultimately may result in a higher form of meaning than was previously possible (Ogunniyi, 2001; as stated by Ogunniyi in Book 2 SIKSP, 2009).

> *The CAT construes learning as a dynamic process that entails a delicate balance between reason and emotion, body and mind and nature and nurture – all interacting in diverse ways to attain some level of equilibrium 'or in neural science terms homeostasis or more correctly allostasis since different activities demand different levels of Homeostasis'(Sapolsky, 1998).*

Table 4: Cognitive states of the Contiguity Argumentation Theory (CAT)

Cognitive States	**Description**
Dominant	A powerful idea explains and predicts facts and events effectively and convincingly or resonates with an acceptable social norm that affords an individual a sense of identity e.g. a scientific explanation of lightning in terms of static electricity as opposed to the explanation proffered for the same phenomenon within an indigenous worldview.
Suppressed	An idea becomes suppressed in the face more valid, predictive, empirically testable evidence, or established social norms e.g. the scientific explanation of the cause of a disease may be suppressed in the face of cultural beliefs about possible diabolical motives of enemies behind the disease.
Assimilatory	A less powerful idea might be assimilated into a more powerful one in terms of the of the persuasiveness or adaptability of the dominant idea to a given context e.g. the indigenous idea of not leaning against a metal pole, tree or wall which may have arisen from experience can easily be assimilated into the scientific concept of lightning as an electrical phenomenon.
Emergent	There may be circumstances where no prior idea exists and a new one has to be acquired or developed e.g. a considerable amount of scientific concepts such as atoms, molecules, magnetism, conservation of matter, laws of motion, etc. have usually been learnt from school science.
Equipollent	When two competing ideas have comparably equal intellectual force, the ideas tend to co-exist without necessarily resulting in a conflict e.g. the theory of evolution versus creationism.

Source: Ogunniyi (1997, 2007); Ogunniyi & Hewson (2008) - Adapted from Langenhoven (2015).

The principles of the CAT model are clearly seen in the Learning Outcome 3 of the RNCS Grades R-9 (2002) science curriculum expects learners to be able “to demonstrate an understanding of the interrelationship between science and technology, society and the environment” (Department of Education, 2002, p.10).

As useful as the Toulmin Argumentation Pattern is in assessing the quality of arguments, it does not specifically address metaphysical or abstract IK-rated beliefs that influence and impinge on learners’ understanding of diverse phenomena. It was because of this limitation that Ogunniyi (2004) proposed the Contiguity Argumentation Theory. The effectiveness of argumentation instruction in enhancing and developing learners’ understanding of school science is well supported by a plethora of studies (e.g. Erduran et al., 2004; Ogunniyi, 2004, 2005, 2007a & b, 2011; Osborne et al., 2004a). In an attempt to mediate between science and IK Ogunniyi (2007a) thus proposed the Contiguity Argumentation Theory (CAT) as a way of capturing learners’ experiences that are beyond the scope of school science. CAT is rooted in the Aristotelian contiguity notion of resolving conflicting ideas. The theory posits that “two distinct co-existing thought systems”, as science and IK could be said to be, “tend to readily couple with, or recall each other, to create an optimum cognitive state” (Ogunniyi, 2008, p. 161). Unlike TAP, which only deals with logical substantive arguments (Toulmin, 1958), CAT “deals with both logical or scientifically valid arguments as well as non-logical metaphysical discourses embraced by IKS” (Ogunniyi & Hewson, 2008, p. 161).

I argue that the principles of the CAT model are clearly discernible in the Specific Outcome 3 of the CAPS (2011) Grades R-9 (Department of Education, 2011). One can discern a similar principle in the science education curriculum which expects learners to be able “to demonstrate an understanding of the interrelationship between science and technology, society and the environment” (Department of Education, 2002, p. 10). Research shows that only if argumentation is specifically and explicitly mentioned and addressed in the curriculum will learners to have the opportunity to explore its use in social science (Ogunniyi, 2016; Riffel, 2015; Langenhoven, 2016; George, 2014; Angama, 2016). Thus, in this study I argue that only when this kind of teaching and learning strategy is specifically mentioned and giving specific examples in a curriculum, can designers of curricula expect learners to develop and consolidate their understandings of complex scientific and meteorological concepts. The reality in the present education context in South Africa is that science education as it is taught in the majority of schools focuses on learners' ‘understanding’ manifested by their accurately reproducing of science concepts with teachers using teaching methods such as transmission teaching and learning, drawing very little, if at all, on reasoning and discovery in the 'delivery' of scientific 'facts'. These 'facts' learners often learn by rote and reproduce in tests (Riffel, 2013; Amosun, 2013). However, the existence of different world-views in a classroom is important for teaching a Natural Science curriculum. We have to keep in mind that several times per week during classroom teaching learners "cross from the culture of home, over the border into the culture of science, and then back again" (RNCS, 2002, p. 12).

Teaching methods that use argumentation facilitated by appropriate activities and teaching strategies in the social science geography classroom can, besides developing learners' deeper understanding of meteorological concepts, provide a means of promoting a wider range of educational goals, including social skills, reasoning skills and the skills required to construct arguments using evidence (Osborne, Erduran & Simon, 2004a). Thus, in order to encourage teachers and to emphasise that they need to facilitate argumentation during social science lessons, they (teachers) need to be encouraged to adapt their teaching styles to a more dialogic approach (Alexander, 2005), one that actively involves learners in class and lesson discussions. Teachers should also be encouraged or exposed to the appropriate in-service training, to use teaching methods to interact with learners in a way which fosters their argumentation skills. Specifically in the South African context of the realities of poorly trained teachers and teachers trying to come to grips with versions of the curriculum, teachers need to be exposed to 'up-skilling' or in-service training where they can have hands-on experience of this kind of teaching strategies based on the argumentation instructional models of TAP (1958) and CAT (2004).

According to Ogunniyi (2001), the CAT assumes that when different ideas interact they tend (through a sort of dialogical process) to find areas of commonality i.e. areas where their subsumed elements are compatible, and this may ultimately result in, or develop into, a "higher form of meaning" than was previously possible (Ogunniyi, 2001; in Ogunniyi, Book 2 SIKSP, 2009). Furthermore, Learning Outcome 3 of the *Revised National Curriculum Statement Grades R-9* (2002) Science Learning Area (subject) expects learners to be able "to demonstrate an understanding of the interrelationship between science and technology, society and the environment" (Department of Education, 2002, p.10). This outcome serves as a good departure point to consider the central concern of the study namely, the conceptions of selected meteorological concepts a particular group of Grade 9 learners developed and the process through which this took place.

2.8 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 it 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 experienced 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.

2.9 What other studies say about dialogical argumentation in classrooms

One complexity of learners' learning science is communication. This section examines other research studies that relate to dialogical argumentation and learning in science education classrooms. Until the very recent past, there has been little debate about a likely connection between argumentation and science education. The scenario is now changing as more and more attention is being paid to the science exposure of learners' who live in communities in which traditional practices and beliefs guide daily actions. The interest has been fuelled, in part, by the global thrust towards school science programs that are intended, not for a select few, but for all students. The "science for all" movement is intended to equip all students to use their knowledge of science in their daily lives. "Science for all" and "science for daily living" take on new meaning when indigenous communities' needs are considered in cultural context.

Currently, there are three approaches dominating the IK field that are all derived from anthropology. These are worldviews (Cobern, 1991), collateral learning (Jegede, 1995), and border crossing (Costa, 1995; Aikenhead, 1996). Cultural anthropology (Maddock, 1981) and postcolonial scholarship (McKinley, 1996) both influenced the direction of indigenous science education research toward humanistic school science. In 1981, Maddock focused on theory building through a review of literature in science education and anthropology. He argued against the deficit model that focused on bring Western modern science into developing nations. His viewpoint was that science and science education are cultural enterprises, which form part of the cultural matrix of society, and that educational considerations concerning science must be made in light of that wider perspective. He considered the science curriculum projects of many nations and emphasizes that they were greatly influenced by Western scientists. Many of the science curricula developed by Western scientists was simply transplanted from one culture to another, with no cultural dialogue, often for little regard to resources or place. Typically, it had been assumed that 'primitive' cultures had no science, yet there had been little research in these cultures to confirm that assumption. Finally, Maddock concludes with the argument that to continue to progress, science education, both in its practice and research, needs to adopt an anthropological point of view.

Empirical research incorporated Maddock's viewpoint of including an anthropological approach to science education research. These studies were localized and used this humanistic framework (Ogunniyi, 1982; Henry, 1987; Ogunniyi, 1987). The purposes of these studies were to study specific curricula in a specific location. These new curricula were attempting to focus on science learning that was relevant to everyday life. These studies used quantitative techniques with a dialogical argumentation instructional model (DAIM), the same as in this study, to determine how students or teachers were negotiating their opposing viewpoints (science worldview and indigenous knowledge view) often through Likert-scale or surveys. Most of the findings described that the curriculum needs to be relevant to the specific culture and not force the learners or teachers to abandon their traditions; however a distinction still remains between indigenous knowledge and science worldview. It was with this use of anthropological definition of culture that a framework for worldview was brought into science education (Cobern, 1991). Within this framework, George (1987) sought to explore the role of practical and culturally relevant curricula in a Caribbean context, which added a new dimension to the argument for indigenous knowledge in school science. She argued that, "Children in developing countries therefore need to learn that technological innovation does not always have to originate in the developed world but that they too have the ability to create" (George, 1987, p. 818). She proposed that in addressing this idea through science curricula, students would have pride of their heritage and would drive to continue to innovate.

2.9.1 Indigenous Language through Argumentation-Based Instruction

Historically, little research has been done to address student learning and indigenous languages. Because of the paucity of research in this area, there is no consistency among researchers about how, or if indigenous language should be included in science instruction and the majority of research is in debate of how much indigenous language to use in the science classroom. Clerk and Rutherford (2000) carried out a study of English language learners in South Africa and found that the use of vernacular hindered student learning in a science classroom. They argued that there should be more English language usage to avoid confusion. However, this study did not examine the questions they asked the students from a linguistic viewpoint, which has demonstrated helping to eliminate misconceptions in the testing (Clerk & Rutherford, 2000). McKinley (2005) argued that one of the main ways in which indigenous knowledge systems will survive and thrive is through the establishment of programs taught through indigenous languages so that a dialectal relationship between language and science knowledge is established that continues to act as the wellspring. However, the critical issue is not only what happens in the science classrooms but also what happens in the teacher education institutes. Indigenous languages in science education face many barriers with a possibility of extinction of the languages and this area of research is in urgent need. Therefore, the focus needs to move away from what makes teaching and learning effective for indigenous peoples to understand, but to what makes an effective indigenous language learner and teacher of science?

2.9.2 Indigenous classrooms

Constructivist ideology holds that learners do not come to the science classroom with empty minds about natural phenomena, but come with knowledge from their home backgrounds. In this regard, Ausubel's (1968) assertion is that, the most important factor influencing learning is the learner's prior knowledge, which the teacher should find out and tailor his or her teaching accordingly, remains valid in all science classrooms. Throughout the years, science educators have stressed the importance of prior learning in the construction of new knowledge in the science classroom. From the social constructivist point of view, learners' prior knowledge which is obtained from everyday experience and home culture serves as the raw material for knowledge construction (Driver, Asoko, Leach, Mortimer & Scott, 1994; Stamovlasis, Dimos, & Tsaparlis, 2006). Since the indigenous child brings his or her worldview along to the science classroom, (Cobern, 1996; Ogunniyi, 1988), a rejection of that knowledge inadvertently deprives such learners of their raw material for meaningful knowledge construction. This implies that the cultural influence of the home cannot be disregarded in a constructivist classroom. Consequently, learners' cultural background knowledge, which is the lens through which they interpret experience, ought to form part of science classroom discourses.

In the same vein, many science education researchers have argued that science is more appealing to learners when it is viewed as relevant to their home background knowledge and livelihoods (Aikenhead, 1996; Ogunniyi, 1988, 2004). In order to attract learners of non-western origin to science, therefore, their indigenous worldviews should not be dismissed or ridiculed. Instead, such knowledge is now viewed by many as a significant contribution in the discourse taking place in the science classroom. This stance has been the driving force in the Science and Indigenous Knowledge Systems Project that has been training science teachers to integrate science and IK for over a decade (Nhalevilo & Ogunniyi, 2014; Ogunniyi, 2011). Integration of science and IK has gained momentum in the last decades because of several potential benefits. One of such benefits is that learners from indigenous communities will learn science more meaningfully when it is made more relevant to them by recognising and including their cultural values into school science classroom discourses (Aikenhead, 1996, 2001; Koopman, 2017; Aikenhead & Jegede, 1999; Jegede & Okebukola, 1991b; Ogunniyi, 1988, 2011; Ngcoza, 2019).

2.10 Challenges of integrating science and IK

There have been many challenges militating against the implementation of a science-IK curriculum in South African classrooms. Firstly, the policy document does not explicitly say how the integration of the two systems would take place, nor did it consult the teachers who were to implement it (Ogunniyi, 2007 a & b; Onwu & Mosimege, 2004). Secondly, most of the science teachers who were to implement such a curriculum had been so assimilated by the scientific mode of inquiry that, as Ogunniyi (2004) has put it, "they are hardly more than chroniclers of the scientific knowledge" (p. 292). Consequently, higher education programs aimed at training science teachers needed to be changed in order to produce teachers with a knowledge of the nature of science and the nature of IK; teachers conversant with the epistemological and methodological differences of science and IK. Such attempts at training a new breed of science teachers have exposed some pertinent issues. For example, Onwu (2009) has reported some pertinent challenges faced by practicing science teachers who would want to integrate science and IK. These challenges include the following:

There are too many IK practices according to different cultures making difficulties to choose which IK to use and which to leave out. IK is time-consuming; information on IK is often not documented or not readily available. Teachers lack models to emulate and appropriate teaching strategies to effectively handle science IK integration. The curriculum lays emphasis on scientific content knowledge coverage, leaving no room for IK. Some teachers believe that certain IK issues should not form part of the science curriculum. Some teachers have the perception that IK is outdated, degenerated, demeaning, and not in synch with modern or current thinking. The question is: *if teachers themselves face such challenges, will learners be more motivated to desire the integration of science and IK, especially in a rapidly changing technological age?*

The multicultural debates are linked to other debates in science education aimed at inclusion, such as the constructivism approach, 'science for all', and SSI initiatives, which can improve the learning and achievement in science of a wider range of students. "However, the failure of science education research during these times was in not taking culture, language, 'race' or colonization as major factors in any of the projects" (McKinley, 2005, p. 230). This is despite that fact that a number of indigenous writers have argued the importance of connecting school science education to the students' cultural background (Cajete 1995; Kawagley, 1995; Kawagley & Barnhardt 1999; McKinley, 1997). Making the connection to the cultural background can be done in two different ways, both of which are the foundations for place-based curriculum: 1) making science 'relevant' to the student, which usually involves teaching in culturally relevant contexts or everyday science, 2) using culturally responsive teaching or culturally based pedagogy (see Bishop & Glynn 1994; Ladson-Billings, 1995).

Another study on discourse and argumentation by Zeynab Badreddine (2009) "Building context and continuity in classroom discourse; a case study at the high school level" were reviewed and looked at. This study presents a case study where it focuses on the importance of temporal links in teachers' discourse in particular how these links participate in the drawing of classroom content from the beginning of the school year. From a socio-cultural perspective and by taking the teaching learning process as a dynamic process, it was built on three theoretical concepts:
(1) The definition of *context and continuity* developed by the works of Mercer (1987, 2008).

> The definition of context and continuity developed by Eduards & Mercer (1987, p. 63). Mercer defines continuity by referring to the context. From Mercer's point of view, context "refers to everything that the participants in a conversation know and understand, over and above that which is explicit in what they say, that contributes to how they make sense of what is said". Thus, *"continuity is the development of such contexts through time"* (Eduards & Mercer, 1987, p. 63). The term *continuity* refers to and puts a stress on the evolutionary construction of meanings through discourse interaction, establishing thus coherence between the meanings developed and presented in a past context and the present context. It involves the idea that the meanings attributed to a taught content in a particular moment evolve during the sequence (Badreddine & Buty, 2011, p. 778).

(2) The definition of macroscopic, *mesoscopic*, and *microscopic* scale taken from the works of physics education for studying the progression of knowledge in time:

> The time scale defined in the work of physics education (Tiberghien & al., 2007) for studying the progression of knowledge in time, its coherence and continuity. These authors define three scales in order to describe and to organize class phenomena through time. In

their study, Tiberghien et al. (2007, p. 102) define three different time scales for an analysis of phenomena related to the teaching and learning process:

> *"the macroscopic scale that corresponds to the academic time (weeks and months), the mesoscopic scale that corresponds to the didactic time (minutes and hours), and finally the microscopic scale that represents a smaller granularity, around minutes and seconds. This microscopic scale is at the level of utterances and gestures of actors […], the level of interactions".*

(3) And finally the concepts of *themes* and *episodes* in order to organize the taught knowledge respectively at the mesoscopic scale and microscopic one.

> Finally, in order to organize the taught knowledge respectively at the mesoscopic scale and microscopic one, we borrow the concept of "theme" (idem) and "episodes" (Mortimer et al., 2003). A theme is defined as the "central topic of a discussion during a given time interval in the classroom. These units have a structure, with boundaries and a thematic coherence. They include most of the time an introduction and a conclusion, the majority of utterances is connected to the same theme" (Tiberghien et al., 2007, p. 97). A theme represents the central topic of the discussion during a given time interval in the classroom. "The thematic units [are used] in order to structure the taught knowledge at the mesoscale (time scale of a few dozen of minutes) by its content". As for the notion of episode, it represents "a coherent set of actions and meanings produced by the participants in interaction" (Mortimer et al., 2007, p. 61–62). The episodes provide access to the rhythm of the classroom life, the dynamics of the classroom interaction and progression of taught content, at the microscopic level.

2.11 Indigenous Knowledge Systems inclusion in compulsory History as school subject

A task team appointed by Minister of Basic Education, Angie Motshekga has recommended that history be made compulsory in schools (Department of Basic Education, 2018). A History Ministerial Task Team (MTT) was set up in 2015, and after three years, its findings were finally made public on Thursday, 31 May 2018 by the minister. (Department of Basic Education, 2018).

According to MTT's recommendation, the compulsory History subject should replace Life Orientation (LO) as a compulsory subject between Grades 10 and 12, which should only remain compulsory until Grade 9. The team came to these findings after spending three years researching how 12 other countries have taught history in their schools (MTT, 2018).

> *"History education at school has the potential to offer explanatory, analytical and interpretative skills. Ideally, learners have to be capable to assess arguments and develop an ability to construct counter-arguments which have to be synthesised within a historical narrative,"* (MTT, 2018, p. 12).

The report recommends that the changes be implemented on a phase-in basis, starting from 2023, to allow the education department time to prepare and train teacher to cope with the deficits on unqualified history teachers.

> *"However, in general, the MTT is of the view that we should not only be pre-occupied with the 'student deficit model' because teachers who are unqualified to teach history should acknowledge that they are underprepared and ill-equipped to teach History. We should accept and acknowledge the existence of a 'teacher deficit model' and its implications, namely that, for the DBE to address such deficits, inclusive teacher development (or teacher training) programmes must be devised and these should also include unqualified teachers who must be offered a chance to upgrade their qualifications if they are committed to teaching History".* (MTT, 2018, p. 83)

The report also noted in concern 5 (p. 78) that the **Eurocentrism** nature of the history taught in the current curriculum, as well as other issues, including *gender, agricultural* and *food production* and *(IKS) Indigenous Knowledge Systems* need to get emphasized with the new approach to teaching History. The major concern of the report reflects and argues the following:

> *"The curriculum is very much like the post-1994 sanitised interim-curriculum, in that it is very Eurocentric. This has become accentuated in CAPS, because the archaeological past has been removed so that African history is recent and only emerges through foreign texts. Furthermore, oral history and understanding of or engagement with* ***indigenous knowledge*** *is played down in CAPS".*

> *"There is a call for a history curriculum that speaks to learners. It should be one that builds learners as responsible citizens in post-1994 South Africa. CAPS offers very little in the way of an African perspective; the language of expression is English, and the content more often than not draws on foreign documents or records. This creates the impression that Africans did not have a past prior to the arrival of European colonisers in the continent, and because Africa and Africans are always 'written about', they never have agency according to the Eurocentric liberal paradigm which informs CAPS. It offers little African perspective. Indeed, in all the subject content, histories and analyses of countries in other continents and world events in general (for example the ancient Chinese civilisation), should actively consider the relationship and impact on the African continent and on South/southern Africa"* (MTT, 2018, p. 78).

Furthermore the report finds that there is an overwhelming focus on the leaders and little attention is paid to the people (indigenous peoples living ways), including the ordinary people on the street. The task team under chairmanship of Professor Sifiso Mxolisi Ndlovu, made the following recommendations known in the MTT (2018) report that would streamline the implementation of a new History curriculum for South African Schools:

> "*The teaching, assessment, recording and reporting on Geography and History under the guise of 'Social Sciences' must be remedied. The subjects must be separated. This will make it possible to avoid an average 'Social Sciences' mark attained by writing two distinct subjects. In terms of teaching, currently, both subjects have equal notional/instructional time per week and per term (3 hours per week and 15 hours per subject in a given term. Note that the notional/instructional time has not been increased in the Senior Phase). The final promotional mark should reflect the time spent teaching each of the subjects separately. This will address the challenge of bias towards Geography and vice versa. The MTT proposes that it is high time to drop the spurious 'Social Sciences' category and allow the two disciplines to exist as separate subjects, taught by qualified History and Geography teachers respectively. This will serve to strengthen the perception among learners that History has value and importance, and will ensure that learners are taught the subject properly"* (MTT, 2018, p. 83).

2.12 CAPS realignment to accommodate History inclusion

The MTT reports that the CAPS (2011) curriculum has serious limitations and must be strengthened. The MTT recommends that the RNCS/NCS (2002) as a whole should be revisited and a better synergy between the RNCS/NCS (2002) and CAPS (2011) be made in terms of both the content framework and the approach to teaching History. Too much of value was lost from the RNCS/NCS (2002) in the CAPS (2011) process. An example is the phasing out of the local history component, oral history, palaeontology and archaeology in the FET curriculum. A positive element of CAPS (2011) is its simplicity (MTT, 2018, p. 131).

The full implementation will only be in the year 2030 and the MTT recommends complete overhaul of CAPS, it must be recognised that this must be undertaken as a strategic process which involves experts and educators. The discussion and analysis presented below highlight the important point that reviewing and strengthening content is not a simple exercise but is a complex, elaborate process that has to be linked to the GET phase (see page 133 of the Ministerial Task Team report of February 2018 for full implementation plan).

2.13 International Conferences on Integrating IKS with Science

International Conferences on IK were some of the first ways of dialogue that happen at tertiary institutions level that spark some interest within the Modern Science World that were directly link to the research field of Indigenous Knowledge Systems in the Western Cape province of South Africa. Various interested stakeholders including; neighbouring countries, neighbouring institutions, community & tribe leaders, government officials, private funding houses and private businesses were invited to attend the "IKS Research & Innovation Indaba's" that was the driving forces behind the "Melting Pot" (SIKSP, 2012) dialogue between IK-and Science integration specialist that has set the landscape for further investigations and research in the Nature of Indigenous Knowledge Systems (NOIKS) sphere. Figure 2.1 gives a diagrammatic representation of IKS development on a global platform.

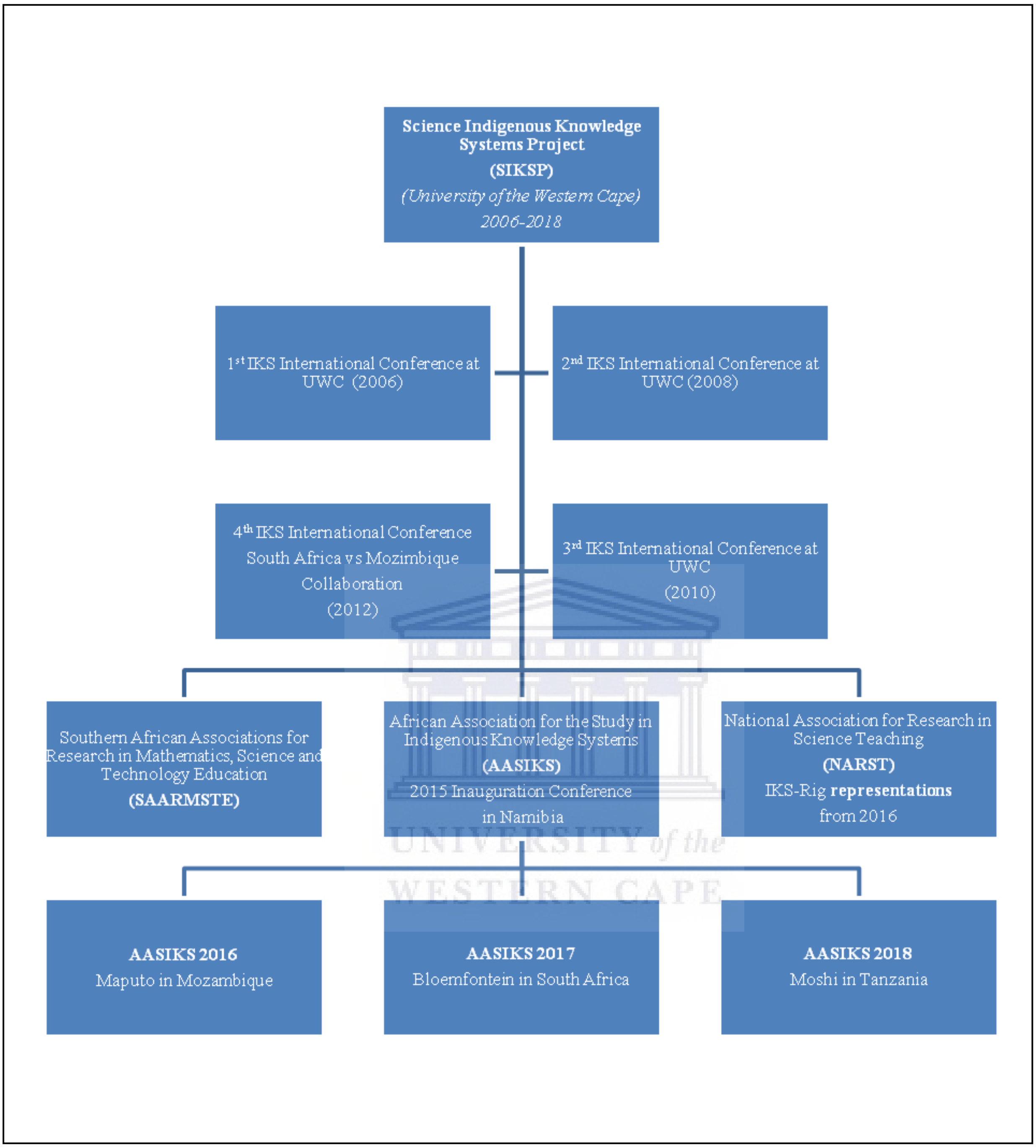

Figure 3 Diagram of Indigenous Knowledge Systems (IKS) International Conferences

These conferences main foci were pinned down on research collaborations between Southern African; Sub-Saharan region and Southern African Development Community (SADC) countries, which include countries such as; Zimbabwe, Namibia, Botswana, Lesotho, Zambia Mozambique, Swaziland, Malawi and Tanzania to share their rich local socio-and cultural knowledge on an international and global scale. These knowledge sharing encounters has lead then to roundtable negotiations and the establishment of the first African Association for the Study of Indigenous Knowledge (AASIKS) on the African soil.

2.13.1 International Conference of the Science and Indigenous Knowledge Systems Project

All 'African universities must be used as spaces to reclaim African identity, and to aid in decolonising the mind-sets of Africans, if we are to preserve the indigenous knowledge accumulated during the course of the continent's history' was the overall message delivered by dignitaries, delegates and guest speakers (Ogunniyi, 2013).

The SIKSP international conference was a collaboration conferences between South Africa and Mozambique held between 29th till 31st of October, 2013 at the School of Public Health at the University of the Western Cape – themed Harnessing Indigenous Knowledge Systems for Sustainable Development – aimed to address the growing worldwide outcry to learn from indigenous peoples about how they preserved human health and knowledge, and how they occupied and made use of their environments for centuries without damaging them to the extent that heavily industrialised societies have.

South African-Mozambican Collaboration

The difference between this (fourth) conference and earlier IKS conferences of its kind were that it was co-sponsored by the SIKSP/ South African-Mozambican Collaborative Programme interested in harnessing the potential of indigenous knowledge systems for socio-economic development. There were overwhelming appearances of converging interest on the part of both countries to authenticate their hard-won independence thorough the indigenization of their knowledge production systems. Besides, both countries are irrevocably committed to the emergence of scientific and technological vibrant cultures while at the same time retaining their African identity. Against such solid alliances, the responsibility of academic community in both countries has assumed a new dimension. With rapid environmental and global weather pattern changes caused largely by science and technology activities there has been a greater awareness worldwide about the need to tap the potential of indigenous knowledge for our planet's sustainable future. Various national and international bodies, governments, non-government organisations as well as the general public have become acutely concerned that we live in a delicate planet with little left to sustain life in all its fullness. The public outcry against the recklessness of multi-national companies in the way they exploit natural resources without compensation and the negative impact of globalisation are fast marginalising the majority of human population particularly the indigenous people (Ogunniyi, 2013). The abuse of Intellectual

Property (IP) and human rights have become a priority agenda of the United Nations (UN) and affiliated organs such as *Food and Agricultural Organization of United Nations* (FAO), *United Nations Education, Science and Cultural Organization* (UNESCO), *United Nations Development Programme* (UNDP) and *United Nations Children's Fund* (UNICEF). For the same reason many African countries have formulated IKS policies to regulate the mass exploitation of their natural resources (Ogunniyi, 2013)

The conference brought together experts from a variety of fields who engaged in an intensive and engaging scholarly discourse, providing useful insights into the deeper issues surrounding indigenous knowledge and its relevance in the 21st century. Topics discussed included such matters as integrating medicines into public health systems, integrating science with indigenous knowledge, and investigating indigenous knowledge for sustainable development.

Professor George Sefa Dei of the University of Toronto said that African universities must build capacity locally for the development of an indigenous knowledge-based school curriculum. Such an indigenous curriculum would be reframed to prioritise the critical interests of Africans, and be aimed at solving Africa's problems (rather than prioritising questions that others find important) and re-evaluating the goals of the curriculum and the content in terms of the indigenous knowledge of Africans. "We must unmask hegemonic worldviews and knowledge systems masquerading as neutral, universal or singular, and provide students with tools to analyse where African knowledge is incompatible with other knowledge systems," (University of the Western Cape, 2013).

He warned, however, that this would require a precise and careful definition of this indigenous knowledge, so that it is not simply imagined in response to, in reaction to, or in opposition to other knowledge systems (especially hegemonic European knowledges systems).

Dei (2014) added that the current direction of post-colonial education in Africa should be fully understood as a large part of the problem of education. "We have become extremely adept at mimicking Western and Eurocentric theories and methodologies, which hardly speak to African realities," (University of the Western Cape, 2014)

Professor Meshach Ogunniyi from University Of the Western Cape (UWC) and then director of the School of Science and Mathematics Education (SMME) at the host university echoed these sentiments, arguing that the 'science curricula adopted by many African countries were transplants which were not suitable for African indigenous soil (so to speak), and carried with them the baggage of imperialism (Ogunniyi, 2013). Professor Ogunniyi said that an inclusive science/indigenous knowledge curriculum is foundational to learners' understanding of the relationship between school science and the worlds they inhabit in their lives outside of school. He noted that *"A science/indigenous knowledge curriculum taught in inclusive ways tends to encourage cross-cultural interactions among all learners, and to enhance the development of social identity, especially among learners from marginalised indigenous communities".* This, he explained, promotes economic progress and social justice, in that no worldview is suppressed on account of science (University of Western Cape, 2013).

The overall Indigenous Knowledge Systems conference held over a period of 6 years has paved the way to bring major role players together and discussed the importance of lead to the launch of the AASIKS in Namibia in October 2015.

2.13.2 African Association for the Study of Indigenous Knowledge Systems (AASIKS)

In October (28-30th) 2015 the inauguration of AASIKS took place in Windhoek, Namibia to form a national and international network of representation to liase in the field of IKS for the African continent to collaborate internationally with other stakeholders. This AASIKS-association was a direct vision and product of the Science Indigenous Knowledge System Project (SIKSP) of the University of the Western Cape where the researcher is a member headed by Professor Meshach Ogunniyi from University of the Western Cape. This African association is open to all Universities and Tertiary institutions— driven to document indigenous knowledge in Africa and globally.

At the inaugural welcome by the then interim president Professor Meshach Ogunniyi— he presented the following message to the conference delegates, as a plea to collaborate on IK-research projects (adapted from original foreword):

> *A recent review of studies done between 1970 and 2012 in a number of African countries on indigenous knowledge systems (IKS) revealed that these human enterprises have been used and abused in various ways. For instance, pharmaceutical companies have recruited scientist, pharmacologist, indigenous knowledge experts, entrepreneurs and others to study, prospect and evaluate the agricultural, medicinal, and commercial value of indigenous flora and fauna all over the continent. The saga surrounding the patency of the rooibos tea by a large international food company has been going on in the courts for*

several decades. Rooibos plant, a native Western Cape, South Africa has been harvested by the indigenous peoples for centuries for its dietary and medicinal benefits. Knowledge emanating from indigenous communities around the world has been stolen and commoditized by various international commercial companies leaving the real owners impoverished, devalued, cheated and marginalized. In fact, indigenous knowledge (IK) has been used by the advanced economies to oppress the indigenous people worldwide (Ogunniyi, 2015)

We can clearly see the need and cry for such an association as AASIKS who can represent the global masses that long for representation in a forum of this kind. This will mean that protection from further alienation of IKS will stop, and that lost knowledge and resources can now be documented with the knowing that it will be valued globally and used for educational purposes worldwide.

AASIKS 2015 Inaugural Theme

The theme of the inaugural conference of AASIKS revolves around issues such as: reviewing the impact of IKS on the attainment of the African Millennium Development Goals, especially in such sectors as agriculture, architecture, banking, community development, education, science and technology, medicine, poverty alleviation. Politics and governance, and in pursuance of this to explore the potential of IKS to African socio-economic development as well as seek for innovative ways for integrating IKS into science technology, engineering and mathematics (STEM) education in African classrooms—all in an attempt to achieve the goal of self-reliance.

The sub-themes focus on issues such as: African IKS and the Millennium Development Goals; Health and Food security within the context of African IKS; African economic prosperity and IKS; African indigenous ways of knowing; knowledge production; values and environmental security; gender, culture, literacy, and employment; science and technology; governance within the African IKS; and the African Diaspora and the promotion of African IKS worldwide. We can virtually see the aim of this theme and sub-themes is to awaken all the stakeholders regarding the importance of IKS as a viable option amidst the present impasses and disillusionment in which the continent has found itself since the independent era of the about five decades ago. This is a clarion call to remind stakeholders that while some progress has been made in a number of sectors, the potential of IKS for socio-economic development and cultural renewal has hardly been tapped into.

It is in my view that the AASIKS association is the right platform to discuss at length indigenous knowledge systems (IKS) and what they can offer not only for our own generation but those who are to follow us. We have a moral responsibility to leave for them a heritage that would make them proud to be African at any place and at all times.

Although IK has been in existence for centuries, it was only recently that an increasing attention has been paid to it by different sectors of society. International UN bodies such as UNESCO, FAO, UNDP, UNICEF, World Bank, governments, non-governmental organizations and the public at large have been concerned with the abusive ways in which IK has been treated worldwide. According to Ogunniyi (2015) the reason for this awareness include, among others: the diverse environmental problems believed to have been caused by scientific and industrial activities such as: environmental pollution; erosion of the ozone layer; greenhouse effect; excessive flooding and drought; global warming; flooding and desertification; and the perceived failure of western science to solve a congeries of human problems such as poverty, hunger, resistant diseases or pests. In science education the call to include IK in the science curricula in many countries has been mainly due to the general poor performance of students especially non-mainstream indigenous students who constitute the bulk of the African science classrooms (Ogunniyi, 2015). Ogunniyi (2015) further argues that there have been public outcries worldwide against the recklessness in the way in which the earth's resources are been depleted daily.

Ogunniyi (2015) further claims that today, the tropical rain forests and other flora regimes are facing the possibility of extinction. A great proportion of the fauna have become endangered. The killing of elephants, lions, and rhinos to mention but a few are destabilizing the eco-systems all over Africa. The destruction of the fauna and flora at such a fast rate without the opportunity for the essential recovery period and the way in which the current globalization phenomenon has marginalized and exploited without compensating people in developing countries and the indigenous communities worldwide by the industrial nations have assumed a new dimension for all concerned. The issue of intellectual property, and the rights associated with IKS have assumed a higher status in the agenda of the UN and its affiliated bodies. For the same reason many African countries have formulated IKS policies to regulate the mass exploitation of their material resources.

AASIKS foster IKS knowledge production

The AASIKS association will only be the beginning to greater collaboration across our institutions or sectors to see to it that our talk about IKS does not become a mere cliché but a rallying slogan for programmatic action. The inclusion of indigenous knowledge into the dominant paradigms of knowledge production and application has been a great challenge for the various agencies and gatekeepers of knowledge. While considerable number of these gatekeepers are sympathetic to the inclusivity and acceptance of indigenous knowledge as legitimate in their own right, many consider the whole idea as retrogressive, specious and totally unwarranted in this day and age. Even among the sympathizers for inclusion the motives for doing so are largely driven by economic interest, the most poignant in this regard being in the fields of agricultural, medical and pharmaceutical sciences. While the concern of true sympathizers is noteworthy it needs to be stressed that knowledge production and preservation are the rights of all humans regardless of their stage of scientific and technological development. The right of indigenous peoples whose knowledges and cultures have been exploited and bastardized for about 500 years can neither be negotiated nor can their pursuit of self-determination, self-actualization, socio-cultural identity and sense of being be compromised.

Because of the exclusivist posture of the dominant voice, the knowledge that would have enriched and increased our chances of survival as humans has been greatly depleted or lost altogether. It is therefore, gratifying to note that critical voices from the academia and local indigenous communities are becoming more vociferous in their demand that the silenced voices be heard and heeded to stem the tide to current disastrous consequences brought about largely by scientific and technological activities on the one hand and the ill-informed policies fuelled by the demands of globalization in its strive to commoditize knowledge on the other. The point here of course is not to romanticize all aspects of IKS as there are aspects that are not harmful but dangerous and should be avoided at all cost. The central focus in AASIKS association should be to harness only those aspects of IKS that could contribute positively towards the sustainable development of the continent.

2.14 The National Association for Research in Science Teaching (NARST) support Global and Local (Glocalization[1]) and IKS

The researcher of this study was invited as a conference delegate of the 2016 NARST Annual International Conference in April 2016 in Baltimore, Maryland, USA. The main theme of the conference fell under the umbrella of Toward Equity and Justice: Many Different Voices, Cultures, and Languages in Science Education Research for Quality Science Learning and Teaching.

[1] Glocalization: the practice of conducting business according to both local and global considerations.

The current global warming crises has made government and states parliaments more aware of the importance of investing into IKS research projects—to foster and gather a deeper understanding of how important indigenous knowledge is to human survival.

The combination of effective **Glocalization** science learning using *global interaction* and *local science teaching* to foster the understanding of everyday-science knowledge (local science or ways of doing) – will benefit from global communities sharing their educational research and outcomes, as well as using an international monitoring system to familiarize learners with the effective learning of science concepts taught within a local context.

From here, children can develop *glocal* literacy, *glocal* learning strategies, *glocal* leadership, and *glocal* vision in science education. And this will help researchers and policymakers co-construct healthier learning environments that provide a collaborative atmosphere for fostering global citizens' scientific literacy.

According to Mei-Hung Chiu (2016), the newly elected president of NARST (The National Association for Research in Science Teaching) argues that *glocalization* should continuously play a role in facilitating a dynamic and interconnected community and in sustaining research and practice outcomes. *Glocalization* will move the science education field towards greater collaboration (and communication) instead of competition among children, science teachers, science education researchers, and policymakers (Chiu, 2016).

Various data is providing us with both the localized and the global dimension of educational research. The seemingly contradictory needs of a globalized vision and localized accommodation have revealed a true challenge for all science educators, regardless of where they are from. *Glocalization* of science education is, thus, as pressing as ever and it complement the use of Indigenous Knowledge (IK) in the classroom.

Indigenous Knowledge RIG at NARST International Conferences

In 2016 The National Executive committee of NARST (National Association for Research in Science Teaching) has accepted the application of AAIKS (African Association for the Study of Indigenous Knowledge Systems) to host open forums on IKS, and to showcase some of the research by an array of scholars at their annual conference meetings. This far more the best cry to introduce African-IK to the global-science-world and to strengthen the relations between Science and Indigenous Knowledge — very important way of sharing and disseminating knowledge.

2.15 Indigenous Knowledge studies in Science Education

Study A

The main focus in this case study is on two episodes situated in a same theme ("the representation of the solar system as an almost empty (lacunar system"), and extracted from a video-recorded sequence at the beginning of the school year. The teacher in question is an experienced teacher. These two episodes describe how the teacher draws the *knowledge context* and ensure continuity of the class with regard to knowledge on a short scale and on a longer one. It is a study in progress that aims:

> (1) to understand how different teachers from different disciplines and different profiles manage from the beginning of the school year the construction and managing of knowledge in the classroom discourse,
>
> (2) to provide teachers with tools related to the managing of knowledge through time.

The study found that by studying the practices of experienced teachers, this work will enable the research to underline some of their performances and to bring tools to science teachers related to the managing of knowledge through time, more particularly, tools that enable teachers to explicit to students links between the past, the present, and the future of the taught content. This study is an analysis that will be extended to the other teachers in order to create collections of regularity and variability between teachers' practices. Badreddine (2009) believe that explicit these links to teachers and pre-service teachers, in order to use them efficiently in there teaching sessions, may increase students learning process. Furthermore, she aims to study the types of knowledge when links are made in the classroom discourse and the position of these links with regard to the progression of the lesson.

Study B

Another study that was reviewed out of interest to dialogical argumentation instructional model (DAIM) was of Evagorou, Papanastasiou & Osborne (2009) on "The case of designing and validating a tool to assess 11-14 year old students written argumentation". The purpose of this study was to present the process of designing and validating a tool to assess 11-14 year old learners' written argumentation in science. Given the emphasis in argumentation in science education in the recent years, methodologically the assessment of argumentation has become one of the dominant issues in the field. In this study the researcher present two written argumentation tools that were designed for 11-14 year old learners, the validation process, and the main outcomes from testing the argumentation tools with 246 learners (students) in the UK. The analysis of the data from two versions of the questionnaire (Test A and Test B) show that both tests are reliable for evaluating written argumentation when the first item is removed (Cronbach's alpha .674 for Test A and .705 for Test B). Additionally the analysis of the data implies that choosing a convincing argument is more difficult for the students than any of the other three aspects of argumentation that were evaluated in these tests (choosing a convincing counterargument, writing an argument, writing a counter-argument). Finally, the results from the questionnaire suggest that argumentation might be content specific. Implications for research include the design of a new tool combining the questions from both tests, using aspects of the questionnaire to explore whether argumentation is context specific, and exploring whether deciding on a convincing argument is a higher sub-skill compared to writing an argument.

In conclusion the above study implies that choosing a convincing argument is more difficult for the learners than any of the other three aspects of argumentation that were evaluated in these tests (choosing a convincing counterargument, writing an argument, writing a counter-argument). Finally, the results from the questionnaire imply that argumentation might be content specific since for the same structure of the two tests, Test A had a lower Cronbach's alpha, and that was higher when Question 1 (which was heavily relying on students' knowledge on electric circuits) was removed. The hypothesis that argumentation is context specific is also supported from findings in previous studies.

Some implications in the above mentioned research study was noted that includes the design of a new tool combining the questions from both tests to see if this provides a higher internal consistency measure, and also using aspects of the questionnaire to explore:

(a) whether argumentation is context specific, and

(b) that deciding which is a convincing argument is a higher sub-skill.

Since the findings from this study suggest that choosing a convincing argument from a list of given arguments is more difficult that constructing an argument, implications for practice include finding ways to support students when deciding upon convincing arguments, since this is a skill useful in their everyday life.

Study C

Another study that was reviewed was from Hanife Hakyolu (2010) from Dogus University and Feral Ogan-Bekiroglu (2010) from Marmara University with the title "Tracking of Students' Scientific Argumentation Quality". According to the researchers the study of argumentation is still a young field and more research needs to be carried out on students' argumentation quality (Hakyolu & Ogan-Bekiroglu, 2010) . Therefore, the purpose of this study was to examine the quality of students' argumentation and to find out how their argumentation quality changed as their involvement in scientific argumentation increased. Case study design was guided the research. The participants of the study were 13 senior pre-service physics teachers, four of whom were females. Argumentation sequences were implemented in the methods course and lasted six weeks including two subjects, i.e. kinematics, and heat and temperature. Data were collected via learners' worksheets and video recordings made during the argumentations.

The study then concludes that learners' argumentation quality does not increase as the number of argumentation and their involvement in argumentation increase. Second, if students have familiarity with the concepts that are argued on, they can reach the highest quality level of argumentation although they do not have any experience with argumentation process in their previous instructions. Third, changing of subjects in argumentation may get learners' interest and thus affect their quality of argumentation. Fourth, concepts that argumentation is founded on can influence argumentation quality. Finally, there is no consistency in learners' argumentation quality through argumentation sequences when content as well as context of argumentation change in each sequence. This study has implication of presenting the changes in students' argumentation quality in scientific argumentation sequences.

Study D

Another "Study of the interrelationship between students' arguments and features of task in science classes" (Konstantinidou, Castells & Mª Cerveró, 2010) from the University of Barcelona were also reviewed to examine the inter-class relationship among learners' within an argumentation instructional setting. From previous studies we have identified types of arguments that learners use when they solve problem-tasks in a science class. In this study, the researcher focuses on the way the features of the tasks determine the type of argument that learners' use. It is a qualitative study that gives a deep understanding of learners' scientific conceptions, and how learners interrelate their ideas with the types of arguments they use in a science class situation of dialogue in small groups. The analytical framework is mainly based on the Theory of the

Argumentation of Perelman, and the schemes for presumptive reasoning of Walton. With this analytical framework the researcher have analyzed several transcribed dialogues of learners' during open activities in a secondary school, and recognized the argument and premises that learners' use in their arguments. A result from the study is that tasks influence the argumentative schemes and the premises used by learners' in a different, and sometimes unexpected, way. This depends on specific features of the tasks, but also on the personal interpretation that students make, which could be related to their ideas and misconceptions.

In conclusion, this study seeks to improve our understanding of learners' arguments in relation to science conceptions. For science education the result from the research about the interrelationship between the four elements identified by means of the analysis (features of the problems-tasks, previous scientific ideas students have, personal interpretation of the tasks' situations and the argumentative schemes used by the learners performing the tasks in small group) is very relevant. The research were limited, further studies are needed about argument schemes that students use in science classes to improve our comprehension of learners' conceptions in science and also our knowledge of common sense argumentation. An implication of this research could be to include not only learners' misconceptions in teachers' training programs but also the most common learners' argumentative schemes for deeper understanding of their reasoning. This is important because the teachers will be able to use these argument schemes in their dialogical classes as a "tool" to favour the process of learning science and to provide "clues" to help them to choose appropriated activities in science education.

2.16 Chapter Summary

As stated earlier, this study is underpinned by an argumentation framework as espoused by Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT). The two theoretical frameworks are chosen because of their amenability to classroom discourse dealing with phenomena on which learners might be holding conflicting worldviews. These frameworks provide the necessary context for inductive, deductive and analogical reasoning. They also accord with the Piagetian and Vygotskian notion of constructivism, namely, that knowledge is constructed as one makes sense of the world around him/her. This type of reasoning can be used as an instructional tool for learners who constantly interact with their environments and surroundings in a sensible and more meaningful way.

The focus in this study is on environmental education, specifically of scientific meteorological literacy. Stapp (1978) as outlined by Wilson's (1994, p. 2) definition of meteorological literacy in the Journal of Environmental Education in 1996, outlined environmental education "as a means of producing an environmentally literate citizenry, empowered and motivated to solve environmental problems". However, over the past two decade and a half, research has begun to reveal broad academic benefits of using the environment as a foundation for instruction. Multiple studies indicate a positive correlation between meteorological literacy and students achievements overall (Wilson, 1994).

One of the reasons for the focus on indigenous knowledge systems (IKS) in this study is that the latest Curriculum and Assessment Policy Statement (CAPS) (2011) document for Natural Science of the Department of Basic Education indicates a change in the curriculum plan, effective from January 2011, that incorporates "indigenous knowledge". It vaguely indicates the assessment strategies towards IKS in the classroom in *Specific Outcome 3.2* that state:

> ***3.2 RELATIONSHIP OF INDIGENOUS KNOWLEDGE TO NATURAL SCIENCES***
> *Examples that are selected (and that should, as far as possible, reflect different South African cultural groupings)* ***will*** *also link directly to specific areas in the Natural Sciences subject content.* (CAPS, 2011, p. 63)

Implementing these aims will have direct implications for the Natural Science curriculum in South African schools – with no space, framework or resources to develop IKS properly. So, the provision for IKS in the national curriculum has opened debate amongst IKS-researchers, curriculum developers, academics and education specialist, because IKS is part of any culture or society and can't be ignored for the purpose of creating a smoother assessment curriculum policy statement in education. IKS forms the basis of every learning area, whether in science, life and living skills, social science, and should be seen at school as a point of departure to learn and create new knowledge and healthy argumentation in class among learners of all ages.

CHAPTER 3 - METHODOLOGY

3.1 Introduction

The main aim of the present study is to investigate the social and cultural relevance of aspects of Indigenous Knowledge Systems (IKS), Meteorological Literacy and Meteorological Science Concepts, specifically as they are taught and learned in a Grade 9 classroom, using a dialogical argumentation-based instructional model (DIAM). This chapter details the research design and methodology used to determine the effectiveness of the DIAM-model in developing the understanding and application of these concepts of a sample of Grade 9 learners. The research instruments used to collect data are informed by and employ qualitative and quantitative methods, or 'mix-methods', and are derived from the theoretical framework that underpins this study. This chapter also details the procedure followed to formulate the findings and results according to the research problem.

3.2 Research setting

This research was mainly conducted in the East Metro-pole District Centre (EMDC) of the Western Cape Education Department in the Western Cape Province. The areas of the province included large parts of the Cape Flats and Helderberg Region, and parts of the northern-and southern suburbs of Cape Town, South Africa. The researcher was also able to conduct valuable contact sessions with community elders who had, together with family members, relocated from areas outside the borders of the Western Cape. They offered to share their in-depth socio-cultural knowledge in these sessions in order to assist the principle researcher with a baseline understanding within the context of Indigenous Knowledge Systems used within a community context. They shared their understanding around IK-based knowledge from the past related to the current research. The areas from where the elders came were all those where previously disadvantaged communities of Northern Cape, Eastern Cape and Mpumalanga regions had lived and where many of their family members continued to reside. The two main schools involved in the study, and where the primary data were collected, have formally hosted the oldest informal community in the Western Cape and called '*Blik Dorp*' (pseudonym), with a 70-year-old history dating back to 1948 under the previous government. The two sites were identified and selected for the research based on their particular composition of learners who had relocated from rural towns in the adjacent provinces of Northern Cape, Eastern Cape and North West Provinces of South Africa, such as Springbok, De Aar, Hanover, Noupoort, Middelburg, Kuruman, and Uppington, and parts of the Klein Karoo district areas of Western Cape Province such as Oudtshoorn, Zoar, Calitzdorp, Dysseldorp and Ladismith with a rich socio-cultural history based on the value system and legacy of the spirit of *Ubuntu* (Ogguniyi, 2016).

Figure 4: Provinces of South Africa

3.2.1 Historical background to the setting

History of *Blik Dorp* Helderberg

Blik Dorp with its tin roof and shack-like informal housing structures, has given permanent residence since early 1950's to more than 750 families in the Helderberg Basin of the Western Cape. The first primary school of the area was erected during the apartheid era as a temporary structure (wooden walls on concrete slabs) adjacent to *Blik Dorp* in the early 1950's. In 1987 (31 years ago) the first high school of the area was established to cater for, and accommodate the growth of, the town, together with the two existing primary schools, all servicing an apartheid 'ghetto-ised' community consisting of more than 9 000 citizens at the time (Stats SA, 2005).

Blik Dorp was substantially rebuilt to replace the shacks with proper brick and cement houses under the RDP (Reconstruction and Development Policy) Act of 1996, under the new ANC government. At the time of conducting this study, in mid-2017, the community had two high schools and two primary schools (the one primary school was re-built in 2015 from a semi-temporary structure to a formal double story building at the same location). The high schools where the study was conducted are both located in the same area described above in the Western Cape; the study sample drawing learners from the same socio-economic and educational backgrounds to act as feeding schools in the area. The one school site (site X) in Onverwacht street, in the *Rusthof* area (previously known as *Lost World*), had one headmaster, two deputy principals, 28 teachers (educators) and 980 learners from grades 8-12 at the time, with an average 1:35 teacher-learner ratio. The second school site (site Y) in Broadlands street, in the *Gustrow* area, had the same top management structure combination with 26 teachers (educators) and a learner total of 896, with an average teacher-learner ratio of 1:34.

3.3 Mixed Method design

Gray, Mills and Airasian (2012) noted in their article about Educational Research Competence for Analysis and Application that "Educational research is the systematic application of a family of methods that are employed to provide trustworthy information about educational problems" (Gray et al., 2012, p. 1689).

This current study is based on a case study design with two main components, namely, a quasi-experimental design with qualitative and quantitative research design components – also known as a mixed-method approach. This approach attempts to establish a 'relationship between variables by exercising very tight control over key aspects of the setting in which the research is conducted'. In the experimental design form, the approach entails manipulating one variable (known as the independent variable) to observe the effects this has on another variable (the dependent variable). The two types of methods can be defined in terms of the data collected using these methods as:

- **Quantitative** data are considered to be objective data in the form of numbers, information gathered when participants check their responses to closed-ended response options. These data are analyzed using statistical procedures.

- **Qualitative** data are the subjective data: words or images, information, often in the form of perceptions and views of participants and gathered from open-ended questions when participants are not given responses categories or scales to check.

These two methods together provide the basis of a *mixed-methods approach* in this study, the major *strengths* and *weaknesses* of a *mixed-method approach* were carefully considered for this study (see appendix R) and each is based on five essential characteristics of a mixed-methods approach:

- The response to the researcher's research question / hypotheses, the collection and analysis of both **quantitative** and **qualitative data**
- The use of a **rigorous procedures** in conducting both the qualitative and qualitative phases of the research
- The **integration** (or combination) of the findings from the quantitative results and qualitative findings
- The development of procedures for this data collection, analysis and integration: mixed-methods **designs** appropriate to/to facilitate these procedures
- The use of appropriate and recognized/legitimate **theory** (and philosophy) as it relates to these procedures

The purpose of using triangulation as a verifiability process is directed at the need to increase the validity of a given study. Denzin (1998) identified four types of triangulation: (1) data triangulation - the use of various different sources of data in a study; (2) investigator triangulation- the process of using several different researchers in a study; (3) the use of different theoretical frameworks to interpret the same data set; and (4) methodological triangulation - the use of multiple methods or instruments to study the same problem. In this study use is made of all of the above methods of triangulation except for (2) investigator triangulation.

Overall, triangulation is a complex process and may involve a variety of strategies to increase the validity of the study. However, the cost of the whole process in terms of time, energy and resources should be borne in mind. The assumption underlying triangulation is that no single method is adequate for solving the problems associated with possible rival or conflicting explanations. Each method used reveals only an aspect of reality and hence the need to use multiple approaches to capture that reality as much as possible. Cresswell and Miller (2000:126) define triangulation as "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study".

In the current study the work by Lincoln and Guba (1985) was of interest to the processes of data gathering and analysis. They advise that the following measures can increase the degree of credibility: prolonged engagement in the setting, persistent observation, triangulation of data, and peer debriefing. Hence, in any study the following measures should be borne in mind in an attempt to establish the constructed realities of the participants and those realities perceived by the researcher:

1. records and document analysis
2. personal reflections
3. field notes
4. informal discussions

Two types of data that could be collected are: (1) monological data, i.e. records and document analysis, researcher value orientation, reconstructive analysis and observations, and (2) dialogical data, i.e. qualitative interviews with the participants. This sort of data, collected through informal discussions, observations and document analysis at the site could serve as a tool to validate the data collected during the interviews. The researcher should confirm transcripts and field notes by comparing and contrasting them with information gathered by mono-logical data generation (Robson, 2002).

In order to increase the dependability and the stability of data over time, careful and systematic recordings of the details of each stage of the process should be kept. These details could be used in what Lincoln and Guba (1985) call an inquiry audit, which can assist the researcher to trace back in the event of a misinterpretation of data. Changes can then be made to restore dependability and confirm that procedures were followed fairly and correctly. Finally, the examination of records and profiles (educator files, diaries, schedule of work, portfolios, lesson notes etc.) should confirm the trustworthiness of views expressed by the participants (Golafshani, 2003). These document sources are drawn upon to present vignettes of best practices in the science classroom.

3.4 Sampling

Creswell (1998, p. 118) sees purposive sampling as providing a rich bank of data collected through empirical and qualitative means inclusive of focus group interviews.

Two intact class groups from two public high schools (respectively referred to as school "X" and school "Y") in Strand were chosen as sample groups. The school is situated in a distinct socio-cultural and economic background area in the Helderberg Basin. The sampling involved two Grade 9 classes from the same school. Participants ranged from 14-16 years of age. The classes from which the groups were chosen were positively selected on the basis of **comparability** with respect to:

- Classes doing the same subject and taught by the same teacher
- Formal class test and reports
- Learners from comparable socio-cultural and economic backgrounds

The two separate groups were two intact Grade 9 classes taught by the same educator who was assigned in the study to teach C group. Both educators from the respective high schools had been trained in the IKS/Science based approach and had been made aware that they were to keep all content close to the meteorological topics as set out in the geography section of the CAPS Social Sciences curriculum.

3.5 Research Instruments

As a teacher previously employed in the service of the Western Cape Education Department (WCED), over the years I have noticed the lack of effective English communication or use of English as the language of learning and teaching (LoLT) in many public schools. This made me decide to design all the instruments in both Afrikaans and English, and for the purpose of the study to only use the English version for ease of discussion and argument. Most of the subjects sampled in both the (E) and (C) groups indicated a reasonable to good command of the English language. All participants, even those whose home language was neither English nor Afrikaans, could be said to be fluent in English and could read, write and speak both Afrikaans and English fluently.

3.5.1 Translation of Instruments

Previously English instruments (questionnaires, worksheets) would normally be used in my research setting, and subsequently translated into Afrikaans during the data collection process on site. I observed that this translation process occasionally causes disruption during the data collection and intervention stages when learners want to concentrate while completing the questionnaires. I thus decided to either translate all instruments from English to Afrikaans (and even certain words into isi-Xhosa) to serve a multi-language or trans-languaging purpose. Learners would then easily be able to cross between languages in whatever ways convenient for them when answering the questions to the best of their abilities. At this stage we explained to the learner participants that it is acceptable to answer or complete each question in whichever language they felt they could express themselves easily / comfortably/ optimally.

By doing these translations at this stage we maximised the likelihood that learners' who were not First Language English speakers would supply relevant and valid answers to all questionnaires. Learners would be able to access the Afrikaans version if they did not understand something and this optimizes the use of the questionnaire by ensuring they can understand it more clearly and it offers them equal opportunities to understand and to express themselves fully.

3.5.2 Development of the instruments

We have to note at this stage for the purpose of this study that, while formulating, designing and developing the instruments that we administered in this study — we aligned them all with the Curriculum Assessment Policy Statement (CAPS) for schools falling under the Western Cape Education Department and adhering to the National Curriculum Statement (NCS) (Department of Education, 2012).

Some of the instruments were adapted from previous dialogical argumentation studies, in the field of IKS using the IKS-Meteorological Integration Model designed by the researcher for the use of integrating (Western) Science and IK, for example those of Ogunniyi (2008), Siseho (2013), Langenhoven (2014), Diwu (2010) and Riffel (2013). Added changes were made to existing instruments to streamline these into the current study of the social and cultural relevance of IK to current classrooms. Some of the researcher's/author's own questionnaires (Riffel, 2012) that were administered during his Master's degree thesis were adapted to format valid and reliable instruments for the current study.

Table 5 below provides a summary of the instrument structure used in the mixed research methods study.

Table 5: Instruments and analytic categories of the CAT (adapted from Diwi, 2010)

INSTRUMENTS USED IN BOTH STUDY GROUPS	MEASUREMENT SCALES USED AND OPERATION SEQUENCE FOR EACH ANALYSIS.	ANALYTICAL INTERPRETATION METHOD
Pre/Post-test Conceptions of Weather (CoW) scale	1) 5-point Strength of Argumentation scale 2) 5-point World View Response classification	1) Quantitative with 2)Qualitative
Pre/Post-test Attitude toward Natural Science (Geography/IKS scale	5-point CAT categories' sub-scale	Qualitative
Post-intervention Meteorological Literacy Test (MLT) scale	1. 5-point Strength of Argumentation scale Items' levels of skill classification	1) Quantitative 2) Qualitative
Classroom observations	Learner responses and excerpts	Qualitative
Focus group interviews	learner responses and excerpts	Qualitative

The design of the instruments has largely been influenced by my industrial experience as a meteorological scientist as well as by previous teaching experience in Natural Science (Geography) at secondary school level. I have attempted as much as possible to incorporate this experience into the instrumentation design.

3.5.3 Format and procedure of instrument development

Weather instruments such as barometers, rain gauges, temperature meters, min-max meters, compasses, hygrometers, and anemometers were presented to them as scientific instruments. IKS related weather prediction knowledge had previously been shared among all participants.

Weather instruments were handed out to each group of 5 to 6 members to discuss and identify the usage and key features of the weather instrument at hand. Each group received a different weather instrument.

They discussed the instruments and presented their findings on what they thought the particular scientific (weather) instrument could be used for—referring to the description, measuring units and scientific-use and meaning. The practical workshop was followed by a reflective session on the findings - followed by smaller and larger group discussions and exchanging of cross reference knowledge.

3.5.4 Views of Indigenous Knowledge Questionnaire (VIKQ) for teachers

Instrument development:

Further qualitative data were collected by means of an adapted version of the *Views-on-the-Nature-Of-Indigenous-Knowledge* (VNOIK) (Cronje, de Beer & Ankiewicz, 2015). The adapted version of the VNOIK is currently referred to as the *Views on Indigenous Knowledge Questionnaire* (VIKQ) (see appendix X). The VNOIK was previously used by Cronje et al., (2015) in a study to determine a wide range of views of science teachers on the nature of indigenous knowledge from different schools in a semi-rural area in the North-West Province. The adapted VNOIK instrument was considered suitable to explore whether and to what extent a sample of my very own study in the East Metro-pole District Centre (EMDC) in the Western Cape, South African science teachers were holding, either a partially informed view or an informed view on the nature of indigenous knowledge and whether the instrument has been the foundation for data collection in numerous research publications (Cronje et al., 2015). VNOIK is a ten-item questionnaire that aims to provide as accurate information as possible concerning the measuring of the effect of a short learning programme and to identify further development needs of the science teachers in the sample of those participating in the UWC study in addressing the tenets of science and indigenous knowledge effectively in the classroom and in curriculum development in IK-science teaching.

3.5.5 Empirical Design of VIKQ

The study undertook the development of the VIKQ instrument in such a way that it could be used to determine and investigate the views of the sampled science teachers on indigenous knowledge. The VIKQ design was based on a design-based strategy and piloted among the Science and Indigenous Knowledge Systems Project (SIKSP) involving members of the University of the Western Cape. Responses from the SIKSP members, together with an additional literature review, suggested a suitable questionnaire based on the framework developed by Lederman, Abd-El-Khalick, Bell and Schwartz (2002) on the views-on-the-nature-of-science (VNOS) Form C (Abd-El-Khalick et al., 1998) and grounded in the nature-NOIK framework. All items used in the new VIKQ derived from a tougher and comprehensive literature study, including Curriculum Assessment Policy Statement (CAPS) documents, science classroom resources and textbooks, the VNOS instrument, and indigenous knowledge examples used by leading scholars (e.g. Ogunniyi

& Duwi, 2012; Langenhoven, 2014; Jegede & Aikenhead, 1999) in the field of IKS. The views expressed in the indigenous knowledge questionnaire (VIKQ), described in appendix X , were to be elicited from 10 open-ended questions aimed to probe respondents' views on the nature of indigenous knowledge according to the NOIK (Cronje et al., 2015). The same kinds of open-ended questions were used in the focus group interviews (FGI) and for the same purpose of triangulation.

3.5.6 Conceptions of Weather (CoW) Questionnaire – Learner instrument

Instrument development:

The questionnaire provided three sections for respondents to complete: their demographic details, attitudes towards science, and conceptions of weather. The purpose of the questionnaires was to elicit information regarding the learners' knowledge and views about meteorological science in Geography and climate and weather phenomena and processes with specific reference to the social and cultural relevance of indigenous knowledge in South Africa. Section one of the questionnaire is for the learners' personal data, two and three are for the learners' responses in terms of their views on and attitudes towards science and traditional weather forecasting content knowledge respectively.

Attitude toward Natural Science

Part 1 of the survey focussed on the learners' perceptions on the **importance of geography** as a subject. The questionnaire consisted of 20 questions or items to do with what the learner's opinion was on the importance of Geography. Possible answers to an item were on a five-point Likert Scale as is shown in Table 6 below. The learner was asked to read the statement of belief about geography and then tick a relevant box which matched his/her belief.

Likert scale for survey

The survey questionnaire had five scales with acceptable reliability: Learning geography as a science (Item 2: Learners are encouraged to participate in classroom activities); Active learning (Item 5: I would like to visit places where I can learn more about the weather and the environment e.g. Weather Stations); Lesson structure (Item 8: Geography lessons are worth the time and effort

I put in); Geography knowledge (Item 9: Cold fronts bring much of the rain that South Africa needs'); Importance of geography (Item 13: Knowledge of the environment is important for our survival on earth).

Table 6: Learners beliefs and assessment scale

Learners Answer	Assessment scale
Strongly agree	The learner's view matches perfectly with the statement given.
Disagree	The learner's view tends to disagree with the statement given.
Agree	The learner's view tends to side with the statement given.
Strongly disagree	The learner strongly opposes the view expressed.

3.6 Validation, Reliability and Piloting of instruments

The instruments designed were subjected to validity and reliability tests. The validity and reliability were tested among 20 group members as science experts in the Science and Indigenous Knowledge Project (SIKSP) at the University of the Western Cape (UWC), South Africa. The members were all part of a structured Masters in Science Education programme consisting of six students, later joined by five Bachelor of Education (Hons) students and four additional Masters students, attached to other programmes, in addition to two (2) post-doctoral graduates and three (3) science education lecturers, a total of twenty (20) SIKSP researchers. All participants were post-graduate in-service science teachers who taught Natural Sciences or Life Sciences or Physical Sciences or Mathematics or one or other combination. The participants showed a keen interest in designing curriculum resource materials for science/IKS topics with the express purpose of promoting the implementation of a science-IKS curriculum.

Rating of all the instruments was also done through the same panel of experts in the same SIKSP group. Other colleagues, like Geography subject in-service teachers acted as specialist teacher at their respective schools were asked to provide comments. The instruments were piloted in a neighbouring school, given the pseudonym, "Xample Secondary School". As mentioned earlier, this school was initially planned for the comparison group (C group), but because the principal could not appoint an assisting teacher in time to administer the intervention, it was used for piloting the instruments. *Triangulation* was also employed as part of the piloting process. This was used as a means to obtain multiple perceptions on specific questions or issues to clarify meaning of the questions for respondents and to verify the repeatability of the observation or interpretation of the research instruments by respondents and researchers.

Prior to obtaining parametric statistics to address the research questions, issues of internal consistency and normality of samples need to be ascertained. It is good practice to first make sure the instruments that are used for collecting data are valid, otherwise statistical results obtained may be unreliable (Diwu, 2010). With regard to normality of a sample, some statistical techniques are based on certain assumptions. These assumptions dictate that prior to the use of the particular statistics obtained, the appropriate assumptions be borne in mind. All parametric statistics are sensitive to how scores of a particular sample are distributed around the sample mean. When low and high scores are equally distributed around the sample mean, then that sample is said to be normal. The Kolmogorov-Smirnov normality test is used in the current study to provide a measure of the degree of significance of the normality of a particular sample. In terms of the Kolmogorov-Smirnov statistics, when significance values that are greater than 95% or *p-values* less (<) than 0.05, the sample scores are said to be normal. Thus, in the current study, where the sample scores were not normal according to the Kolmogorov-Smirnov test, non-parametric statistics were employed (Pallant, 2001; Dawson & Trap, 2004; Ogunniyi, 1992).

Statistical techniques that are not sensitive to how data is spread around the mean are termed "non-parametric". As in the case of the reliability of an instrument, if the wrong statistical techniques are used, the results elicited from that particular statistical method will also be invalid. For the current study, the following tests were done to ensure that any statistical claims made were valid. While no one instrument is reliable under all circumstances or conditions, the Cronbach alpha values instrument indicates how reliable a particular instrument is for general conditions. Likewise, it is very seldom that one obtains, or impossible to obtain, a perfectly 'normal' sample in social science studies.

According to Pallant (2001), the Cronbach Alpha coefficient is the most commonly used indicator of internal consistency or indicator of how each item in a scale correlates with the others in terms of the construct that the scale intends to measure. Pallant (2001) therefore recommends that the Cronbach alpha coefficient should be above 0.7. In the above case, 0.7 represents that the instrument concerned should be reliable 7 times out of 10, or 70% reliable. He also adds that the Cronbach alpha coefficient is very sensitive to the number of items within a scale and cites Briggs and Cheek (1986) as recommending a mean of the inter-item correlation of 0.2 - 0.4 in the event that the scale items are under 10 (Pallant, 2001, p. 11).

3.7 Pilot test results

After a careful critique of the instruments and proposals at the UWC Friday seminars, the instruments were given the go ahead by the evaluation team to be piloted. After the piloting stage, all learner responses were categorized according to ordinal scales and captured into the (SPSS) Statistical Package for the Social Science. The reliability tests were obtained by using the Cronbach alpha reliability values as indicated in the above section. The Conceptions of Weather questionnaire (CoW) obtained an initial reliability value of less than 0.7 for the original 14 items and, through an elimination process provided by SPSS software analysis, the number of items achieving a reliability of 0.73 became 8. The items selected for analysis were items, 1 – 6, and 8 – 11. All the 25 items in the Meteorological Literacy Test (MLT) achieved the Cronbach reliability *alpha value* of 0.72 and hence were all eligible for analysis.

The survey conducted in the two schools in the area chosen for the study site acted as a form of preliminary data gathering to guide the main research study in the right direction. The type of questions that were asked in the survey were aimed to provide the researcher with possible knowledge of how learners perceived their immediate school environment as well as their perceptions of the Geography classroom setting. These questions ranged from the availability of resources in the geography classroom to their understanding of various terminology and concepts in the Geography subject. This information provided the researcher with baseline data for setting the level and type of questionnaires for the formal research that followed. All information gathered from the survey was treated as highly confidential and only used for the purpose of this research.

3.8 Research Design

Rather than making a comparison between two groups sampled for the purpose of research, comparison can be made between two classes within the same school – one receiving a particular treatment or intervention, the other acting as a control group. The quantitative aspect of the study in the form of quasi-experimental pre-test-post-test control group design is shown below:

The research design can be both quantitative and qualitative in nature e.g.

O_1 X O_2 (Experimental group) = (E)

O_3 O_4 (Control or Comparison Group) = (C)

O_1 X O_2 = Pre-observations

Figure 5: Quasi-experimental control group design

In Figure 5 $\mathbf{O_1}$ and $\mathbf{O_2}$ represent the pre-and post-test observations for the experimental group (E), whereas $\mathbf{O_3}$ and $\mathbf{O_4}$ stand for the pre-and post-test observations for the control group (C). **X** stands for the treatment, namely the (DAIM) dialogical instructional method. The dotted line indicates that intact rather than randomized groups were used (Ogunniyi, 1992).

In order to investigate the relationship between the dependent variable and independent variable, the *pre-test-post-test design* was chosen for this study. This research design allows for testing the subjects (learners) in the study before and after the treatment or intervention. This design also allowed the researcher to establish whether the use of a particular teaching strategy (in this case dialogical argumentation) would cause or generate the observed changes in the dialogical argumentation or scientific reasoning in the learners and to exercise some control, on the part of the researcher, over the effects presented through this type of experiment. Dowling and Brown (2010) argue the following concerning various unpredictable (not able to be controlled) but important factors, together with the importance of attempting to control for the effects of these on learners' performance:

> *There are, however, a number of possible influences on the performance of the children that you would be unable to control. This is particularly acute if your treatment takes place over an extended period of time, say over a series of science lessons covering a school term or semester. In this case you would not know whether the observed changes were due to the treatment or to activities that were taking place*

> *outside the experimental session. Even the general maturation of the children over the period of time may be important. Although these factors cannot be directly manipulated, an attempt can be made to* ***control*** *for their effects through the design of the experiment* (Dowling & Brown, 2010, p. 44).

Therefore, a second group (control group) of learners were sampled and introduced into the design. This group did not receive any form of treatment or intervention – now referred to as a *pre-test-post-test control group design,* with an *experimental group* (E) and a *control group* (C). Only members of the (E) group, but not those of the (C) group, received the DAIM treatment. Both groups were tested before and after the treatment was given to the (E) group only. Pre-post-tests provide the researcher with the means to compare changes (or absence of changes) in the performances of the subjects who received the treatment with those who did not.

3.9 Intervention

DAIM with IKS-methodology

Dialogical argumentation, also referred to in this study as the Dialogical Argumentation Instructional Model (DAIM), occurs when different perspectives are expressed on a subject with the hope of reaching consensus in the end. The purpose in this study of using this instruction model was to persuade others of the value of indigenous knowledge and the validity claim of this knowledge through well-reasoned or well-grounded arguments. Through dialogical argumentation learners articulate their "reasons for supporting a particular claim and then strive to persuade or convince" other learners (Ogunniyi & Hewson, 2008, p. 146) about the value and validity of such a claim. Dialogical argumentation provides the critical "environment for learners to externalize their doubts, clear their misgivings or misconceptions, reflect on their own ideas and those of their peers in order to arrive at clearer and more robust understanding of a given topic than would have otherwise been the case" (Ogunniyi, 2008, p.173).

3.9.1 Intervention process

The intervention referred to as (X) focused on and was used for the Experimental (E) group only. The intervention was in the form of a CoW (Conceptions of Weather) questionnaire and based on local indigenous knowledge. The Dialogical Argumentation Instructional Model (DAIM) class room model was used to apply the teaching part of the intervention to the E group. The Control

(C) group was used to compare pre-and post-test results from the two groups in order to establish whether the intervention applied had been successful in terms of learners' reaching a consensus.

During the two-month intervention stage the experimental group (E-group) formed four randomized groups. Each group was asked to choose a group leader who would present the outcomes of their discursive arguments arising from the various tasks to the whole class. It is worth noting that in each session the group had to choose another leader and in addition rotate their individual roles such as reader of the worksheets containing the instructions, recorder, and manipulator of apparatuses or materials. This process was also intended to develop skills other than the understanding and use of meteorological concepts using appropriate resources. For reasons of space limitation further details of the procedures followed in the study which have already been published elsewhere are not repeated here (e.g. Ogunniyi, 2004, 2007a & b; Siseho, 2013; Siseho & Ogunniyi, 2011a & b).

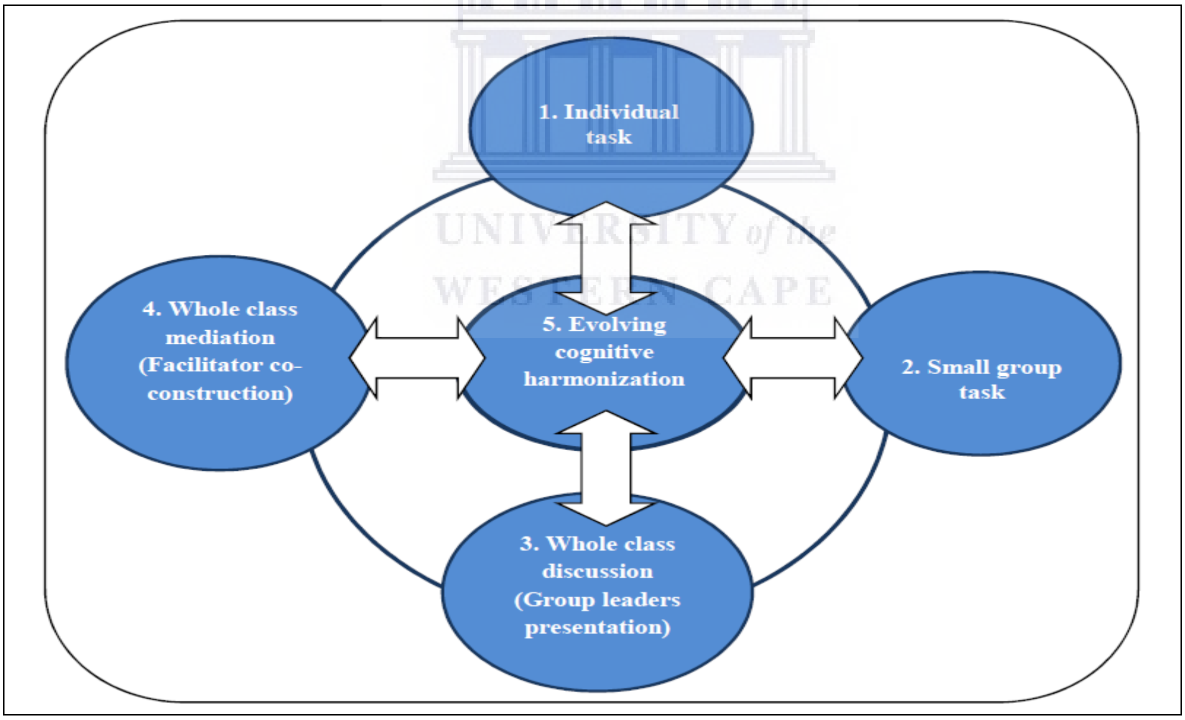

Figure 6: A Pedagogical Scheme for Implementing Dialogical Argumentation Instruction
Source: *Ogunniyi, (2009). Second National SIKP Workshop, Cape Town*

Figure 7 below illustrates the characteristics of, and steps involved in, the Pyramid Argumentation Model

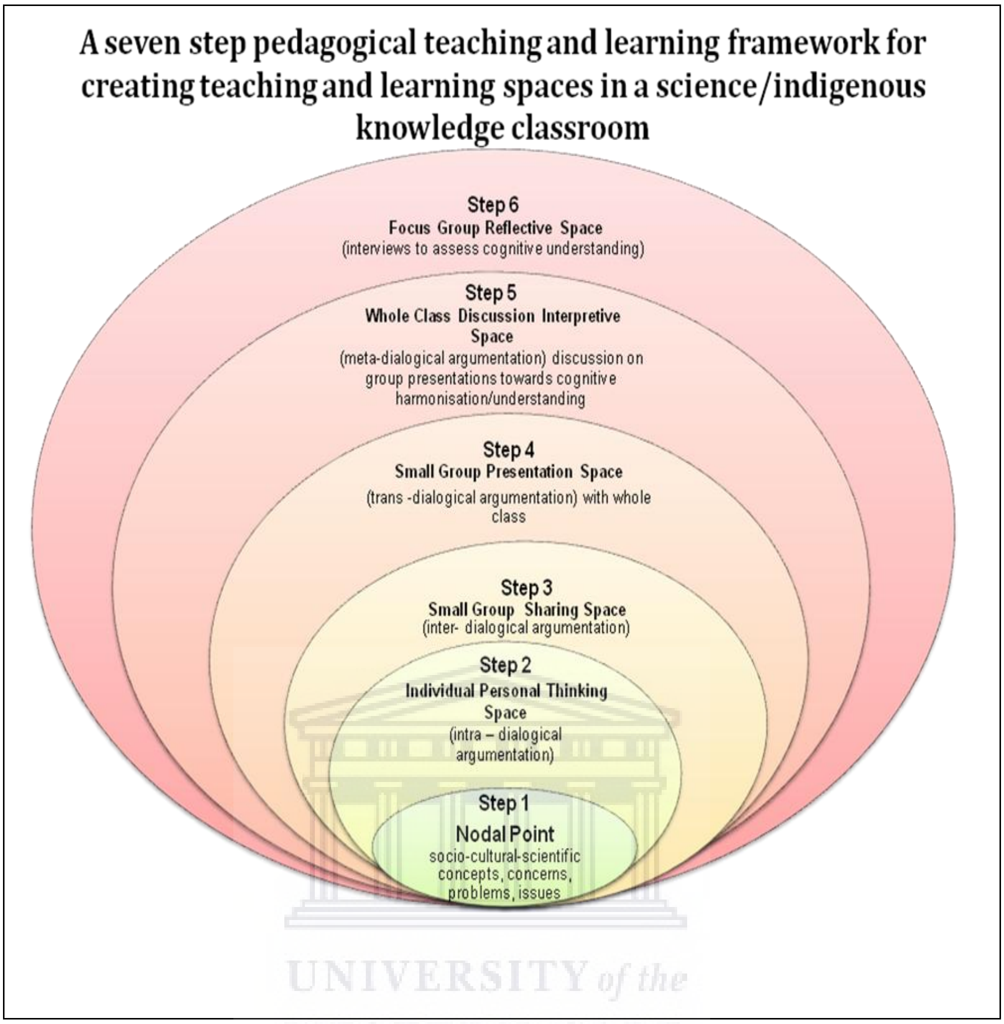

Figure 7: Pyramid Argumentation Model (PAM) Source: (Langenhoven, 2014)
(For integrating science and indigenous knowledge systems world views)

- The shape of the Model is a pyramid, square base supporting four faces. Each face represents an important module in the process of implementing an integrated Science/IKS curriculum
- The base represents argumentation teaching and learning theories such as TAP and CAT as analytical lenses for interpretation amongst others.
- This visual model is intended to simplify and synchronise the modular curriculum structure intended to provide a rationale and implementation strategy for integrating (western) science and indigenous knowledge worldviews in a university teaching and learning programme for initial science student teachers as well as in-service graduate science teachers.

1. **Pyramid Argumentation Model (PAM)** – Centre base or middle section The base represents the Theoretical and Analytical lenses used to view conceptual and contextual understandings of an integrated science/indigenous knowledge systems curriculum Argumentation Theory (Langenhoven, 2014; Toulmin, 1985 & Ogunniyi, 2004)

Step 2-5: Teaching and Learning Pedagogical Theories

2. **Nature of Science (NOS) –** Pyramid side 1
   Provides insight into the dynamic evolution of scientific concepts and highlights the dynamic nature of science.
3. **Nature of Indigenous Knowledge Systems (NOIKS) –** Pyramid side 2
   Includes religious, traditional, cultural and spiritual belief systems as alternative, dualistic, emerging, equipollent and assimilated worldview into modern/western science.
4. **Nature of Visual Modelling (NOVM) –** Pyramid side 3 (Using visual models)
5. **Dialogical Argumentation Instructional Model (DAIM) –** Pyramid side 4
   (a teaching strategy to create teaching and learning spaces for reasoning, dialogue, argumentation and communication related to socio-cultural-scientific decision making). Supported by argumentation theory TAP & CAT.

Figure 8: Picture (A) of PAM-model designed by PGCE student 2013
Source: (Langenhoven, 2014)

Figure 9: Picture (B) of PAM-model design by PGCE student (2013)
Source: (Langenhoven, 2014)

3.9.2 Outline of IKS-intervention lesson content

The intervention took place after school hours to allow the learners the space and time to have their normal contact session with teachers. All the lesson plans and content were designed around the Social Science (combination of History and Geography) Grade 9 syllabus based on the current CAPS (Curriculum and Assessment Policy Statement. 2011) standards. The following were included in the lesson plans and learners were assessed (according to the CAPS 2011 assessment guidelines):

3.9.3 General Aims of the South African Curriculum (CAPS) 2011

The Curriculum and Assessment Policy Statement (CAPS, 2011) general aim has acted as a guideline to align and design IKS lessons used during the intervention stage:

The aim is as follow:-

(c) The National Curriculum Statement Grades R-12 is based on the following principles:

> *Valuing indigenous knowledge systems: acknowledging the rich history of this country as important contributors to nurturing the values contained in the Constitution* (CAPS, 2011: 5)

The CAPS (2011) requested Geography content topics include (CAPS, 2011, p. 19)

1. Maps skills (focus: Topographic and orthophoto maps)

2. Development issues (focus: South Africa and World)

A. Intervention stage lesson plan and topics designed for the purpose for this research study

(i) Tools for predicting weather the IKS way

(ii) Cultural weather research

(iii) Weather sayings: What sayings are still being used or active in the area?

3. Surface forces that shape the earth (Physical Geography)

4. Resource use and sustainability (focus: World)

B. Intervention stage lesson plan and topics for the purpose for this research study

(iv) Know your weather instruments: rain gauges, barometer, compass and thermometers

(v) Record weather data information from various instruments

(vi) Measuring of weather conditions (temperature, relative humidity, barometric pressure) using various weather instruments

Number of periods is 10 with 45minute sessions.

3.9.4 IKS Classroom Activities

For all activities a limit timeframe was introduced to keep the research on track: (Approximately 4 in-class hours, plus an ongoing journal for 5 days)

Indigenous Knowledge and Cultural Weather Perspectives

A few key understandings were taught as indicated below:

- Knowing historically what the weather would bring was important to those who lived off the land and is important to a variety of people today.
- Historically, all cultures had ways of determining what the weather would be prior to technology.

• Weather patterns can be identified using cultural knowledge as well as technology.

Below are some essential questions that were asked to stimulate the learner argumentation on the topic of weather.

1. Why is it important to predict weather?
2. How do we predict weather?
3. How does weather dictate outdoor activities?
4. What is the impact of weather forecasts on various segments of society?
5. What are the essential characteristics of your local weather patterns?

Lesson Outline

Lesson 1: Introduction

This lesson is an introduction to the weather. Learners will learn the basic difference between weather and climate. Learners will help derive the need for weather forecasting. Learners will learn the historical need for weather prediction. All cultures have developed methods of translating weather. Locally, the indigenous people have passed down this information through oral history. Learners will make notes based on the oral history document provided in **Appendix Q**. Learners will be given other cultural sayings related to weather. Once they have this background, they are ready to start conducting their own weather sayings (sayings about weather perdictions) research.

Lesson 2: Cultural Weather Sayings Research

This lesson directs learners to conduct their own weather sayings research. Learners are guided to look to their family, friends, or other sources to find out cultural weather sayings. Learners will look for specific weather indicators from animals, wind, clouds, and other signs. Learners are encouraged to find and to record their own resources.

Lesson 3: Cultural Weather Sayings Sharing

This lesson is designed to share the learners' research. It will allow learners to share their sources, their knowledge, and to fill in gaps. After the sharing is done, learners will work on a performance task for testing their comprehension of the cultural teachings. Learners will complete the five-day scenario, choose an option, and explain their choice based on what cultural saying they used to make their choice. When they are finished, learners can work in small groups to compare and to share their choices and reasons.

Lesson 4: Weather Forecasting Journal

This activity is to be completed as a performance task to show learners' understanding and application of cultural sayings. This journal assignment can be completed immediately after the introduction activities or it can wait until learners have learned more about modern forecasting techniques. This task takes place over the course of five days as a homework project. It involves the learners in weather observation and data collection. Learners will collect personal weather data (temperatures, wind, clouds, animals, etc.), as well as the meteorological forecast for the day. Learners are encouraged to add weather observations as the day progresses. They are also required to write a summary at the end of the day, discussing how the predictions worked, did not work, and what observations may have been omitted.

3.10 Data Analysis

A quantitative and qualitative data analysis method rendered rich text data for triangulation and interpretation (Creswell, 1998). Descriptive data graphs and tables are used where appropriate. The large bank of data was triangulated, with a view to crystallising patterns of ideas through an interpretive viewpoint. The qualitative data was coded into categories using Atlas.ti (Cologne, Germany) software and NVIVO (software for easier interpretation (Friese, 2012), whilst the quantitative data set was analysed using the SPSS (Statistical Package for the Social Science) software programme where appropriate (Pallant, 2001; Field, 2003). All data were analyzed in terms of statistical correlations between the measured variables. In brief the data transcripts (audio and video) were subjected to both a descriptive and a conceptual level of analysis. The study also adopted a "sequential explanatory mixed methods" design as illustrated in figure 10 below (Creswell, 2002). This design enabled the researcher to "collect both quantitative and qualitative data, merge the data, and use the result to best understand a research problem" (Creswell, 2002, p. 564). This mixed methods approach was chosen for this research where both confirmatory and exploratory questions are posed and allows for easier tracking of trends and categories for further analysis also known as the "convergent design of qualitative and quantitative data analysis" (also see **Appendix R** for data flow chart diagram).

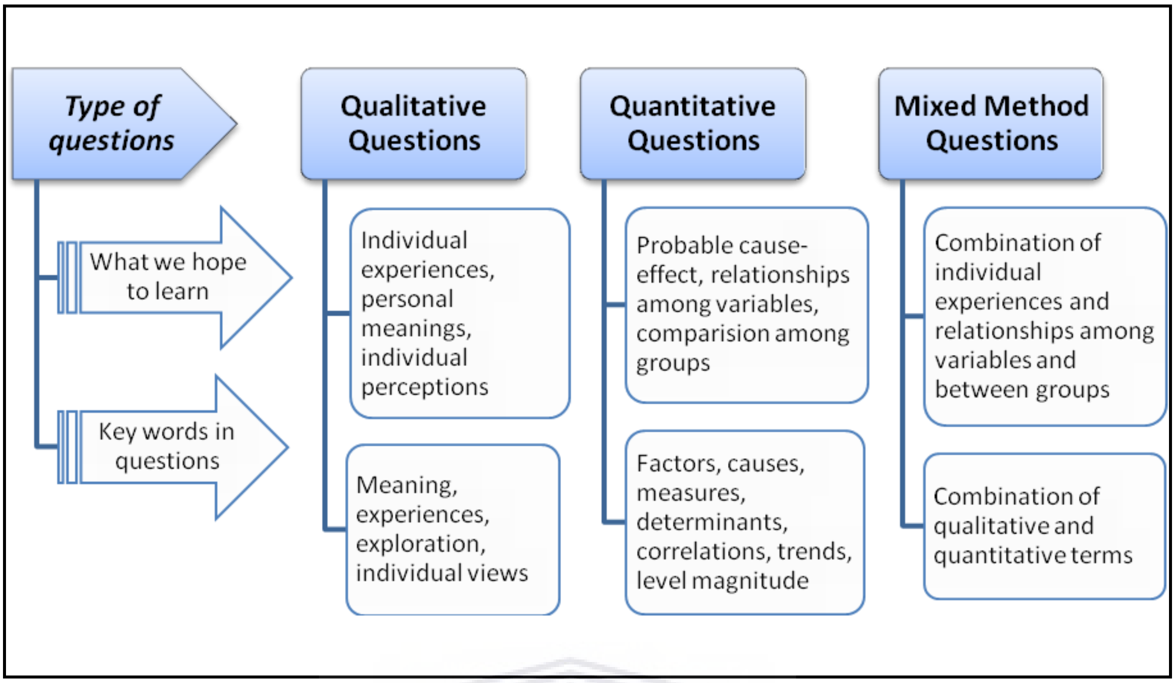

Figure 10: Relationship between quantitative, qualitative and mixed-methods (Creswell, 2013)

The data collection for the qualitative design consists of the following:

- Observation of the daily school population, with scheduled visits to classrooms where teachers teach Geography, Natural Science and Life science, to acquire a background perspective on what it is like to be at the school and inside the space where learning takes place.
- Learner and teacher views in relation to concepts dealing with indigenous knowledge and meteorological literacy.
- Other data collection instruments, such as questionnaires, interviews, tests, and a range of observations.
- Separate interviews with subject teachers contributed to the qualitative data collection process at the samples schools.
- A questionnaire distributed to the two sampled school teachers.

3.10.1 Qualitative analysis

Why use a coding structure analysis?

The use of a coding structure to analyse the study's qualitative data correctly came as a suggestion from the SIKSP (Science Indigenous Knowledge Systems Project) group members at the University of the Western Cape and was based on the Miles and Hurberman (1994, p. 12) approach or framework for qualitative data analysis labelled as 'transcendental realism' (Punch, 2009, p. 174). A new coding structure design emerged (as in Figure 10 below) using the 'transcendental realism' approach with its three main components of data analysis. The interactive model from Miles and Hurberman (1994) framework helped in the analysis of the qualitative data for research question two (RSQ2) in three main components, namely (1) data reduction (2) data display (3) drawing and verifying a conclusions from the data (Punch, 2009, p. 174). Punch (2009) also mentioned that 'these three overall components are interwoven and concurrent throughout the data analysis' and concludes the following:

> *The first two, data reduction and display, rest mainly on the operations of coding and memoing. In virtually all methods for the analysis of qualitative data, coding and memoing are the two basic operations that get the analysis going.* (Punch, 2009, p. 175).

As previously mentioned, the qualitative data were collected using various types of instruments, such as written responses, group feedback, observation schedules, and learners' interviews to answer research question three (RSQ2).

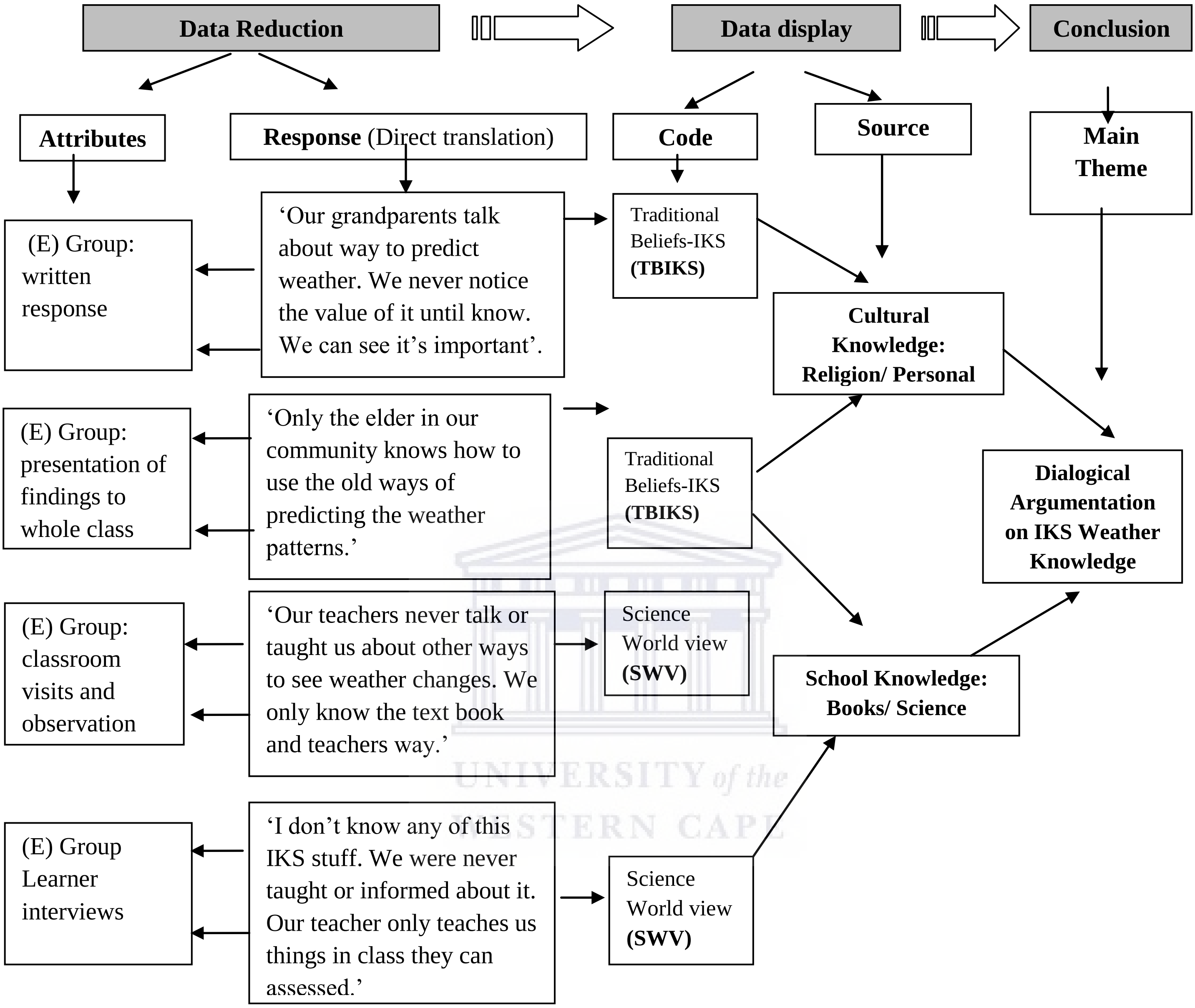

Figure 11: Illustration of the coding structure - qualitative data analysis (Riffel, 2012)

The coding structure assisted me to (1) reduce and bring all the various forms of attributes and responses of data together (2) formulate and verify two central data displays namely codes and themes that helped reduce and move data without any significant loss of information to (3) the dialogical argumentation on science-IKS weather knowledge central concluding theme.

Two major codes were displayed and focused on, namely the traditional beliefs –IKS (TBIKS) code and the Science world view (SWV) code. From here the information provided from the data was directed into two different types of sources which were either a cultural knowledge source (KNS) that represents religion and cultural beliefs, or a school knowledge source that represented the textbooks and science literature. In concluding, the coding structure gave the study a more comprehensive summarised view of the learners' enhanced or augmented attitudes towards, ideas and perceptions about their own environment.

3.11 Ethical Considerations

A research application letter was issued to the Western Cape Educational Department (WCED) to ask for permission to perform the research study at the selected schools.

A letter of consent was also addressed to the School's Governing Body (SGB) informing them of the research aims and process, and the obligations of the study where the survey and research were to be conducted. A meeting with senior school management of the participating school was held to inform them of all pre-post intervention sessions to be conducted. A detailed timetable with schedules for classroom observation and group intervention sessions was submitted to the principal's office.

The letter stated that all participating schools were to be entitled to a summary of the research study that was conducted for future organizational and curriculum planning. All participating learners would also be informed of the implications and value of the study and how the data were to be analyzed and interpreted, and for what purposes. A letter of consent was signed by parents of all the underage participants in the research study. All students were also informed of their rights and obligations within the research process.

The following ethical checklist was followed to ensure that the study conformed to the ethical standards laid down by the Senate Research Committee of the University of the Western Cape:

- The principals' permission letters from the two schools was sought (Appendix A1).

- Permission to conduct the study was sought from the research department of the Western Cape Education Department (WCED) - (letter attached as Appendix A2)
- The purpose and value of the study was explained both orally and in writing to all participants involved in the study.
- Teachers and learners consent was also sought.
- All interviews were strictly confidential, and a confidentiality letter was written to the schools concerned.
- Learner questionnaires were to be anonymous and confidential.
- Names of schools would be kept anonymous and no information about the schools or learners would be divulged to any person.
- At the end of the study the school principal concerned received a summary report of the findings of the study conducted in his/her school.
- Consent Letter - A copy of the consent letter (APPENDIX H)

The final reports on this study will be made available to the Western Cape Education Department, participants and their schools and a copy will be available at the University of the Western Cape (UWC), Bellville, South Africa. The study results will only be used for the purpose that they are being conducted for: academic purposes. Data were secured through password protected safe storage to ensure that no unauthorised persons could gain access to any information in ways that may compromise the integrity of the participants.

3.12 Chapter Summary

In chapter 3, I presented a description of the empirical methods that were used to conduct this research. I further elucidated the research study strategy, which is the mixed sequential explanatory strategy and the selection of this approach was justified. The appropriateness of the instruments to respond to the research questions was also discussed. A detailed description on the process of data collection, its analysis as well as the interpretation thereof has been presented. A brief discussion on the validity and reliability of the study were presented, and to ensure that the instruments measure what I intend them to measure has also been included**.** The chapter was presented in such a way that can enable an experienced researcher to replicate a similar study within certain reasonable limits.

In the next chapter (chapter 4), I present descriptions of the research findings on learners' and teachers' perspectives on IKS, concerns and practices regarding current reform efforts in the Helderberg Basin of the Western Cape, South Africa. These include the data analysis and their interpretation from the two phases e.g. interpretation and understand of IKS integration into natural science curriculum from the grade 9 learners view and the high school teachers perspectives on IKS as curriculum implementation, of the study. I also describe my experiences in the interactions with teachers in the Helderberg Basin. In my descriptions, I ensure that these teachers' experiences are described in the best way possible to give a vivid picture on what is going in the classrooms pertaining to IKS curriculum implementation as well as what goes on in the teachers' minds. Thus, through the data analysis and the interpretation thereof, I synthesise how the study responds to the research question.

CHAPTER 4 - DATA ANALYSIS & FINDINGS

4.1 Introduction

The previous chapter described the research method and design and the phases of the research. The purpose of this chapter is to present and discuss the results from each phase of the data collection process and how these relate to the four research questions as set out in Chapter One.

The reports and analysis of the results are formulated around the research questions. The data analysis is structured as follows: the qualitative data analysis is followed by the quantitative data, and a brief summary of these.

As mentioned earlier the main purpose of the study is to investigate the effectiveness of a Dialogical Argumentation Instructional Model (DAIM) in enhancing grade 9 learners' understanding and awareness of the social and cultural relevance of Indigenous Knowledge Systems (IKS) in weather patterns and selected meteorological concepts. This chapter focuses on and investigates the social and cultural importance of IK used in meteorological literacy amongst both teachers and learners. Through the use of two research instruments as well as focus group discussions on the ways in which it affected the learners' performances are investigated. The instruments used were (1) a meteorological literacy (MLT) science achievement test, and (2) a conceptions of weather (CoW) attitudes test. The data collected using these are intended to reveal how they relate to and/or achieve the stated aims of the current CAPS (2011) curriculum policy statement of the Department of Education in South Africa. This chapter also draws for analysis from various interesting data sets collected in a previous similar research study conducted by the author, data collected from the same population group during the 2010 – 2012 period.

4.1.4 IK for understanding the scientific environment

As was described in the previous chapters, a related focus point of this study is to determine the understanding shown by the learners in the study sample of weather and climate phenomena and to determine how they interact with these phenomena within the classroom space. A further emphasis is placed on how learners perceived and interpreted these selected meteorological literacy and conceptions in line with the current Natural Science curriculum or the Geography part of the Social Sciences curriculum at Senior Phase level. Table 4.1 below lays out the type of qualitative (qual) and quantitative (quan) instruments used in the research to extract and gain important information from learners in terms of their perceptions and experience on the importance of indigenous knowledge for weather predictions and encourage their awareness of how this knowledge could help them in understanding in an immediate and experiential way the scientific and cultural basis of the weather conditions around them.

For easier and more concise explanation and unpacking of each research question, qualitative (Qual) and quantitative (Quan) data were analysed to explain the relevant findings and the results. The instrument structure layout (see Table 4.1 below) also indicates and confirms the specific target audience for each group of participants and each respective analytical method used to interpret the results.

Table 4.1 Instruments structure: Qualitative / Quantitative

INSTRUMENTS USED IN BOTH STUDY GROUPS	MEASUREMENT SCALES USED AND OPERATION SEQUENCE FOR EACH ANALYSIS	TARGET AUDIENCE /PARTICIPANTS	ANALYTICAL INTERPRETATION METHOD
Pre/Post-test Conceptions of Weather (CoW) scale	1) 5-point Strength of Argumentation scale 2) 5-point World View Response classification 3) 5-point CAT cognitive state categories' sub-scale	Learners	1) Quantitative 2) Qualitative
Pre/Post-test Attitude toward Natural Science (Geography/IKS scale)	5-point CAT cognitive state categories' sub-scale	Learners	Qualitative
Post-intervention Meteorological Literacy Test (MLT) scale	5-point Strength of Argumentation scale Items' levels of skill classification	Learners	1) Quantitative 2) Qualitative
Classroom observations	Learner responses and excerpts	Learners / *Teacher*	Qualitative
Focus group interviews	Learner responses and excerpts	Learners / *Teachers*	Qualitative
Interviews with learners	Transcriptions from recorded data (recordings)	Learners / *Teachers*	Qualitative
Interviews with teachers	1) Transcriptions from recorded data (recordings) 2) 5-point CAT cognitive state categories' sub-scale	Teachers/ Headmaster	Qualitative

4.2 Research Question 1 (RSQ1)

What Indigenous Knowledge Systems (IKS) do the Grade 9 learners' in the sample currently hold, if so, is this connection related to their age, social class or gender?

4.2.1 Introduction

As earlier noted experimental research is not primarily concerned to provide and describe the past and present events but in describing the consequences of a direct intervention into the *status quo.* So in this chapter the data analysis will follow a type of analysis that will deliberately focus and manipulates and/or control certain conditions which will determine the consequences of interest to the study at hand. As any social scientific researcher the author seeks to analyze and present his findings of his research in such a way that will permit precise description, explanation and prediction. We also have to note at this stage the many consulted literature presented no consensus among science educators about what *aspects of IK* should be included in the curriculum (Ogunniyi, 2011). The views range between partial or cautious inclusion (e.g. Finley, 2009 as quoted by Ogunniyi, 2011) to accepting the two as equal and legitimate forms of knowledge provided of course that they are not judged on the same theoretical frameworks (e.g. Snively & Corsiglia, 2001; Bishop, 1990; Garroutte, 1999; Nichol & Robinson, 2000; Aikenhead, 2000).

What aspects of IK should be analyzed?

The notion of data analysis in social sciences research relies very much on providing sound empirical evidence for interpreting certain learner experiences, but as in the case of indigenous knowledge research this study had to use all the necessary human experiences for analyzing and explaining the different ways of knowing. So chapter four focus on these human experiences that fall in a whole system of genres of verbal art depicting genuine experiences that have been articulated in forms of cultural myths, proverbs, idioms, poems, narratives, drama, dances, songs, storytelling, symbols, and other or organizing metaphors (Ogunniyi, 2011) to give meaning to the relevance of aspects of indigenous knowledge research.

Link between CoW questionnaire, NOIK framework and Contiguity Argumentation Theory (CAT) (see Appendix M)

In order to examine the scientific and symbolic excerpts of the CoW test a “linking rubric” (see appendix M) were used to help assess and reveal meaningful responses apart from the learners scientific explanations the symbolic meanings were just as valid and taken into consideration. The rubric using the NOIK framework confirms that in any science classroom there are probably different levels of discourse as outlined in the Contiguity Argumentation Theory (CAT) pattern (Ogunniyi, 2007b; Ogunniyi & Ogawa, 2008) depending on the socio-cultural environment in which the learners have been reared. Therefore the researcher cannot ignore such levels of discourse in the responses of learners’ and had to design the “linking rubric” (see appendix M) seen as an important analytical tool cause of inter-locutory arguments going on in the mind of learners. Learners hold different worldviews on scientific topics, and to ignore such levels of discourse would nullify one of the goals of the new CAPS curriculum i.e. to make science relevant to the home experience of learners. Some of the interesting explanations relating to indigenous knowledge weather prediction emerged during the intervention stage include among other the following:

- The dialogical argumentation space created among learner allowed learners to express opinions in a non threatening atmosphere.
- Most explanations that emerged were from a personal experience.
- Several explanations about weather prediction and weather phenomena (i.e. lightning and thunderstorms) knowledge comes from cultural and past experiences and dialogue entered into with elders in their community.
- Culturally highlighted story telling particulary those participants engaged on a personal level with cultural norms feel confident enough to state their claims and support the claims with grounds i.e. give valid scientific explanations (Stone, 2009).

Furthermore, the results of the learners’ pre-test and post-test Conceptions of Weather Test (CoW) were tabulated in table 5 (below) and were obtained by using the Wilcoxon Signed Rank test. This result is a comparison of pre-test and post-test scores for each group to determine learners’ current understanding of weather related geography as well as the types of instruments that can be used to determine weather conditions.

To show that the two groups in the experimental and control group were comparable, a t-test was conducted. The results on the 2-tailed t-test (df=29) showed that there was no significant difference between the groups for the experimental and control groups. This implies that items in table 6 require a good understanding of weather related geography knowledge as well as what type of instruments can be used to determine certain weather conditions. Items 1 (Weather instruments), 2 (Geography science concepts) 3 (Cold fronts patterns) and item 4 (Indigenous Knowledge on weather) were of importance here to evaluate if learners' understand the current geography curriculum knowledge of the grade 9 school curriculum syllabus. Sections 1 and 2 required that the learners show that they can relate to what type and kind of instruments can be used to determine immediate weather conditions although they had not been exposed to home use of weather instruments before. Learners also indicated that their only knowledge of such weather instruments came from textbooks and pictures and that they had never had the opportunity before to view them in real life situations and discussed their proper functions.

Table 7: Learners' pre-test and post-test means scores on conceptions of weather

Conceptions of Weather items	**GP**	**PRE**	**POST**	**Std Dev**
	Individual Items			
1) Weather Instruments	E C	6.58 5.75	7.50 6.36	2.34 (1.7) 2.83 (2.50)
2) Geography science concepts	E C	4.88 3.91	5.06 3.45	1.21 (1.06) 0.99 (1.36)
3) Cold Fronts patterns	E C	2.35 1.83	3.18 2.18	1.11 (2.07) 1.26 (1.47)
4) Indigenous Knowledge on weather	**E** **C**	**5.05** **2.83**	**14.12** **3.45**	**3.32 (3.22)** **3.12 (2.42)**
	All 4 Items			
All 4 Items combined	*E* *C*	*18.88* *14.33*	*29.87* *15.45*	*3.3 (4.28)* *4.39 (3.72)*
t-ratios (df=29) t-crit = 2.045		0.09 -7.62	0.93 1.77	

N = 29, t-ratios (df=25), t-critical value = 2.052, Alpha value is 0.05

Table 8 (below) shows that in the pre-test the E-group scored a mean value of 18.88 and the C-group a mean value of 14.33 respectively. The mean rank scores of 18.88 and 14.33 had standard deviation scores of 3.3 for the E group and 4.39 for the C group. This was more than the t-critical value of 2.052 for all 4 items in question. A non-significance result of t = -7.62 and a p = 0.09 was obtained. This result also confirms that the two groups were indeed comparable. For item 1 (Q1) both groups scored almost the same scores: the E group scored a mean value of 6.58 with a standard deviation value of 2.34 and the C group scored a mean value of 5.75 with a standard deviation value of 2.83 at the end.

Table 8 Learners' pre-test and post-test means scores on conceptions of weather

ITEMS	GP	PRE	POST	Median	Std Dev
All 4 ITEMS	**E**	18.88	29.87	19.00 (30.50)	3.3 (4.28)
	C	14.33	15.45	15.50 (17.00)	4.39 (3.72)
BTWN GRPS SIG.		0.09	0.9257	2-tailed Test, critical value =2.052 at df = 29	
t-ratios (df=29)		-7.62	1.77	(Both pre-post –test analysis for both groups)	
T-crit = 2.045					

In Table 8 above it is evident that a paired sample t-test was conducted to evaluate the conceptions of weather construct for the experimental and control groups for the pre-test. The results show that there no significant difference for each of the dimensions.

Calculating the effect size for paired-samples t-test

Although the results presented above (in Table 8) tell us the difference we obtained in the two sets of scores was unlikely to occur by chance, it does not tell us much about the magnitude of the intervention's effect. One way to do this is to calculate the effect size (Cohen, 1988) statistics (see below e.g. eta squared).

$$\text{Eta squared} = \frac{t^2}{t^2 + N - 1}$$

Figure 12: Cohen's (1988) Eta Effect size

The results of the analysis conducted above (table 8) can be presented as follows:

A paired-samples t-test was conducted to evaluate the impact of the intervention on learners' scores on the Conceptions of Weather Test (CoW). There was a statistically significant decrease in CoW scores from Experimental group (M=30.50, SD=4.28) to Control group (M=17.00, SD=3.72, t(29)= -7.62, p<.0005). The eta squared statistic (.50) indicated a large effect size.

To interpret the eta squared values the following guidelines apply (Cohen, 1988): .01=small effect, .06=moderate effect, .14=large effect. Given our eta squared value of .50, we can conclude that there was a large effect, with a substantial difference in the Conceptions of Weather scores obtained before and after the intervention.

4.2.2 High School Survey

The results from the high school survey were used to add background information to the study and provide some indication of learners' attitudes towards integrating indigenous knowledge with meteorological literacy and science concepts. The results from this survey indicate that both boys and girls who completed the survey had a range of different perceptions and attitudes towards weather, especially when it came to understanding how indigenous knowledge could influence their own understanding, together with the relevance of social and cultural issues pertaining to weather phenomena, such as lightning, and of weather in general.

Table 9: Learners' pre-test mean scores on items categorized according to Geography

KNOWLEDGE OF GEOGRAPHY INSTRUMENTS	MEAN RANK	IKS WEATHER FORECASTING KNOWLEDGE	MEAN RANK
1) Weather Instruments	**E = 6.58** C = 5.75	**4) Indigenous Knowledge on weather**	**E= 5.05** C= 2.83
t-ratio at alpha = 0.05	**-0.77**	t-ratio at alpha = 0.05	**0.28**
2) Geography science concepts	**E= 4.88** C= 3.91	3) Cold Front patterns	**E=2.35** C= 1.83
t-ratio	**-1.69**	t-ratio	**-6.29**

Alpha value is <0.05, t critical = 2.052 with df =27
Sample consisting of 28 learners in 2 classes

The items in table 9 require a thorough understanding of weather related Geography knowledge as well as what type of instruments can be used to determine certain weather conditions. Items 1 (Weather instruments), 2 (Geography science concepts) 3 (Cold front patterns), and item 4 (Indigenous Knowledge of weather) were of importance here to evaluate whether and to what extent learners understand the knowledge required by the current Geography curriculum of the grade 9 school curriculum syllabus. Sections 1 and 2 of the test required that the learners show they are able to relate to weather instruments, and what type and kind of instrument can be used to determine immediate weather conditions, even though they had not previously been exposed to home use of weather instruments. Learners also indicated that their only knowledge of such weather instruments came from textbooks and pictures and that they had never had the opportunity before to view these instruments first hand and in real life situations or discuss their proper functions.

However, they are not having previously been exposed to weather instruments did not seem to influence their knowledge of how these instruments relate to weather observations in and around their home environment. Some learners gave meaningful answers as is shown in the following excerpts:

> *Item 1: Which of the instruments shown above would best measure each of the following conditions? Give reasons for your answer:*
> *_______________ a) 20mm rain fall on a specific day.*
> *Give reasons: ____*
>
> Written exhibits of learners:
>
> Learner E 012: Answer to item 1 (a): "*Rain gauge"*
>
> Reason: *"It show how many rain will fall on that day"* (direct translation)

Although learner E 012 does not go into much detail about measuring rain on a specific day, the main thing to be noted is that the learner understands which instrument is best used when it comes to measuring rainfall. Most of the learners in the E group gave vague and partial answers. Below are two excerpts from C group learners in their answers to the same item (direct translation):

> *Learner C 006: Answer to item 1 (a): "Rain Gauge"*
>
> *Reason: "because a rain gauge is for the measure of the rain"*
>
> *Learner C 008: Answer to item 1 (a): "Rain Gauge"*
>
> *Reason: "Many people say it like – my elbow is full pain. It massure the water" (direct translation from learner script)*
>
> *(Somehow the learner unknowingly brings in a little bit of IKS knowledge)*

In addition to what Learner E 012 indicated, learner C 006 highlighted the fact that a rain gauge is used to measure rainfall, showing a clear understanding of what is being asked in item 1. On the other hand, learner C 008 gives an indigenous knowledge (IK) view/way of how "an elderly person with joint pain" would know if it will rain soon during winter time. Without realizing it, learner C008 presented an answer that one could argue links with indigenous knowledge (IK) on one of the ways to predict weather. The general observation after analysing learner C008's reason to item 1 indicates to the researcher that the learners possessed an already existing form of indigenous knowledge (IK) before the pre-test was administered. A follow up interview with learner C 008 led to the conclusion that he had "overheard some elder family member mention it" in a conversation at home. This specific answer from learner C 008 alerted the researcher to possibility that indigenous knowledge systems (IKS) that are somehow still alive in the community where the research was conducted and could easily and usefully be tapped into if approached positively. The initial plan of the research was however to promote learners' use of IKS knowledge in developing their understanding of meteorological science concepts in the Geography classroom.

If we look at the respective mean rank scores of both groups, a 6.58 mean rank for the E group and a 5.75 mean rank score for the C group on item 1 was obtained, putting the two groups in close proximity with regard to weather instrument knowledge levels. Although four learners in the C group and two learners in the E group left blank spaces in their answers, the mean rank differences of 0.83 for item 1 was a minor difference in terms of their significance. Furthermore, both groups gave positive answers, indicating that their current knowledge of weather instruments is in line with the National School Curriculum (NSC), Natural Science syllabus, grade and age.

In item 2 (Geography science concepts) a good understanding of geographical concepts is required to complete statements as true. The mean rank score of 4.88 for the E group, and 3.91 for the C group, were the second lowest of all four items with a mean difference of 0.97 between the two groups. In this section it is required of learners in both groups to select a word from a given list that will make each of the eight sentences a true Geography statement. In a general observation of learners' pre-test scripts, it was noticed that the learners do not read and understand the questions correctly, resulting in them giving wrong answers. This could be the result that the Language of Learning and Teaching (LoLT) is Afrikaans and the study were primarily designed in English and later translated into Afrikaans. This was picked up in the focus group interviews (FGI) held with the E group learners. Most of the learners in this group could relate to or give correct answers when asked the same question in verbal or dialogue format, showing a lack of understanding when reading the same question. Learner E 005 replies: (direct translation) *"ek weet nie altyd wat ek lees nie"* (meaning: I do not always understand what I'm reading), when asked if they understood all the pre-test questions of the MLT test.

For item 3 (Cold fronts patterns) and item 4 (Indigenous Knowledge as regards weather), the focus shifted in the pre-intervention stage in terms of how much 'home knowledge' the learner has currently acquired in order to complete the task at hand. This "home knowledge" could include the type of knowledge "acquired or overheard" from parents, grandparents and elders who maybe have (had) rural or traditional cultural roots. The items in 3 and 4 focused on the learners' home knowledge that they bring to school or to the classroom.

Views on Indigenous Knowledge Questionnaire (VIKQ)

In order to ensure that all relevant data that derived from the VIKQ - from all respective responders is coded and evaluated correctly, a rubric was used as a guideline as explained in Appendix L. The rubric ensures that responses from each of the questions on the questionnaire were coded according to an informed view, a partially informed view or an uninformed view on indigenous knowledge. Each learner's responses were allocated according the weighting output as follow: an uninformed view (UI) scored 0 points, a partially informed view (PI) scored 1 point and an informed view (I) scored 2 points, as can be seen in *Appendix L*. The results of the rubric were then calculated into average scores, rounded off to get each individual learners predominant category on his/her responses on indigenous knowledge as a whole. The average scores can now be used to individually analyse and categorise each participant although in group format – on the other hand it also indicates to the researcher the learners perceived view on indigenous knowledge.

VIKQ results of Pre-Post Intervention

The sampling for the VIKQ questionnaire (adapted from Cronje et al., 2015) was spread among the two secondary school and administered to both the experimental and control group as a pre-post intervention questionnaire. The full group that participated from both the E and C-groups respectively was a diverse group with 35% of the learners being African (originally from the rural parts of the Western Cape, South Africa) and 55% of the learners coloured (a small group representing the coloured learners relocated from the Northern Cape to the Western Cape, South Africa). Adaptations were made in the way the questions were stated in order to illuminate confusion. The questionnaire was then administered to both the E-group and C-group learners in two separate interventions completing the questionnaire within an hour.

Using the Nature of Indigenous Knowledge (NOIK) tenet and Nature of Science (NOS) tenet (see Appendix J) to determine which participants needed professional development on indigenous knowledge. The percentage of uninformed, partially informed and informed views for each question before the intervention was also taken into consideration and calculated to determine those aspects of indigenous knowledge that were under-develop, or came across as ill-informed views on indigenous knowledge in the community. Some results that arrived from using the NOIK and NOS tenet can be highlighted as follows and include:

- None of the participants that completed the VIKQ had an informed view on what indigenous knowledge is (Q1; tenets 1-9);
- The majority of the participants (70%) did not realise that indigenous knowledge was empirical based (Q2; tenet 1), while only 28% realised the inferences were made by indigenous knowledge practitioners (Q3; tenet 3);
- The holistic nature of indigenous knowledge was known to 11% (Q7; tenet 9) of the participants , 28% understood the role that myths play in indigenous knowledge and (Q8; tenet 4);
- 30% of the participants realised that the elders could also be influenced and therefore indigenous knowledge could be subjective (Q10; tenet 5)

These results help to inform the researcher how to introduce the DAIM intervention model of argumentation based on IK-sourced resources based on weather prediction and local weather awareness. This determining factor of how science learners view indigenous knowledge and also how deeply informed the type of classroom intervention needed to be for IK-science content knowledge development.

Table 10: Average percentage of Experimental group participants VIKQ before and after intervention

E-group	VIKQ before	VIKQ after	Percentage points change
UI	6%	0%	6% <
PI	81%	49%	32% <
I	17%	45%	28% >
UI = Uninformed view ;	**PI = Partially informed view;**	**I = Informed view;**	**< = decrease; > = increase**

In examining Table 10 the results summarised that only a few (6%) of the experimental group participants held an initially uninformed view on indigenous knowledge; the majority (81%) held a partially informed view and a smaller number (17%) an informed view before the IK-intervention stage. After the intervention there was a positive (>) increase and a change in their view towards the Nature of Indigenous Knowledge (NOIK) as indicated in columns two and three of table10 (above).

Table 11: VIKQ - Frequencies and Cross tabulation between schools

School	Cross Tabulation	Uninformed	Partial Informed	Informed	Total
		Frequencies			
SSS	Count (N)	**3**	**7**	**5**	**15**
	Expected Count	2.4	6.3	6.3	15.0
	Adjusted Residual	.6	.5	-.9	
RHS	Count (N)	**2**	**6**	**8**	**16**
	Expected Count	2.6	6.7	6.7	16.0
	Adjusted Residual	-.6	-.5	.9	
Total	**Count**	**5**	**13**	**13**	**31**
	Expected Count	**5.0**	**13.0**	**13.0**	**31.0**

N = 31, t-ratios (df=29), t-critical value = 2.052, Alpha value is 0.05

After the pre-test quantitative data were statistically analysed (Table 11) it was evident that the two groups were indeed similar in terms of their conceptions of weather instruments and geographical concepts. Also, the quantitative data showed that the two groups had a degree of conceptual understanding of the usage of various different weather instruments. The data also indicate that learners were being exposed to science/IKS knowledge without realising it. According to Jegede (1996), these every day experiences can be termed indigenous knowledge systems (IKS). Another interesting finding was the low performance level shown by both the E and C groups on item 4 (Cold front patterns). This could be the result of very little exposure to weather related phenomena in their own surroundings. Although cold fronts, with their associated weather patterns, are a natural and familiar occurrence in the Western Cape region during winter months, some learners still struggle to grasp this concept.

A variety of weather measurement instruments, such as barometers, temperature meters (Minimum and maximum), hygrometers, oil damped compass, plastic garden rain gauges (see Appendix P) were taken to class and used in conjunction with the DAIM lessons. These instruments were put on display at the beginning of the session and each group had to identify a chosen item, give a brief description of the instrument, and explain to other groups their common usage. This engagement stimulated the intervention process amongst the groups. Although learners indicated that they were never introduced to IKS at school level, their inputs and comments during the intervention period were valid and striking. Some groups responded that IKS knowledge is only present, or remains, in the minds of the elders in the community and that they as youngsters would like to learn more about IKS. Some learners even indicated that their grandparents still talk about some of the 'old ways' of doing things without the use of modern technology. This laid the basis for further engagement with the experimental group. They were also made aware that IKS is not widely documented, or that very little literature is available on the local IKS in the specific geographical area from which the research population and samples were drawn.

In summary, since indigenous knowledge systems (IKS) form part of the new Curriculum and Assessment Policy Statement (CAPS) for Grade R-12, and, according to specific outcome 3.2, it is imperative to address the inclusion of IKS orientated materials, resources, and instructional methods. Thus, as this research is intended to show, the DAIM method can only benefit and assist any teaching strategy whose purpose is to enhance learners' current understanding of meteorological science concepts.

4.3 Social class and Cultural factor

4.3.1 Age, gender and religion

Very little differences in terms of social class, cultural diversity related to race, home language and religious representation were prevalent in the data analysis. The subjects mostly came from the same community and there was an almost even gender representation in both groups. Table 12 represents a comparison of the various differences in both (E) + (C) groups according to their gender, religion, race, and home language.

Table 12: Overall Chi-square results for comparing groups

Chi-Square STATISTIC	DF	VALUE	P-VALUE
Gender	1	2.6729	0.1021
Age	1	0.2246	0.6356
Religion	1	0.1134	0.7363
Race	1	0.1037	0.7475
Language	1	0.1037	0.7475
N=31, Critical t-value = 2.045, Alpha = 0.05			

Based on the Chi-square test, the two (E) and (C) groups do not differ significantly on gender, age, religion, race or home language according to the p-values.

The researcher also noticed in this case that using an analysis of covariance and including 'gender' as a factor, that 'gender' is not a significant predictor of post-scores (p=0.56)

4.3.2 Learners' views on the CoW questionnaire.

In the first week of the third term, after the June school holidays, the learner survey and CoW (Conceptions of Weather) instruments were administered to a sample of twenty (20) grade 9 high school learners. An even gender ratio of 10 males and 10 females were present when the survey was administered. These learners were randomly selected and were under no obligation to take part in the survey; it was a voluntary decision on their part to be part of the study conducted during two separate first interval school breaks with no disturbances caused to the school academic time table.

The survey was the first to be administered because it was set up to test the general perceptions and views of learners of Geography. The second survey to be completed was the CoW which specifically tested the learner's conceptions of weather. The two instruments were administered a week apart.

For the purpose of the CoW the same grade 9 group/sample of learners from the same public high school (called school "X" for now) was selected. The school is situated in a socio-cultural and economically disadvantaged area. Participants range between 13 and 18 years of age. The group/sample was purposefully selected on the basis of comparability with respect to:

- Learners doing the same subject and taught by the same geography teacher
- Formal class test and reports
- Learners from the same socio-cultural and economic background.

Table 13: Boys' and Girls' Mean score per group (school A)

Experimental Group	**Variable**	**N**	**Std Dev**
Girls	Pre-test	10	4.08
	Post-test	9	4.67
Pre-post differences		***9***	***3.27***
Boys	Pre-test	7	1.77
	Post-test	7	3.94
Pre-post differences		***7***	***4.46***
t-value = <.0001 **Alpha = 0.05**	**Pre-post scores: Girls & Boys combined**	**16**	**3.75**

Control Group	**Variable**	**N**	**Std Dev**
Girls	Pre-test	3	6.08
	Post-test	3	1.15
Pre-post differences		***3***	***6.80***
Boys	Pre-test	8	3.89
	Post-test	7	2.99
Pre-post differences		***7***	***4.34***
t-value = <.0001 **Alpha = 0.05**	**Pre-post scores: Girls & Boys combined**	**11**	**6.34**

All the learners that participated in the survey and CoW-test came from the same community. The learners belonged to two different religious faiths, namely the Christian religion and Moslem religion. I have noted that the Christian faith has a bigger representation than the Moslem faith in the selected school where the study was conducted. This religious representation also filters through within the community itself. The most commonly used language at home and at school is Afrikaans for those who participated in this study. English is a second language school subject and all participants had sufficient command to be able to fully and clearly understand the questions in English when the survey and CoW-test was administered for the research. Both male and female subjects represented a wide age range between 13 and 18 years old. The age range of 13-15 years was represented by 70% and 16-18 years (grade repeat learners) was represented by 30% of the female participants. On the other hand, the age range for the male participants was almost a similar number, and 80% represented the 13-15 years age range, while 20% represented the 16-18 age group (see Table 14).

Table 14: Biographical summary of participants (School A)

Biographical Item	Girls	Boys
	Participants Biographical Data	
Participants (N)	10	10
Grade	9	9
Age range (years)	13-15 yrs. (7)/ 70% 16-18 yrs. (3)/ 30%	13-15 yrs. (8)/ 80% 16-18 yrs. (2)/ 20%
Home Language	Afrikaans (10)	Afrikaans (10)
Moslem religion	20% (2)	20% (2)
Christian religion	80% (8)	80% (8)

4.3.3 Conceptions of Weather (CoW) Questionnaire

Quantitative research methods were introduced in the form of a Conceptions of Weather (CoW) questionnaire. This questionnaire consisted of concepts dealing with meteorological literacy and IKS aspects/perceptions of this.

4.3.3.1 Results of CoW based on CAT

The report of results should be seen in the context of the original questions and combines the descriptive data with survey data. Where survey and descriptive data (pre-test) were noted, the Contiguity Argumentation Theory (CAT) was applied to describe the type of findings. The CAT cognitive states can be used as an analytical tool to interpret views held by teachers and learners in terms of five possible categories, one of which would express most closely the participants present mental or cognitive state. "The five cognitive states are given as: **Dominant; Suppressed; Assimilatory; Emergent; Equipollent**" (Langenhoven, 2014:16) and are discussed in detail in the literature review, Chapter two.

This CoW questionnaire was administered two weeks after the survey questionnaire was completed. The same group that completed the survey completed the CoW-test.

Note: (1) Each question asked contained a *Likert Scale* with a reason for answer as indicated below (see Table 4.9) (2) Questions 6-10 included a source of information choice (see below). This source of information was used to analyse and code learners' responses either into a Science World View (SWV) or the Indigenous Knowledge Science World (IKSW) view according to their beliefs and perceptions of weather phenomena.

During the CoW-test the following was noted: learners have little knowledge about IKS and the impact that it has on the global community and the value IK knowledge holds within any local community. They reported very little indigenous knowledge being displayed or used at home by parents and other family members. If any IKS knowledge was being used in daily traditions the elders and others never noted it as belonging to a cultural system of IKS. This made it very difficult or even impossible for learners to get acquainted with what is seen as 'cultural knowledge' or IKS when answering the CoW-test.

It seemed that much of the traditional/cultural knowledge is derived from elders in the communities. Some of the traditional knowledge made its way into present day situations through stories and folk-lore that was passed on through traditional dances, song, rituals and other cultural engagements like community festivals, weddings, prayer meetings, storytelling and seminars (Riffel, 2013).

3.3.2 Non-Parametric presentation of CoW results

In this study it is important to note the performances of learners based on their own conceptions and beliefs about weather related issues. Although Table 15 presents data in a *nominal* and non-parametric test way, it is important in terms of educational value to test and measure the findings of how well learners perform and respond with an informed or uninformed answer in terms of their conceptions in the CoW test. Other forms of non-parametric testing like sign test, median test, chi-square, Wilcoxon Scores (Ranks Sums) for variables in the pre- and -post tests and the Mann Whitney U-test are used throughout this chapter to illustrate and present various stages of the emergent findings in the study.

Table 15 below presents a *Nominal* type (Ogunniyi, 1984) of measuring scale to illustrate the different beliefs and perceptions of the learners concerning their conceptions of weather. The numeric number is used as a class label with a qualitative property attached. This nominal measuring value is also used to assign a number to present the *amount of a property* possessed by the beliefs or views of learners. The term 'property' simply means the characteristic of the event in question (Ogunniyi, 1984).

Table 15: Non-Parametric —Likert Scale overall results of CoW questionnaire

Nominal Scale	**1**	**2**	**3**	**4**	
Likert Scale	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**	**Total**
Boys Beliefs (%)	15.71	40.71	34.29	9.29	= 100 %
Girls Beliefs (%)	28.57	42.15	17.14	12.14	= 100 %
Total	**44.28**	**82.86**	**51.43**	**21.43**	**(200)/2= 100%**

From an examination of the overall results of the conceptions of weather (CoW) test questionnaire in table 15 one can draw the conclusion that the answers from learners display a more positive and inspired view on the nominal scale 1= Strongly Agree (44.28%) and nominal scale 2 = Agree (82.86%) then disagree, nominal scale 3 = (51.43%) and nominal scale 4 = (21.43%) respectively in response to the original questions that were administered to them in the CoW test. On item 1 'Learning geography through school science is interesting', the response count between boys and girls was surprisingly low. Only two boys

(20%) and two girls (20%) agreed with the statement. This claim can be supported by reasons given by learners as to why they chose to agree or disagree in the following excerpts:

On item 1: some boys (2) responded negatively (direct translation used):

L1: Because there is a lot of stuff to do and to learn about.

L3: Because I don't like it and I don't no what to do when the teacher give the class to me.

Learner L1 is saying that Geography has too many complicated sections to deal with, and alerts one to the fact that it is difficult for him to deal with learning material that one does not understand. He also finds it complicated to handle all the various concepts within the subject. For L3, being in the Geography classroom and in the presence of other learners, besides his subject teacher, is in itself just too much for him to deal with, made more difficult due to the fact that he does not like Geography as a school subject at all.

On item 1: some girls (2) also responded negatively, although one was more negative than the other (L12) (direct translation used):

L10: The teacher doesn't make it interesting, but I make it myself; sometimes he makes it interesting.

L12: The children in class makes it not easy to understand the teacher.

The excerpts below are representative of the learner's responses (direct translation) to certain items in the CoW questionnaire:

No connection emerged from learners between IKS and weather-related geography, although 80% (16) agreed that using IKS to learn geography can help them understand the weather better. Out of the 20 participants only six, three girls and three boys responded to their choice of answers.

On Item 2 ('Using my indigenous knowledge to learn geography helps me to understand weather better').: some girls (3) responded:

L8: I don't always know what the weather would be.

L9: To know everything about the weather is better than to understand that.

L10: Sometimes I'm wrong but it help a little with geography.

On Item 2, some boys responded:

L15: No, if you don't know geography how can you understand the weather?

L16: Yes, it show all the countries and show the weather.

L18: To know what is going on with the weather.

On Item 4 ('I believe more in my indigenous knowledge than geography knowledge to understand the weather better') the girls (2) responses were:

L18: It's not the same every time.

L10: I don't believe in both.

On Item 4 boys (3) responses were:

L16: It shows on the news what is the weather going to be.

L18: Their knowledge is better than ours.

L20: Because indigenous knowledge will not show you about the weather.

Among other reasons for the responses to these items, the excerpts above suggest that most learners had very seldom (or not much) been exposed to IKS in the field of Geography and that for them there existed very little connection or relation between IKS and their understanding of weather phenomena, as was demonstrated by their responses to the 5 questions taken from the CoW questionnaire below (see table 16).

Table 16: Sample questions of CoW-test

Order of Questions	Conception of Weather (CoW) questions
1.	Learning geography through school science is interesting..
2	Using my indigenous knowledge to learn geography helps me to understand weather better.
3.	I can use what I learn in a geography class at home and in my community.
4.	I believe more in my indigenous knowledge than geography knowledge to understand the weather.
5.	I am only interested in geography to pass my exams.

Not all learners completed the response section, and this resulted in less than half of the total questionnaires that were administered being fully completed. This also reflected that the learners did not show interest in reading and making time to answer the questions properly. The lack of interest shown even in many of the completed questionnaires leads to the impression that most of the learners are not geared up with, or particularly interested in, Geography and the impact it has on their daily lives.

Out of the 14 items that were presented in the questionnaire only 2 were fully answered by all participants. Most of the reasons given for responses to the items did not relate to the choice of answer from the Likert scale. For example, the answer given by L01, "I don't like the stuff" to the item 1 question, which was: "Learning geography through school science is interesting". Such answers clearly indicate their lack of exposure to IKS. Distorted perceptions and conceptions of Geography as a subject can be picked up in many of the remarks that were made by the learners. The possibility of language and clear understanding of the questions are not ruled out when making this finding. This indicates that our education system needs to expose learners to IKS. Apart from the fact that IKS is included in CAPS, we run the risk of losing valuable cultural information. The results of the questionnaires indicate that there seems to exist no connection between IKS and weather amongst both girls and boys who were part of the sample. One can clearly see that, for this group of learners, IKS is viewed as adding little value to their social science knowledge.

Brief summary of research question 1

In summary of research question 1, Indigenous Knowledge (IK) that is still alive in local communities and visited family households across South Africa and even Africa and other parts of the Southern African continent that could be included into a schools' IKS-Science curriculum to help promote and foster new interaction with IKS; transfer and to preserve the IKS knowledge in our younger generation or otherwise face the reality that IKS knowledge could disappear and be lost forever, if not taken seriously for inclusion into a science educational academia that would benefit and enhance both the teaching, learning, and assessment space.

Social and cultural relevance of IKS and school curricula development is at a vital stage in the education academia — the integration of IK into the Western Science teaching and learning space has become imperative and urges a need to understand or even "border-cross" (Ogunniyi, 1998) over socio-cultural barriers from various local communities to understand and accept their beliefs, may it be religious or mythical.

It is also evident that a lack of resource materials available to any teacher in a classroom setting is causing divert to the old "chalk and talk" method of teaching. Administrative workload, "individual quality management assurance" protocol are used as measuring tools to measure teacher-subject content knowledge and learner achievement performances in subject departments. Thus, resulting that teachers create a more shuttle and still learning environment in their classrooms to achieve the desired results. Maqutu (2003) agrees and reports that it 'relates the choice of teaching strategies to factors such as many teachers being novices and the availability of teaching materials'. The "chalk and talk" teaching strategies are dominated by minimal students' talk except when students are asked or invited to ask a question by the teacher (Qhobela & Moru, 2011).

4.4 Research Question 2 (RSQ2)

What are these learners' ideas and attitudes towards integrating indigenous knowledge system (IKS) into meteorological science?

Introduction

To answer research question two (RSQ2) the conceptions of weather (CoW) questionnaire and the meteorological literacy (MLT) test pre-post test results were used. Both the high school survey (HSS) and conceptions of weather questionnaires were administered at the beginning stage of the research before the intervention stage. The data MLT test was designed as a pre- and post-test instrument before and after the intervention stage. The high school survey supplied the researcher with valuable background information and data to compare the learners' attitudes towards their own school and home environments after the study. The MLT results assisted me to unpack the qualitative findings of the other CoW instruments and also to validate the responses given by the (E) group learners. Figure 13 below is a scatter diagram illustration of the pre-post-test scores for both (E) and (C) group learners' performances before and after the dialogical argumentation instructional (DAIM) intervention model.

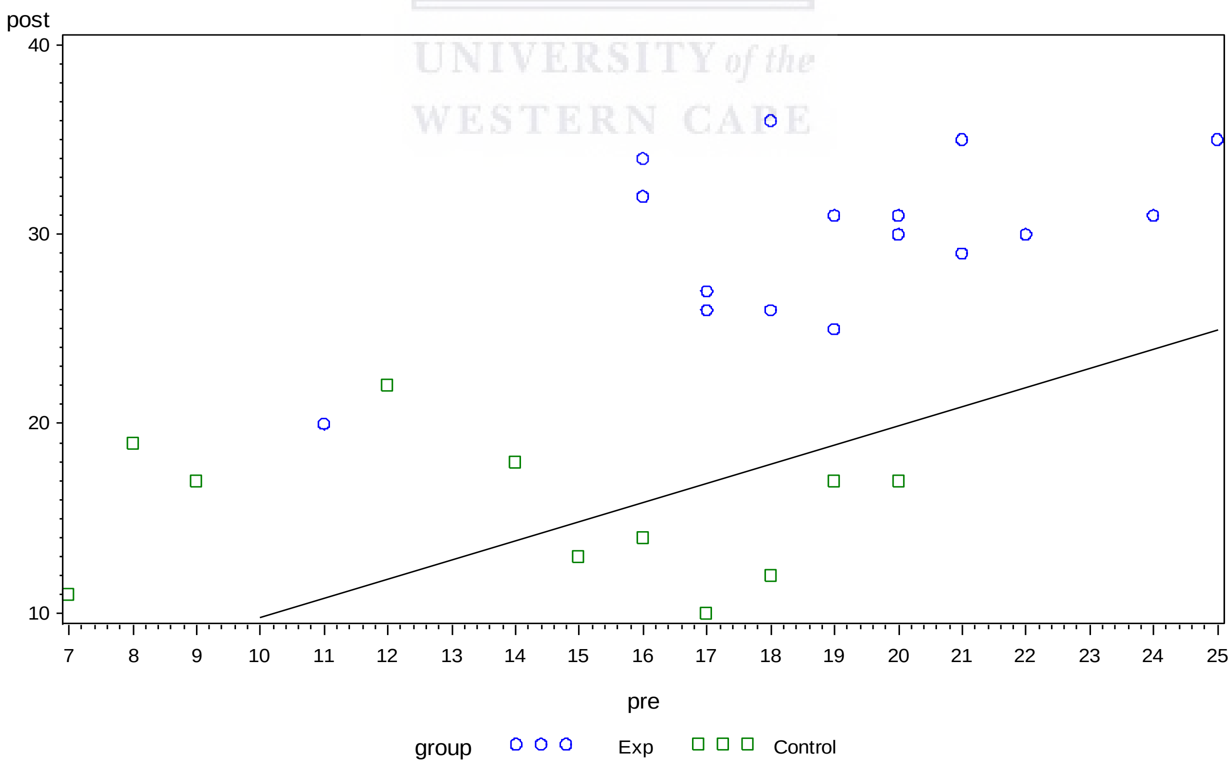

***Figure 13: Scatter diagram of Pre-Post test scores for E and C group** (Identity line shown for reference)*

4.4.1 Scatter Diagram

An examination of the scatter diagram (Figure 13) gives us a visual impression of the correlation between the two groups. The circles marked as (o) together represent the experimental (E) group, and the square marked as (□) represents the control (C) group in the pre-post meteorological literacy (MLT) test. The line (identity line) represents the base line scores for each pre-post test score. If the placement of either the square (□) or circles (o) appears to be on the line, we can assume that the performances in the pre-post test scores were the same for both tests before and after the intervention took place. The pre-post test scores were plotted against each other to get the pictorial representation of the relationship between the pre-test scores (x-scores) and the post-test scores (y-scores).

Analysis of Scatter Diagram

The visual impression of the E group shows a more positive correlation as compared with the negative correlation of the C group between the two tests. The E group's (circles) are all plotted above the identity line (base-line) towards the far upper right-hand corner, while the C group (squares) are plotted, some below the identity line and some to the lower left-hand side of the scatter diagram. This gives us a rough idea of the performances of learners in both groups in relation to their pre-post test scores. We can conclude that the E group has a positive correlation with a better visual representation than the C group with its scattered and negative correlation representation. Both E and C groups showing different types of correlation (Figure 13) means that both groups end up with different end results in both pre-post achievement tests, and that this could be as a result of the intervention that was applied only to the E group and not to the C group. I discuss the pre-post-test analysis under the sub-headings to follow.

Analysis of pre-post-test scores using a scatter diagram

The scatter diagram (Figure 13) shows the overall pre-post test scores of both groups after the dialogical argumentation instructional model (DAIM) intervention process was completed. The right side (y-score) of the table indicates the post-test scores, while the baseline (x-score) represents the pre-test score marks out of 50 points. The straight line (identity line shown for reference) indicates an equal mark out of 50 points for both pre-post test scores. In the E group 16 learners were exposed to both pre-post tests and are situated in the upper right corner of the table. This position on the table indicates that the learners from the E group obtained a mean value of 18.88 in the pre-test and a mean value of 29.87 in the post-test, with a mean value difference of 10.87 between pre-post-test with a standard deviation of 3.75.

Table 17: Experimental group pre-post-test scores

E GROUP	PRE-TEST	POST-TEST	PRE & POST DIFF
MEAN	18.88	29.87	10.87
SD	3.31	4.28	3.75
t-TEST: N = 16, Critical t-value = 2.131, Alpha = 0.05			

In the C group 15 learners were exposed to both pre-post-test and are situated in the lower left corner of the table. The position on the table indicates the C group learners obtained a lower baseline score in the pre-test, and below average scores in the post-test as well. The C group pre-test mean value was 14.33 and in the post-test a mean value of 15.45 with a mean difference of 1.3636 between pre-post test scores, with a standard deviation of 6.34. This table shows that the E group learners' performance improved with a mean 10.8750 difference. And the C group learners' performance improved with a mere mean difference of 1.36 value. The E group difference between the two mean values indicates that after the DAIM was administered their performance improved from a pre-test mean of 18.88 (37.76%) to a post-test mean value of 29.87 (59.75%), with an overall increase of 21.99 % in their performance. Furthermore, the C group difference between the two mean values indicates that after the pre-post-test was administered (without the DAIM intervention) their performance remained almost the same from a pre-test mean value of 14.33 (28.66%) to a post-test mean value of 15.45 (30.90%), with an overall improvement of 2.24% in their performances.

Table 18: Control group pre-post-test scores

E GROUP	PRE-TEST	POST-TEST	PRE & POST DIFF
MEAN	14.33	15.45	1.36
SD	4.39	3.72	6.34
t-TEST: N = 15, Critical t-value = 2.201, Alpha = 0.05			

Table 19 shows the respective tabulated results from both the E and C groups' pre-post-test scores. It would be naïve not to acknowledge that the improvement of the E group was due to the intervention that was administered to the experimental group after the pre-test. Otherwise, the effectiveness of the dialogical argumentation instructional model (DAIM) had a positive effect on the learners' overall performances after the pre-post MLT test was administered to the E group learners.

Table 19: The means procedure of pre-post test scores (E) and (C) Group

Group	Variable	N	Mean	Median	Std Dev
Experimental Group	Q1	16	6.58	6.0	2.34
	Q2	16	4.88	5.0	1.21
	Q3	16	2.35	2.0	1.11
	Q4	16	5.05	6.0	3.32
	Pre-test	***16***	***18.88***	***19.0***	***3.31***
	R1	16	7.50	8.0	1.71
	R2	16	5.06	5.0	1.06
	R3	16	3.18	2.5	2.07
	R4	16	14.12	13.0	3.22
	Post-test	***16***	***29.87***	***30.5***	***4.28***
	Pre-post Difference	**16**	**10.87**	**10.0**	**3.75**
Group	**Variable**	**N**	**Mean**	**Median**	**Std Dev**
Control Group	Q1	15	5.75	6.5	2.83
	Q2	15	3.91	4.0	0.99
	Q3	15	1.83	2.0	1.26
	Q4	15	2.83	2.0	3.12
	Pre-test	***15***	***14.33***	***15.5***	***4.39***
	R1	15	6.36	6.0	2.50
	R2	15	3.45	4.0	1.36
	R3	15	2.18	2.0	1.47
	R4	15	3.45	3.0	2.42
	Post-test	***15***	***15.45***	***17.0***	***3.72***
	Pre-post Difference	**15**	**1.36**	**-2.0**	**6.34**

Note: Variable Q1 – Q4 = Questions in the pre-test stage, Variable R1-R4 = Questions in the post-test stage

Variability and standard deviation:

The standard variability test was applied to show a central tendency of the (spread) variability of the scores in the above scattered diagram (Figure 13). I also made use of the most commonly used measure of variability known as the standard deviation value. The standard deviation was computed by following the steps as indicated by Ogunniyi (1992, p. 29):

1. *Subtracting the means from each score,*
2. *Squaring these differences,*
3. *Summing up these squared differences,*
4. *Dividing the sum obtained by the total number of scores in the distribution, and*
5. *Finding the square root of the resulting sum* (Ogunniyi, 1992).

4.4.2 Why use a coding structure analysis for RSQ2?

The use of a coding structure to analyse the studies qualitative data correctly came as a suggestion from SIKSP (Science Indigenous Knowledge Systems Project) group members at University of the Western Cape and is based on the Miles and Hurberman (1994, p. 12) approach or framework for qualitative data analysis and is labelled as 'transcendental realism' (Punch, 2009). A new coding structure design emerged using the 'transcendental realism' approach with its three main components of data analysis. The data analysis is based on the interactive model from the Miles and Hurberman (1994) framework which was of value in the analysis of the qualitative data for research question two (RSQ2) in three main components, namely (1) data reduction (2) data display (3) drawing and verifying a conclusion from the data (Punch, 2009, p. 174).

Punch (2009, p. 175) also mentions that 'these three overall components are interwoven and concurrent throughout the data analysis' and concludes the following:

> *The first two, data reduction and display, rest mainly on the operations of coding and memoing. In virtually all methods for the analysis of qualitative data, coding and memoing are the two basic operations that get the analysis going.* (Punch, 2009, p. 175)

As previously mentioned, the qualitative data were collected through various types of instruments such as written responses, group feedback, observation schedules and learners' interviews in the process of answering research question two.

The coding structure assisted me to: (1) reduce and bring all the various forms of attributes and responses of data together, (2) to formulate and verify two central data displays, namely codes and themes that helped reduce and move data without any significant loss of information (3) to assess the effect of using dialogical argumentation as an instructional tool on IK weather knowledge prediction as a central concluding theme (see Figure 11 Chapter 3). Two major codes were displayed and focused on, namely the traditional beliefs–IKS (TBIKS) code and the Science world view (SWV) code. From here the information provided from the data was directed into two different types of sources used in the Geography classroom in developing weather concepts: either a cultural knowledge source (KNS), that represents religion and cultural beliefs, or a school knowledge source that represented the standard textbooks and science literature. In conclusion, the coding structure gave the study a summarised view of the learners' attitudes, ideas, perceptions and understandings of their own environment.

Illustration of coding structure

In the above illustration the qualitative data from learners' written responses were coded into cultural knowledge or school knowledge. Cultural knowledge includes views that learners in the sample had derived from religion and their own personal points of view. Learners were asked to give reasons why they chose the type of sources of information to support their answers. The information is summarised in Table 20 below.

Table 20: Choice of Sources based on information & perceptions

1. **Science** (information derived from and influenced by a *science perception*)	2. **Religion** (information derived from and influenced by *religious beliefs*)
3. **Personal View** (information based purely on own *personal view*)	4. **Cultural View** (information based on *norms* and *standards* from a *cultural belief/beliefs*)

Attributes or responses from the following four qualitative data collection types were coded: group work, group presentations, class room visits and observation schedules, and personal interviews with learners from the (E) group. This was taken and coded into two single codes namely, traditional beliefs that represents the indigenous knowledge system (IKS) view, and a Science view that represents the (modern) science world view (SWV). Some learners claimed that they had never been confronted with the topic of IKS at school level. This raised some concern for this study because Natural Science is seen as a Social Science subject in Foundation Phase under Life Skills. Then Geography and History is bundled together under Social Science in the Intermediate and Senior Phases. In the Further Education and Training (FET) phase Geography and History becomes a separate subject of choice, and has to deal with the integration of IKS into the curriculum. In addition, very little evidence was provided in some of their answers to support their claims. What came out of the coding structure was that very little of the knowledge that is currently present amongst, or has been acquired by, the learner in the sample about IKS/weather perceptions came from a cultural belief way of knowing. Most of the knowledge about IKS/weather related issues came from textbooks, a limited supply of science literature, and from the school - from (inside) the classroom.

4.4.3 Pre-test result of Views on Indigenous Knowledge Questionnaire (VIKQ)

Comparison of individual experimental groups' pre-post test results of VIKQ views

Item 10 in the VIKQ questionnaire, tested the importance of IK knowledge transferability from elders to the younger generation. The following summary was made using Pearson Rank Test for Chi-square results: (1) both E groups each from one of the two schools involved projected a highly (18 out of 31 participants) uninformed view on this question, with a t-value of 2.192 *Pearson chi-square* with a .533 significance (see pre-test results diagram below) on the matter of whether indigenous knowledge practitioners (bearers of indigenous ways of living), should or should not pass on any unchanged/unmediated IK; (2) very confusing examples were provided to support their chosen statements, and (3) the examples given by learners in the sample tended to be a distorted "imaginary view" of what current problems could be solved were indigenous knowledge practitioners to change and modify their IK-knowledge and link it with/integrate it into learners' experience and daily ways of living.

Table 21: Pearson Rank Test: Pre-test results of Experimental Groups

Pearson Rank Test	**Value**	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	**2.192**[a]	3	.533
Likelihood Ratio	**2.623**	3	.453
Linear-by-Linear Association	**1.851**	1	.174
N of Valid Cases	31		

N=31 (30) Pearson Correlation Coefficient = (r)

It would be naïve not to mention that the pre-post-test linear relationship association, as tested in the Pearson correlation coefficient ("r") between the two variables, involves item 10 (informed, uninformed views) from the two experimental groups from each of two schools (SSS and RHS). A positive, strong and adequate relationship between these variables was drawn from the linear projection of r = 1.851 that indicated a strong correlation between these variables tested.

Pre-post test results of Experimental groups

An analysis of the pre-post bar graphs of item 10 in the VIKQ instrument, makes possible a clear assumption that the DAIM-IK presented in the intervention stage has a substantial influence on learners' perception and understanding of how IK could be of benefit in the daily lives of the community from which learners come, and thus, beyond the classroom.

Table 22: Pearson Rank Test: Post-test results of Experimental Groups (SSS and RHS)

Pearson Rank Test	**Value**	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	.364[a]	2	.834
Likelihood Ratio	.365	2	.833
Linear-by-Linear Association	.118	1	.731
N of Valid Cases	31		

N=31 (30) Pearson Correlation Coefficient = (r)

Below is the exact question abstract of item 10 of the VIKQ questionnaire, with narrated choice of possible answer as posed to the sampled experimental groups (see **Appendix K** for full sample):

10. Indigenous knowledge is passed from one generation to the next by elders. The elders are deemed to be very important and some people believe their ways of knowing (knowledge) is the truth and cannot be challenged. Does this mean that current practitioners of indigenous knowledge must use this knowledge exactly as it was passed on to them, or can they use their creativity and imagination to modify (change) the indigenous knowledge to solve current problems?

- *If you say yes and believe that indigenous knowledge practitioners cannot change this knowledge, explain why. Use examples if possible.*

- *If you believe that indigenous knowledge practitioners can change and modify their knowledge, explain why. Use examples if possible.*

(Abstract from VIKQ – Views of Indigenous Knowledge Questionnaire, current study)

It is clear from the pre-post test result presentation on item 10 that there was a significant increase in the sampled learners' understanding of the need to value IK and to see its benefits to the larger community before the IK-intervention session.

Brief summary of research question 2

This section presents the findings which emanated from research questions 2. The research questions were discussed in terms of the broader argumentation framework consisting of Toulmin's Argumentation Pattern (TAP), Ogunniyi's Contiguity Argumentation Theory (CAT). The findings are based on the research questions under the following sections.

Learners' understanding of the selected meteorological concepts as a result of the instructional strategies and curriculum interventions.

In terms of the learners' preconceptions on weather prediction, the findings showed that:

- The performance scores for both the CoW as well as the DAIM group were found to be statistically comparable. Performance for both groups were however found to be higher for the context-familiar phenomena and lower for those that are context-dependent and much lower for those that are discrepant such as weather prediction. In this regard, the learners' preconceptions on the selected meteorological concepts were observed to been based on IK internal principles.

- The phenomena of weather prediction presented the most challenge to learners and their response highlighted that weather largely involved context-dependent as well as discrepant concepts. These were with respect to common visible weather perception and observed weather prediction to be less complicated than indigenous knowledge conceptions. In this regard, the majority of learners' for both groups generally exhibited the substance schema of the weather prediction model or what others have called the weather gathering model.

In terms of the learners' interventions on weather prediction, the findings showed that:

- For all selected weather concepts, both interventions of CoW and DAIM seemed to have significantly enhanced the learners' pre to post-test performances. However, the DAIM significantly outperformed the IK-intervention for weather prediction which were more abstract such as those that were found to be context-dependent and discrepant.
- While both groups' cognitive stances were equipollent before interventions, the cognitive stances of the majority of E-group learners were found to be school science dominant after interventions. As opposed to the C- group, the cognitive stances of the DAIM group learners were observed to be predominantly school science emergent.
- As opposed to the CoW intervention strategy, the DAIM intervention strategy seemed to have explained the phenomena of border crossing in terms of the exact mechanisms they follow when they decide to cross or not cross cognitive borders. In other words, the DAIM seemed not to just have enhanced the learners' abilities to provide reasons in support of their claims, but also terms of interrogating the nature of the theories underpinning particular scientific phenomenon.
- The level at which integration is possible between school science and IKS is moderated to a large extent by the nature of the internal principles as well as bridge principles inherent in a particular scientific theory or law underpinning a particular phenomenon. A related observation made was that each scientific weather phenomenon has internal principle peculiar to a particular worldview, hence the importance of the context of how the phenomena are presented.
- As opposed to the traditional classroom teaching and learning approach which seemed to be dichotomizing IK and school science, the DAIM teaching and learning strategy seemed to be the most appropriate intervention approach for integrating school science and IKS in a manner in a holistic manner.

The learners' reflections on their experiences on the IK integrated lessons

Reflection question 1: "Using my indigenous knowledge to learn geography helps me to understand weather better", observations seem to suggest that:

- The majority of learners, irrespective of what intervention strategy was used, believe that their teachers' beliefs about natural phenomena has had a great influence on their attitudes towards science.

Reflection question 2: "I believe more in my indigenous knowledge than geography knowledge to understand the weather", observations seem to suggest that:

- For the CoW learners, IKS and science do not seem to hold the same scientific status as school science. IKS is somehow largely related to religion which the majority of the learners viewed as being opposite to school science. These learners thus exhibit a divergent cognitive stance where science and IK are pulling in different directions.
- As opposed to the CoW learners, the DAIM learners seem suggest that both school science and IK are equally valid scientific knowledge and that IK can help in developing a more robust understanding of school science. These learners therefore exhibit a school science emergent cognitive stance.

Reflection question 3: "I can use what I learn in a geography class at home and in my community". In this regard, findings suggest that:

- The CoW seemed to have enjoyed the inclusion of IK into their science lessons, but seemed to have been disillusioned by the teachers' lack of IK-science mediation strategies. Some of them however had some concerns such as not knowing how IK will be tested (learner C008), not having enough time for discussions (Learner E005) and not knowing how the two link together.

- The DAIM learners suggested that the use argumentation in teaching about IKS:

  1. Made learning science much easier, 2. Made learners proud about their culture and the realization that their culture can also contribute to scientific knowledge.

4.5 Research Question 3 (RSQ3)

What are the challenges teachers encounter in IKS-and-Science integrated Science classroom?

Introduction

Constructivist ideology holds that learners do not come to the science classroom with empty minds regarding natural phenomena: they come with knowledge from their home backgrounds and life experience. In this regard, the assertion of Ausubel (1968) that the most important factor influencing learning is the learner's prior knowledge, which the teacher should find out and tailor his/her teaching accordingly, remains valid in all science – and other -classrooms. Throughout the years, science educators have stressed the importance of prior learning in the construction of new knowledge in the science classroom. From the social constructivist point of view, learners' prior knowledge gained from everyday experience and home culture serves as the raw material for knowledge construction (Driver, Asoko, Leach, Mortimer & Scott, 1994; Stamovlasis, Dimos, & Tsaparlis, 2006). Since the learner may bring his or her worldview along to the science classroom, (Cobern, 1996; Ogunniyi, 1988), a rejection or discrediting of that knowledge inadvertently deprives such learners of their raw material for meaningful knowledge construction. This implies that the values and norms of cultural influence of the home cannot be disregarded in a constructivist classroom. Consequently, learners' cultural background knowledge, which is the lens through which they interpret experience, ought to form part of science classroom discourses.

In the same vein, many science education researchers have argued that science is more appealing to learners when it is viewed as relevant to their home background knowledge and lived experience (Aikenhead, 1996; Ogunniyi, 1988, 2004). In order to attract learners of non-western origin to science, therefore, their indigenous worldviews should not be dismissed or ridiculed – cause their voices and perception could arrived from a different perspective than those that originated from a western-world view. Instead, such knowledge is has come to be viewed by many education researchers and practitioners as making a significant contribution to the discourse taking place in the science classroom. This stance has been the driving force in the Science and Indigenous Knowledge Systems Project that has been training science teachers to integrate science and IK for over a decade (Nhalevilo & Ogunniyi, 2014; Ogunniyi, 2011). Integration of science and IK has gained momentum in the last decades because of several potential benefits. One of such benefits is that learners from indigenous communities (communities with a deep traditional and cultural value) learn science in a more meaningful way when it is made more relevant to them by recognising and including their cultural values into school science classroom discourses (Aikenhead, 1996, 2001; Aikenhead & Jegede, 1999; Chikunda & Ngcoza, 2017; Jegede & Okebukola, 1991b; Ogunniyi, 1988, 2011; Ngcoza, 2019).

4.5.1 Challenges of integrating science and IK

Many challenges currently exist which are militating against the implementation of a science-IK curriculum in South African classrooms. Firstly, as was mentioned in Chapter 1, the policy document is not explicit in terms of how the integration of the two systems would or could take place, nor does it consult the teachers who were to implement this integration (Ogunniyi, 2007 a & b; Onwu & Mosimege, 2004; Koopman, 2017). Secondly, at the time of the publication of the policy document, most of the science teachers who were to implement such a curriculum were thoroughly assimilated into the (modern/Western) scientific mode of inquiry that, as Ogunniyi (2004, p. 292) has put it, “they are hardly more than chroniclers of the scientific knowledge”. Consequently, higher education programs aimed at training science teachers needed to be changed in order to produce teachers with a knowledge of both the nature of science and the nature of IK, in other words, teachers thoroughly conversant with the epistemological and methodological differences between Western science and IK. Such attempts at training a new breed of science teachers have exposed some pertinent issues. Koopman (2017) refers to “science of government” where school science curriculum and teaching took an interest in a kind of didactical approach within the science classroom. This resulted into a blurred sense of understanding the foundations of science. Leaving the learner disconnected from “external nature and human nature and… presented as a series of abstract concepts and definitions”. Onwu (2009) has reported some pertinent challenges faced by practising science teachers who would want to integrate science and IK. These challenges are discussed in the following paragraph.

There are too many IK practices particular to different cultures, making it difficult to choose which IK to use and which to leave out and at which schools/demographic areas (rural/urban). Accessing IK is time-consuming: information on IK is often not documented or not readily available. Teachers lack models to emulate and appropriate teaching strategies to effectively handle Western science and IK integration. The curriculum lays emphasis on (Western) scientific content knowledge coverage, leaving little or no room for IK. Some teachers believe that certain IK issues should not form part of the science curriculum. Some teachers have the perception that IK is outdated (backward), degenerated, demeaning, and not in synch with modern or current thinking.

This raises the question: if teachers themselves face such challenges, will learners be more motivated to desire and participate in the integration of science and IK, especially in the context of rapid urbanisation, and a rapidly changing technological age?

4.5.2 Voices of Teachers regarding IKS

Research question four, and this section of the study, addresses the change trajectories of teacher participants in the implementation of the dialogical instructional argumentation model (DIAM) and is aimed at understanding the thinking of teachers regarding the use of argumentation in classroom teaching as an instructional approach to indigenous knowledge integration into science lessons. Teachers who agreed to participate in the research joined the Social and Cultural Relevance of Indigenous Knowledge Systems at School research project. Research question four explores how these teachers have, since the initial stages of the project, progressed beyond attitudinal, cognitive change to the acquisition of practical skills: willingly and effectively utilising argumentation for IK-Science lessons and becoming agents of its propagation. Three analytical strands were derived from the main questions in the inquiry and simple proportional statistics were used to show the number of participants who expressed that they experienced a shift from their initial stance, in terms of awareness, oblivion or negativity towards IK and IK-Science integration. Their narratives provided the researchers with insights into their progress from initial to current dispositions and perceived change, together with the self-arguments that occurred during the transformation process. Various reasons were proffered for their initial negativity and the factors that led to drastic attitudinal changes were elucidated as well as their concerns.

4.5 3 Indigenous knowledge should be encouraged

Many education practitioners and researchers have argued that Indigenous Knowledge Systems (IKS) have an important contribution to make to socio-economic growth and sustainable development and should thus be promoted and encouraged. But how aware are people of the nature and potential benefits of IKS, and how important is it that policies be implemented to foster awareness in South Africa?

According to the World Health Organisation (The World Health Report, 2002), a large majority of the African population make use of traditional medicines for health, social-cultural and economic reasons. This report details that in Africa up to 80% of the population use traditional medicine for primary healthcare (The World Health Report, 2002).

In South Africa specifically, studies have shown traditional medicine to play an important role in the management of certain ailments, while at the same time the sale of traditional and indigenous products has been shown to have beneficial effects for poverty reduction and employment creation. It is also recognized that indigenous knowledge systems are a resource that provides a firm foundation for sustainable and environmentally sound approaches to agriculture, in particular, and natural resource management in general (Naidoo & Vithal, 2014; Riffel, 2014; Langenhoven, 2016).

4.5.4 School teachers' general perception of IKS

In June 2016 the researcher administered a round of the Social and Cultural Indigenous Knowledge Questionnaire (SCIKQ) (see Appendix T) - to 16 teachers who participated in the research**.** Questions on IKS were aimed at obtaining baseline data on the sampled teachers' perceptions and attitudes towards various IKS and related issues with Science and Geography subject teachers involved in the research study at their respective schools. The items included in the questionnaire vary from western science versus traditional knowledge; the role of IKS in formal curricula; women's roles in IKS; the government's role in IKS, and traditional agricultural and medicinal practices. A local sample of 16 in-service teachers from the participated school in the study responded to the survey.

Table 23: Demographics description of in-service teachers completed Social & Cultural IK survey

Code	Pseudonym name	Gender	Race	Language	Area of Origin	Qualification	Currently living	Yrs teaching experience	Teaching subject
T01-OB	*Onati*	F	Black	Xhoza/Eng	E/ Cape	D +PGCE	Urban	2	Natural Science
T02-SD	*Shaid*	M	Coloured	Eng	W Cape	D+PGCE	Urban	1	Physical Science
T03-NK	*Kingsley*	M	Black	Xhoza	E/ Cape	D+PGCE	Urban	3	Natural Science + Life Science
T04-FZ	*Fezeka*	F	Black	Xhoza	E/Cape	D+PGCE	Urban	4	Life Science
T05-FJL	*Feroza*	F	Coloured	Eng/Afr	W/Cape	D+T	Urban	7	Natural Science
T06-LJP	*Leticia*	F	Coloured	Eng	W/Cape	D	Urban	4	Physical Science
T07-DU	*Dumisani*	M	Black	Eng/Xhoza	W/Cape	D+T	Townhouse	5	Life Science + Natural Science
T08-SR	*Rosaline*	F	Black	Xhoza	E/Cape	D+PGCE	Flat	3	Physical Science
T09-LT	*Lilian*	F	Coloured	Eng/Afr	W/Cape	D+PGCE	Urban	5	Natural Science
T010-NL	*Noluntu*	F	Black	Xhoza	E/Cape	D+T	Urban	4	Life Science
T011-AD	*Andile*	M	Black	Xhoza	E/Cape	D+PGCE	Rural	3	Natural Science + Life Science
T012-EW	*Eddie*	M	Coloured	Afr	W/Cape	D+PGCE	Urban	5	Physical Science
T013-CHC	*Chad*	M	Coloured	Afr	W/Cape	D+PGCE	Urban	3	Natural Science
T014-DJT	*Donald*	M	Coloured	Afr	W/Cape	D+PGCE	Urban	5	Life Science +Physical Science
T015-FO	*Fabian*	M	Coloured	Afr	W/Cape	D+PGCE	Rural	4	Natural Science / Geography
T016-PHK	*Peter*	M	Coloured	Eng	W/Cape	D+PGCE	Urban	4	Life Science

N=16; PGCE = Post-graduate Certificate in Education; T = Teaching Diploma; D = Degree

4.5.5 Observation – teachers' positive attitude towards IK

Overall, the findings indicated a positive attitude on the part of the sampled teachers towards IKS. This finding from a small sample of teachers could be said to go some way to begin to support the idea that IKS has the potential to be a leading contributor to progress in South Africa's education and possibly its socio-economic development. More than half of the teachers (56%) believed that modern science does more harm than good, while more than two-thirds (62.5%) felt that IKS has the potential to offer insights and lessons that can benefit everybody. Of the 16, 75% were of the view that we place too much trust in science and not enough in indigenous knowledge, and 81.25% were of the view that we place too much trust in science and not enough in cultural beliefs and practices (see Table 24 below).

Table 24: Teachers' Attitudes to Indigenous Knowledge Systems (IKS)

Teacher Participants	Average vote in number	General Summary	Percentage (%)
16	9 (16)	Modern Science does more harm than good	56,25%
16	10 (16)	IKS offer lessons that can benefit everybody	62,5%
16	12 (16)	Too much trust in science and not enough in IK	75%
16	13 (16)	Too much trust in science and not enough in cultural beliefs and practices	81,25%
16 In-service teachers	**68.75%**		**100**

Place and role of Indigenous Knowledge Systems in education

The inclusion of IKS in a formal education setting was explored during the survey and the majority of teachers agreed that IKS should be included at various educational levels. Just more than half (56%) of respondents agreed that children do come to learn to respect IKS practices at school. The majority of respondents were in favour of the Department of Basic Education (DBE) including IKS in the school curriculum (63%); a relatively large proportion of the participants favoured the idea of traditional healers receiving formal qualifications and certification for their skills (69%); three quarters of the sample favoured the idea of indigenous skills being offered at vocational training institutes (75%); and a large number favoured the idea of universities offering degrees in IKS (81%).

When asked about traditional agriculture and traditional medicinal plants, nine of sixteen teachers agreed (56%) that traditional agriculture plays an important role in providing livelihoods for South Africans, two-thirds (56%) agreed that traditional agriculture plays an important role in reducing poverty, and 63% agreed that traditional medicinal plants can lead to valuable and beneficial medical discoveries.

Table 25: Respondents data about IKS in Education

Teacher Participants	Average vote in number	General Summary	Percentage (%)
16 x In-service Teachers	9 out of 16	*Learners do respect IKS practices at school*	56%
	10 out of 16	*Education Department should include IKS in the school curriculum*	63%
	11 out of 16	*Traditional healers should receive formal qualifications for their skills*	69%
	12 out of 16	*Indigenous skills should be offered at vocational training institutes*	75%
	13 out of 16	*Universities to should offer degrees in IKS*	81%
	10 out of 16	*Traditional Agriculture and Traditional Medicinal plants could provide for livelihoods of South Africans*	63%
	9 out of 16	*Traditional Agriculture could reduce poverty in South Africa*	56%
	11 out of 16	*Traditional plants can lead to great medical discoveries*	69%

The majority (60%) felt that big businesses are exploiting the indigenous knowledge of communities and that government should be proactive in this respect and, as the response discussed in the next section indicated, government should be protecting these communities and monitoring/regulating what has become an industry.

Government's involvement in IKS preservation, protection and support

Three-quarters (76%) of teachers felt that government should do more to document IKS in South Africa. The majority was in favour of the government doing more to support communities involved in IKS and to promote small businesses which use IKS, as well as spending more on protecting and sustaining IKS.

As has been mentioned, the majority (60%) felt that big businesses are exploiting the indigenous knowledge of communities and that government should be proactive in this respect.

Results from this survey suggest a mandate for government to implement policies that promote and protect IKS and are an indication that there is or could be a place for a culture-derived and culture-driven development framework based on local knowledge of people and communities.

Table 26: Reflective Questionnaire on Social and Cultural Indigenous Knowledge Questionnaire (SCIKQ)

1. What were your views about argumentation-based instruction before and after participating in the SIKSP workshops?
……
2. State your view about the nature of science and IKS before and after attending the SCIKQ workshops
Science: ....
IKS:..
3. Would you say that you have developed sufficient ability or skills to implement a science-IKS curriculum in your classroom as a result of the workshops?
……………………………………………………………………………………………………
4. What were your perceptions of the opportunities to use an argumentation-based instruction in your classroom before and after the workshops?
    a) What challenges did you face while attempting to implement an argumentation-based instruction in your classroom?
    …………………………………………………………………………………………
    b) What attempts did you make to overcome such challenges?
    ....

4.6 Purpose of the Social and Cultural Indigenous Knowledge Questionnaire (SCIKQ)

In 2014, this research project, *Social and Cultural relevance of aspects of Indigenous knowledge systems (IKS), Meteorological Literacy and Meteorological Science Conceptions* received funding from the National Research Foundation (NRF) under the umbrella programme of Indigenous Knowledge at Schools. The projected included / embarked on the Dialogical Argumentation Instructional Model (DAIM), aimed not simply at extracting data from, but also at equipping, social science (geography and history) teachers at the participating schools with skills for IK and science integration. This project also provided an opportunity for the researcher (of this current study) to explore the theoretical precincts of the dialogical argumentation instructional model (DAIM), Contiguity Argumentation Theory (CAT), Nature of Science (NOS), and IK (Nhalevilo-Afonso & Ogunniyi, 2011). This subsequently became one of the main aims of the School of Science and Maths Education (SSME) where the principal researcher is a member, at the University of the Western Cape (UWC).

The 16 participating teachers benefited from the research study-project through the opportunity to become familiar not only with the NCS/CAPS curriculum policy, but also with lesson and materials design through timed vigorous argumentation sessions using science and IK related topics. Participation involved coherent presentation of claims, warrants, counter-claims, rebuttals, unresolved claims and concessions, all of which are set out in **Tables 27** and **28** below.

Table 27: Indicate your perceptions of the opportunities to use argumentation instruction to introduce IK into the science curriculum before and after the SCIKS survey:

Argumentation-teaching:	**Possible Examples / Answer**
In terms of improving the teaching an inclusive and integrated science/IKS curriculum	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
Would make the teaching of a culturally useful and relevant science curriculum	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
What teaching strategies have you used in incorporating IK into the science classroom?	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
What have you found useful when introducing a science-IKS topic?	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
What sort of classroom discourse have you found to create the best environment for integrating science and IK?	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………

Table 28: Indicate your perceptions of the challenges of using argumentation to introduce indigenous knowledge in the science classroom before and after the workshops

Argumentation-based teaching with respect to:	**Possible Examples/ Answers**
The role of language skills on the part of both teacher and learner	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
The place of prior knowledge of learners	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
Factors of time and effort	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
Stakeholders' support	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
Development of curriculum material	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
Role of using different teaching skills and strategies	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………
Do you see argumentation as belonging exclusively to science and not to IKS?	(To be completed by participant) ………………………………………………… ………………………………………………… …………………………………………………

4.6 1 Change - knowledge, attitude, value and practice

Personal attitude '*towards'* a concept differs from having the attitude '*of*'' that concept. This means, attitude *to* IK, differs from an attitude *of* (apposite to) SCIKQ, a more complex locus. It follows then that a real change in stance on the part of the teacher would involve an awareness of IK, the development of a favourable attitude to IK and to the idea of IKS, leading to a discernible valuation (strong desire for IK), and to the implementation of a science/ IKS integration curriculum practice position. This would be a visible drive to authenticate IKS through inquiry and through a personal formulation of tenable theoretical positions. It would also mean a discussion of changes in deportment towards IK, and to creative and sustained integration of IKS into the curriculum. In this context, Osborne, Simon and Collins (2003) cite Klopfer's (1971) list of six progressions that one traverses from the initial reception of an idea to the formulation of an attitude, to development of value and to subsequent adoption of the idea such that it culminates in practical action. These authors, in referring to Klopfer's (1971) categories, contends that perception (awareness) and knowledge (cognition) do not necessarily transpose to attitudinal and value change; neither does an attitudinal position guarantee adoption and practical action.

Participants' knowledge, attitudinal, practical (behavioural) positions are elucidated in the following section.

4.6.2 IKS intervention with teachers

The intervention was aimed at investigating the effect of the argumentation programme on the attitudes of participants in the DAIM programme towards IKS, and identifying whether they had progressed beyond knowledge to attitudinal transformation evidenced by relevant practical activities. The main question, "What narratives can you tell about your experiences and your evolving stance (position) on implementing the curriculum mandate to integrate science and IK in the classroom?" engenders three analytical strands; the initial, current stance on IK, and personal experience of the DAIM. Hence, the three-fold agenda of the report and discussion is to:

1) Document initial and current stances of participants about IK and about Science-IK integration (as required by the curriculum)

2) Identify concerns about a Science-IK integration process, and the trajectories of self-argumentation, and internal debates that arise from those concerns

3) Decipher how participants portray a progression in stance from awareness, to knowledge, to attitudinal and values change, leading to a willingness to engage in practices contingent with the new stance.

This part research question reports the narratives of sixteen participants in the DAIM programme, detailing their initial stance (disposition/attitude) on first contact with the DAIM and introduction to IK for science classroom, using argumentation as a tool. According to Mezirow (1997), change in deportment necessarily results from critical encounters such as the DAIM programme. Such encounters usually lead to the acquisition of new paradigms of thought and action. These authors contend to highlight the process of change; the factors influenced the change and the current stance and course of action expressed by the participants' knowledge.

Using CAT as analytical lens

Toulmin's (1990) Argumentation Pattern (TAP), provides structure to the argumentation process by proposing a framework for discourse whereby discussants with different viewpoints about an issue involve themselves in and structure a discussion systematically (Ogawa, 1995). TAP sets the stage for articulating and presenting ideas while others listen and reflect on the assertion/claims and reasons offered for the claims (Ogunniyi & Hewson, 2008). The goal of argumentation is to establish the validity of claims presented through well-reasoned or well-grounded arguments. The aim is not to win a case (Leitão, 2000), but to clarify misconceptions and reach a state of mutual cognition or possible consensus. When distinctly different ideas come together they are likely to repel each other (Ogunniyi, 2004) first, then an internal argument or self-conversation, occurs at the micro-neuro-psychical level, as competing schemata of thoughts arise in the memory; assumed to be the most active center of consciousness (Ogunniyi, 2000), through which an individual navigates the contexts of daily encounters. This process of internal structuring, restructuring, brainstorming or intra-locution is an active engagement with one's embodied experience. It involves a series of dynamic interactions of the non-logical metaphysical, logical-empirical and rational elements of the mind (Ogunniyi, 2002, 2007a; 2007b). When a person is faced with new concepts, while deciding whether to accept, reject, adopt or admit the new concept, he/she attempts to seek areas of cohesion as ideas coalesce into a deeper level of understanding than was previously possible (Ogunniyi, 1997).

This dynamic process of finding a meaningful state of co-existence for conflicting ideas was categorized into Ogunniyi's five Contiguity Argumentation Theory (CAT) cognitive "stances" (see Table 4, chapter 2): 1) **Dominant** –An idea is overwhelming because it conforms to acceptable social norms, identity and standards 2) **Suppressed** – A suppression of an idea because of a more valid, predictive, empirically testable or dominant norm. 3) **Assimilated** – In this state, the less powerful idea capitulates or is sub-summed by the dominant or more adaptable one. 4) **Emergent** – At this level, a completely new knowledge emerges as the prior knowledge was never in existence or either deemed untenable. 5) **Equipollent** – At this point, two competing ideas are embraced comparably on equal cognitive level, such that they co-exist without any dissonance (Ogunniyi, 2007). Notably, there is no absolute stability within cognitive stances. However, the new information does not necessarily result in a significant modification but a coexistence of prior and new conceptual stance.

Intervention with teachers

In 2016, during the research period, sixteen of the current teacher participants, who had been exposed to the DAIM programme and, had been afforded the opportunity to use argumentation as an instructional strategy for SCIKQ, were given six questions which were deemed useful by the researcher in generating a reflective diary about their experience of the DAIM programme. Research question four only explores the first of the six questions in the inquiry: *"What narratives can you tell about your experiences and your evolving stance (position) on the issue of implementing the Science-IK curriculum or integrating science and IK in the classroom"?* The written narratives were carefully scrutinised, and in the process organised into initial and latter stances, noting any reported changes in knowledge, attitudes, and practices. The researcher is aware of the limitation of surveys in providing the reasoning behind the responses, and thus a three-scale survey with six questions was administered in addition to the *reflective diary*[2]**.** This survey generated richer data that revealed the participants' thought processes, their progression from knowledge acquisition to attitudinal change, leading to valuation and commitment to action (practice) as outlined by Klopfer (1971). It also revealed underlying concerns about Social and Cultural Indigenous Knowledge Questionnaire (SCIKQ). Mixed quantitative and qualitative methods were thus adopted. Simple 'frequency' diagrams (tables and graphs) are used to depict the results. Simple proportional statistics are used to show participants' shift from initial awareness/attitude to changes thereof. For anonymity, pseudonyms were assigned to participants. A dialectic discussion around notable statements that revealed participants' progression from initial attitude to personal valuation, followed by action (practice) is presented. The study explores the participants' epistemology (personal knowledge), axiological (values that determine

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2

Do you openly portray that you hold a favourable attitude towards IK and the integration of IK with science?

- Do you accept that science and IK integration is the best way to develop learners' interest in science?
- Have you adopted the attitude of always promoting the integration of science IK?
- Do you enjoy the science integrated with IK approach to science education more than the conventional approach?
- As a science teacher, do you find yourself having a maintained interest in IK-science related activities?
- Have you developed interest in pursuing a career as a consultant on IK-science related instructional practice?

sensitivities), ontology (effect of knowledge on personal attitude), and progress in attitudinal (affective) competence towards practical action.

Discussions and findings of SCIKQ

Participants' initial and current stances were categorised into three attitudinal positions: negative stance, positive stance and oblivious of IKS. Table 29 shows the analysis (number/percentages) of the initial and latter (current stance of participants in terms of positive stance, negative and oblivious stance towards IKS as a valid knowledge area).

Table 29: Participants' initial and current stance to Indigenous Knowledge (IK)

Attitudinal position and number of participants	Initial Stance (%)	Current Stance (%)
Positively disposed to IKS (4/16)	**21%**	**100%**
Negatively disposed to IKS (10/16)	**53%**	**0%**
Unaware /Vaguely aware of IKS (5/16)	**26%**	**0%**

Initially five (26%) of the sixteen participants were unaware of IK. Ten out of sixteen (53%) were negatively disposed to IK and four (21%) were positively disposed. Naturally three of the four who expressed a positive stance to IK from the beginning and are DAIM committed. They remained adamant about IK's contributions to modern science and insisted that better performance in science would result from using argumentation to link and integrate science and IKS. They who initially expressed a positive stance, disclosed:

> *I valued the role ...before modern science ....became common, ... the role that "herbal remedies ... remedies played in communities ... to treat ...common ailments.* (T02).

> *I always felt that the traditional methods of food preparation, agriculture, architecture, medicinal plant use, use of certain chemicals for different purposes, e.g. minerals for softening food and purifying water, were useful in helping learners to relate science to social life and traditions.*(T01)

When facilitators' responses were exempted from the data set, a completely different picture emerged. Negative stances towards IK increased from eleven out of sixteen; hence, negative stances were 69%, not 53% (a 13% increase!). Combining the negative responses with responses of naivety or unawareness, the percentage of participants who needed a change in stance at the inception of the DAIM became sixteen out of sixteen (100%). That means all the teachers came into the project with negative notions of IK. The various reasons given for their initial negative stances towards IK included perceptions that IK is inferior or simply untenable because it does not value or stand up to testability, and their view of science as the superior, ultimate form of knowledge. Perceived as some kind of witchcraft, they viewed all IK as weird, abstract and tied to superstition. Others neither knew about IK, nor did they understand it, thereby lending credence to the observation of Warrens (1989; 1991; 1992) that most people hold discrepant views of IKS as a valid form of knowledge. However, IKS does no simply involve metaphysical realms of operation; these knowledge systems consist of processes, practices and procedures that are tangible and trialled, as is the case with modern science. The DAIM and SCIKQ enlightened participants about the legitimacy of IK and served as critical encounters that led to personal transformation, as theorised by Mezirow (1995).

IK and its integration with science

Thus, after going through the process, none of the participants reported a negative attitude towards SCIKQ. Table 30 depicts both the participants' initial and latter notions about SCIKQ. All participants (100%) now avowed IK as a tenable and legitimate body of knowledge. None was sceptical of the feasibility of linking IK and science.

Table 30: Participants' latter/current stance towards Science and IK integration

Attitudinal position and number of participants	Initial Stance (%)	Current Stance (%)
Welcomed IK integration with science	**32%**	**100%**
Sceptical of possible IK link to science	**10%**	**0%**
Against IK integration with science	**58%**	**0%**

Participants, in providing deeper insight into the factors that influenced and facilitated their change in stance, mentioned the interactive engagement with theory and practice during the DAIM, reporting that it illuminated their conceptual frame of mind and empowered them to implement the argumentation method in their science classrooms. Most participants had moved to the equipollent stage of Ogunniyi's CAT, as revealed in the following disclosures:

> ***T011:*** *At first I didn't have much information about this issue, so I didn't value it. In the process of interacting … rigorous sharing ideas … I have participated, and even implemented it … I strongly support the integration of Science / IK … I value it as a viable project, whose implementation is long overdue.*

> ***T07:*** *I never thought of any science in IK. … I … began reflecting on the practices of my people and saw that many of them were in fact congruent with science.*

> ***T09:*** *I thought that cultural knowledge was less important than Science and … IKS a type of witchcraft. These workshops are so valuable to me … made me realize … how precious IKS is and how I nearly lost my valuable experience of learning Indigenous knowledge from two cultures (black and coloured)at a young age. Science deprived IKS of its value.*

> ***T010:*** *Everything was weird because it was my first time to hear about it.*
>
> *I began to understand … only recently, did I realise the values and richness in traditional practices. The exposure to argumentation has changed in me ways I look at everything around me, dialogue, etc. …I am quite passionate to see this succeed…I am becoming more critical now and I can express myself better without being offensive. It sounded foreign but interesting.*

> ***T013:*** *Felt that IKS and science were two different knowledges … almost impossible to combine the two. Science … is usually taught as a product. But … My understanding grew ... modern science … just a conglomeration of knowledges adopted from indigenous people all over the world. …. science had many shortcomings … IKS … had advantages … it focused more on the ethical and socio-scientific … not influenced by greed and commercialization which mars the orthodox science ... This … convinced me that there was a real need to mitigate by … integrating the two … to enrich our experiences of the world.*

> ***T08:*** *Working with people … from different communities has given me insight into perspectives on IK that … questioned my western views … taken me out of my comfort zone to explore alternative ideas…, particularly issues of a socio-cultural nature. Argumentation …a strategy to*

initiate discussion and reveal … cultural perspectives … alternative ideas about science … Very illuminating.

T015: *I was not so fascinated by IKS at all I have now reached a level where I am confident of integrating these two worldviews harmoniously.*

T016: *From zero understanding … to the realization that modern knowledge has as its origin in … simple practices that were common …"IKS" … was a way of living … should be today also.*

T04: *Discovered in practical ways, how contiguity argumentation can be used in the classroom. Opened my eyes … argumentation is the most appropriate vehicle for achieving the mandate to integrate science and IK.*

Internal debates about the Science and IK integration

Sixteen of the sixteen participants who wrote the reflective diary responded to a second set of survey questions. Eleven of them gave deeper insights into their cognitive states of mind (self-argumentation) experiences concerning the feasibility of propagating IKS. The second survey helped to elicit participants' progression from awareness to knowledge acquisition, leading to attitudinal change and an adoption of new values and modes of action. Most of those participants who changed their stance positively are still concerned about the impediment before SCIKQ. The fact that some of the participants who earlier reported 100% positive disposition to SCIKQ still carried burdens concerning IK attests to Ogunniyi's CAT theory that argumentation goes on in people's minds. It is therefore not surprising that 50% of participants could not categorically say that they had maintained interest in IK-Science, that they would devote themselves to promote SCIKQ or that they enjoy IK-Science more than traditional methods. Response to the first four questions, meant to probe progression of change, showed that participants who tentatively responded, "somewhat", are almost equal to those who positively responded, "very much".

Their seeming scepticism is probably due to their concern about the prevailing negativity among teachers and learners about IKS and the difficulties such might arise in implementing IK in South African schools. For example, while T07 started out being sceptical of IK, he later embraced the idea, but is still bothered with the impediments to IK implementation. He does not see himself living to propagate it:

T07: *Science-IK integration can develop learners' interest, but … the modern technology … has swept the world … the young generation. … Interest in IK is small; and many people …view IK [as] backward-looking instead of forward…*

> *I have not made up my mind to definitely pursue a career in IKS-related practice … I don't know if it would give me an enviable place in the job market … my country is not much into [IK. They] focus … on getting western modern technology.*

T07's self-argumentation seems unclear in terms of CAT. Obviously, for economic reasons, he is not ready to stake his future on propagating his conviction through a related career. T014, T012, and T05 registered the following concerns about IK-Science:

> ***T014:*** *I do embrace SCIKQ, however … it has lots of challenges and hindrances … lack of teaching resources, an exam orientated curriculum, lack of professional development programmes.*

> ***T012:*** *I firmly believe that … IKS curriculum is the way forward, but we are still a long way to implementing …. It would mean revising the current RNC [to] put more emphasis on prior knowledge, critical thinking … rational learning …. I am 100% in favour … the curriculum isn't. … a lot needs to be done.*

> ***T05:*** *Learners come … with diverse knowledge systems,… Acknowledging the[ir] IK … makes it easier for them to connect [with] science. Currently many teachers do not teach IK … they don't know enough or anything about IK, … it's my duty to inform my colleagues… with skills and knowledge I've gained … I can train and support teachers to implement IKS.*

T05 and T012 seemed resolved to propagate IK, but T05 spoke about her concerns.

T08 thought it important to capture and preserve IK practices and integrate it with science, and T06 was convinced of the value of IK. However, T03 seemed anxious that the "knots and bolts of science" and the inherent nature of science should be preserved because it drives the economy:

> ***T08:*** *I have an abiding interest in the IKS of South Africa's diverse culture. …it is vital to capture what remains of the existing cultural and medicinal practices, stories, proverbs, language nuances … before they disappear forever as the elders [with embedded knowledge] pass… on. One … way of capturing this knowledge is argumentation … learners [can] feel comfortable … and proud of the everyday cultural knowledge they bring from home. ….appreciate IK's… contribution … [its] parallels with … scientific knowledge not … a dichotomy opposed to modern science but … different … equally valid.*

> ***T03:*** *IK lends itself to contextualising science, making it relevant and finding coherence witheveryday knowledge. IK should not … replace the nuts and bolts of science. Science is … what drives the economic-business-technological world. … Acknowledgement and respect for an IKS …would bring … ownership and participation from indigenous peoples*

> ***T06:*** *I am fully convinced that Sciences and IKS need to be integrated…. IK recognition … given … At this stage I am now confident to teach, plan and design materials for SCIKQ. I am guiding and supporting my colleagues … on how to teach, integrate and plan their lessons.*

T06, disclosing aspects of the DAIM course she deemed to serve as catalysts for change in stance and the acquisition of argumentation skills, was of the view that "demonstration lessons …and feedback …given by the other members and… materials … developed at the workshops … gave better understanding on how to design materials/activities for the learners".

> ***T02:*** *In the beginning it was important to isolate the different types of IK – metaphysical [and] practical – … looking at integrating science and IK, … it is important to isolate IK practices which have a practical "empirical" application and compare that to the modern science application. Through this, value can practically be seen and experienced, and thus place it almost on par with each other. Although …IK …might seem cumbersome,… time consuming and …science … efficient, it …show[s] how modern science conceptions and applications have …indeed been based on IK conceptions, … nature of science processes …building on the known, and … progressing … into what we today understand as …modern science conception.*

The view expressed by T02 encapsulates the views of most participants about what they discovered from the DAIM and the SCIKQ project, about conceptualizing the metaphysical aspect of IKS and its practical/empirical nature that correlates with the NOS.

Concerns about IKS integration

The context in which a person is embedded largely influences what is internalised and practised by that person. Participants in this study were all education practitioners and thus positioned to present the views of learners and teachers among whom they practice their profession. This would explain their reservations about IKS in their reports and views about the way traditional science education is embedded in presentations of science as an unquestionable and unquestioned body of knowledge. This, they fear, may prove inhibitory to the acceptance of IK by learners and teachers as valid/legitimate and valued knowledge; hence, their anxiety about the feasibility of IKS.

4.7 Brief summary of Research Question 3

This analyses of the results presented in this chapter were formulated around the research questions. All the participants started off either ignorant of, or opposed to, either or both IK and IK-Science integration. After attending the DAIM sessions and workshops the teachers in the sample experienced a change in stance about IK. They also had the opportunity to acquire the necessary skills to integrate IK-Science through argumentation. Although a hundred per-cent change in stance was recorded amongst the sample of teachers in their reflective diaries about their experience of the DAIM programme, a further probe, using a three-scale, six-point, survey instrument, provoked more disclosures specifically about participants' concerns about the feasibility of convincing teachers and learners about the value of IK and to be open to adopting argumentation as a socio-culturally relevant teaching strategy. Some participants opined that the curriculum itself needs further revision and that teacher development should be mandatory for a widespread socio-culturally relevant practice using argumentation as a potent tool for IKS in the classroom. It is pertinent to note that the admissions all of the sixteen participants reveal that, subsequent to the DAIM course and SCIKQ, they could be said to have reached the equipollent cognitive stance described in Ogunniyi's CAT in respect of IKS.

4.7.2 Teachers' attitudes towards the integration of school science with IKS

4.7.2.1 Teaching and learning opportunities and challenges posed by the integration of IK in the school science lessons.

- **SCIKQ and DAIM interventions**

Key characteristic and distinctive aspects of the two interventions, the challenges and opportunities they presented during the course of the observations are as follows:

- The SCIKQ approaches seemed to be a good teaching and learning strategy geared at assisting teachers to have a uniform approach that is easily evaluated. It also helps teachers to focus and not to deviate from the key concepts specified in the syllabus. In this regard, the SCIKQ approach does not need a lot of prior lesson preparations and can accommodate less experienced teachers with less subject content knowledge as much guidance is given within the textbooks and the subject guideline documents.

- On the other hand, the DAIM approach showed that it is an approach that needs teachers to be well trained and knowledgeable in the subject. The DAIM approach needed more time for lesson planning and resources preparation. Once these had been done, it showed that a large aspect of the syllabus can be covered in fewer lessons as duplication of concepts across various areas of the Physical Science syllabus are visited simultaneously. This seemed to have given the DAIM more broader understanding of the concepts in unfamiliar contexts.

- The DAIM approach has shown that various teaching and learning aspects such as language barriers, teaching and learning across the curriculum and the various categories of the specific aims which are normally dealt with on an individual basis can be infused in one lesson or a number of lessons in a sequence so that learners can develop a holistic rather than a dichotomized or compartmentalized view of knowledge.

- With regard to language and terminology issues, the SCIKQ groups prioritized on English and underrated the effects of language barriers in science teaching. Implications highlighted undesirable unsystematic code switching practices which resulted in transliterations having no cognitive meanings but only served as placeholders to cover up for the teachers' language deficiencies.

The SCIKQ and the DAIM teachers' experiences

Observations in relation to question 1 for the teachers' reflections on their perceived relevance of IKS in the school curricular, the following main observation from the above is made:

- With respect to the opportunities presented by the IK-science integration efforts by the three teachers in their respective interventions show a common theme with regard to the their perceived relevance of IKS in science teaching; that is, 'examples about how everyday knowledge could be used to illuminate on classroom based scientific concepts.' (Teacher T09 paraphrase)…can create interest in IKS, and that argumentation led to deeper understanding of science as well highlighting of commonalities between science and IKS (Teacher T013).

In this regard, various challenges were cited by the three teachers in respect of their perspectives on the integration of science and IKS. Findings in this regard show that:

- The excerpt from the three teachers (both SCIKQ and the DAIM) seemed to suggest that training in respect of IKS integration seemed to be a challenge. Challenges included, 1. clarity from curriculum policy documents on strategies for how to stimulate arguments in classrooms while keeping up with the syllabus, 2. Limited knowledge about IK exemplars and learners having no clue as a result of no IK supporting materials, 3. Finally, no workshops conducted in respect of IK training coupled with IKS materials.

Observations in relation to question 2 on the teachers' experiences in using their respective teaching strategies in attempting to integrate IKS and school science showed that:

- In order to attempt integrating IKS within their science lessons, the traditional teachers had to think about the importance lesson planning for creating IKS exemplars (Teacher T09) and group work was also important to get learners to discuss IKS (Teacher T013).
- In her attempt in integrating IKS within science lessons, the teacher (T04), stated that argumentation helped her with planning everyday IK examples that could be brought into the classroom; getting all learners to participate first time in her lessons, their understanding of the content at a deeper level and finally, that the DAIM had a potential over time of shortening the syllabus coverage.

The traditional teachers had language problems as learners seemed to use an African language for IKS issues (Teacher T09) and classroom management as a result of long uncontrollable debates and overpowering of weaker learners by the more academically inclined learners.

CHAPTER FIVE: DISCUSSIONS, RECOMMENDATIONS AND IMPLICATIONS

Introduction

In this chapter I provide an overview of the study that summarises the basic research findings, followed by a brief discussion of these and recommendations that have emerged from the study. I reflect on the process and experience of conducting the research, identifying some of the study's limitations including factors that suggest potential diminishing of its reliability, and suggest possible solutions to these, particularly in terms of future studies in the research area. In addition, I look at implications of the findings for educational policy, together with curriculum and instructional practices in South Africa, and specifically in the Cape Flats Region of the Western Cape Province where the site of the current study is located.

5.1 Key Features of Chapter Five

Chapter five will identify particular findings, recommendations and implications that seeks to provide answers to the three research questions. In this chapter I aim to describe, analyse, and evaluate whether the integration of scientific knowledge and indigenous knowledge, as expected by current curricular reforms (Department of Education, 2002), is being implemented by high school teachers in selected school settings within the Cape Flats region. Previous studies showed important associations between the learners' indigenous knowledge and the learning of science (Ogunniyi, 1988; Onwu & Mosimege, 2004).

This chapter further unpacked whether teachers held an adequate understanding of science and indigenous knowledge, and how science and indigenous knowledge could be integrated into the teaching-learning process with classes containing children with a diversity of local religious, cultural, and social belief systems. The following research questions will be addressed:

1. What Indigenous Knowledge Systems (IKS) do the Grade 9 learners' in the sample currently hold, if so, is this connection related to their age, social class or gender?

2. What are these learners' ideas and attitudes towards integrating indigenous knowledge systems (IKS) into meteorological science?

3. What are the challenges that teachers encountered in IKS-and-Science integrated Science classroom?

5.2 General Overview

In Chapter 3, I presented a description of the empirical methods that were used to conduct this research. I further elucidated the research study strategy, which is the mixed sequential explanatory strategy and the selection of this approach was justified. The appropriateness of the instruments to respond to the research questions was also discussed. A detailed description on the process of data collection, its analysis, as well as the interpretation thereof has been presented. A brief discussion on the validity and reliability of the study were presented to ensure that the instruments measured what I intended them to measure.

In the chapter 4, I presented descriptions of the research findings on learners and teachers' perspectives on IKS, their concerns, and the practices regarding current reform efforts in the Helderberg Basin of the Western Cape Province, South Africa. These include the data analysis and their interpretation from the two phases, e.g., interpretation and understanding of IKS integration into the Natural Science curriculum from the grade 9 learners' viewpoint and the high school teachers' perspectives on IKS as curriculum implementation of the study. I also describe my experiences in the interactions with teachers in the Helderberg Basin. In my descriptions, I ensure that these teachers' experiences are described in the best way possible to give a vivid picture on what is happening in the classrooms pertaining to IKS curriculum implementation, as well as what goes on in the teachers' minds. Thus, through the data analysis and the interpretation thereof, I synthesise how the study responds to the research questions.

5.2.1 Discussion base on research question 1 (RSQ1)

RSQ1: What Indigenous Knowledge Systems (IKS) do the Grade 9 learners' in the sample currently hold, if so, is this connection related to their age, social class or gender?

A. The role of socio-cultural background on learners' conceptions of weather prediction

- There was a significant difference between the boys' and girls' pre-test conception about the existence of indigenous knowledge systems within the community they currently live in. This was further verified using the t-test for independent groups. The learners' excerpts suggested that the girls presented predominantly rural experiences as opposed to those of the boys which were predominantly from urban settings.

While there has been no significant difference between boys and girls in the whole study, the above findings suggest that there may be particular school science concepts that are more amenable to either one of the gender group. As opposed to learners from westernized backgrounds where there is a general homogeneity among gender groups, boys and girls may be predisposed to certain kinds of indigenous knowledge. For instance, whilst there may be areas of commonality between girls and boys, areas of difference are also possible. For example, Rich cited in Baker (2007) argues that the concept of co-education is a misleading one since it presupposes that because girls and boys receive the same instruction in the classroom, they are therefore automatically receiving the same education. This is also true for the Apartheid South African context where black women were not sent to school and their roles were to be wood gatherers while boys were to go to school to secure better jobs in order to sustain households.

Social and cultural relevance is directly linked to IKS where various groups are custodians of various indigenous knowledges (Diwu, 2016).

- 76% and 70.8% proportions of all learners who respectively disagreed and strongly disagreed to the notion of scientism were from the rural areas and the chi square test shows that this was a significant result. The Pearson chi square test gives a significance value of $p = 0.497$. However, the t-test for comparing the boys to girls on scientism revealed that the two groups were comparable with M = 2.65 and M = 2.67 for boys and girls respectively where $p = 0.930$ and t ratio = -0.088.

The above results which suggest that learners who are from urban contexts are highly likely to be prone to scientism are not unwarranted. Since people who live in the urban areas are largely dependent on buying almost everything and on technology for survival, it is therefore not unrealistic for them to attribute everything to science. As the findings have revealed, this is irrespective of gender.

These findings are supported by Ogunniyi (2004) who noted that, "…the mass dislocation of human population in the colonies from their familiar environments for trade, commerce on administration purposes and consequently the loss of indigenous knowledge and skills developed over centuries." (p. 290). Furthermore, the Department of Education (DoE, 2002) has also echoed the above sentiments when it stated that colonisations over a very long time (over 350 years) resulted in the loss of indigenous knowledge systems thus creating a dependency of western worldview thinking. In the meantime, despite the scientism tendencies brought about by the latter, the school science has not been able to bring complete solutions to societal ever growing problems; instead incurred a lot of disillusionment (Hodson, 2011; Jegede, 1997). Finally, it can be concluded that the socio-cultural background of learners as a context does play a role in the learners' awareness and understanding of the nature of science (e.g., Enderstein & Spargo, 1998).

B. IKS and the Dialogical Argumentation Instructional Model (DAIM) combination has several potentially beneficial implications for classroom pedagogy:

- First, it adds further emphasis and validity to the significance of findings that alternative misconceptions of IKS must be addressed if students are to gain secure understandings of scientific concepts. Teachers need to be aware that lowering the likelihood of false positives (alternative "wrong" ideas) is as instructionally powerful as raising the likelihood of true positives (the "correct" idea). Teachers need to be familiar with what they want to achieve in the classroom and undertake proper planning to achieve the desired outcomes.

Second, if learning does indeed occur through an argumentation-like process of data weighing and integration, constructivist notions of knowledge acquisition is reinforced. From this perspective, simply providing the 'correct' answer is not sufficient. Learners must be given - or provide - evidence to support a claim and be allowed to grapple with assessing other views in order to properly update their belief assessments. Specifically, acceptance by learners of new concepts is a function not only of how well the teacher presents the case for a new idea, but also the extent to which they address the strength of the learner's misconceptions. For learners with strongly held claims, it may take multiple exposures to evidence to change their beliefs. The DAIM model suggests this process is normal, even when the learner is evaluating the evidence rationally. Therefore, even if a student does not initially accept a new concept, instruction can still be considered a success as long as the learner is more open to the idea, and to evaluating a concept using evidence - than they were initially.

Perhaps most fundamentally, this account of scientific reasoning from a dialogical argumentation perspective offers a rationale for why argument and critique are central to scientific activity (Diwu, 2016). If, as suggested, beliefs are transformed not solely by confirming evidence but by negating alternative evidence, it suggests a central role for the critique of the construction of knowledge both for the scientist and the learner of science. It also suggests why the few merchants of doubt who wish to cast aspersions on the scientific evidence for climate change have been so successful. A dialogical argumentation perspective would suggest that the case for climate change would be made much more successfully, not by asserting the validity of the scientific evidence, but rather by undermining the validity of the naysayer's case. On the other hand, knowing why the wrong answer is wrong matters as much as knowing why the right answer is right.

5.2.2 Discussion based on research question 2 (RSQ2)

RSQ2: What are these learners' ideas and attitudes towards integrating indigenous knowledge system (IKS) into meteorological science?

A. Teaching strategies to foster cognitive harmonization in classroom group discussions strategies

- While the performances of both groups had significantly improved after interventions, the cognitive stances by the majority of the E-group learners' shifted from initially being equipollent to those that are school science dominant. The lack of connection between the C-group learners' pre-test and their post-test suggest that their IK worldview was suppressed in favour of the school science worldview. As opposed to the E-group, those exposed to the DAIM intervention shifted from being predominantly equipollent to the school science to emergent cognitive stances. The learners' explanations exhibited IK internal principles which were linked to that of school science using observable predicates that allowed them to make sense of the school science claims.

As has been shown, most of the scholars (e.g., Ausubel, 1968; Campbell & Lubben, 200; Chiappetta et al. 1998; Enderstein & Spargo, 1998; Hamza & Wickman, 2007; Mohapatra, 1991; Nuno, 1988; Yip, 2001) who have been interested in the learners' preconceptions have done so largely from a perspective of changing the learners' IK worldviews into that of school science. As suggested by (Feltham & Downs, 2002; Jegede, 1996), the learners' preconceptions are largely seen as stumbling blocks in the path of scientific indoctrination and hence need to be changed. These observations have been prevalent among the E-group learners who seemed to have abandoned their IK worldviews in favour of the school science worldview.

While it is almost impossible to replace the learners' beliefs with the school science worldview (Gunstone & White, 2000), the observations of the E-group learners' cognitive shifts are typical of coping mechanisms that learners use as a result of the dominance of school science. In this regard, as Jegede (1997) and Tobin and Garnett (1988) have suggested, traditional teaching approaches like the traditional teaching methods usually lead learners to adopt rote learning strategies. This means that the learners learn the tricks of mastering the school science explanations without having to believe any of them (Jegede, 1996). When situation occurs, we can thus assume that the IK explanations are seemingly incompatible to those of school science and the learners' underlying cognitive stances may be regarded as divergent.

In contrast to the above, the majority of the learners exposed to the DAIM retained their IK presuppositions, but seemed to have found a meaningful point of connecting their IK to school science (Ogunniyi, 1988). The DAIM model of teaching has caused learners to predominantly draw their inspiration from IK internal principles, but used bridge principles to make sense of school science internal principles.

Without the understanding of IK internal principle, it would be almost be impossible to understand how learners connect two distinct worldview presuppositions. As other scholars (Marin et al., 2001) have noted, learners' explanations of scientific concepts '…might be unlinked to the content in an adult scientific logical sense'… and yet '… linked for the student.' (p. 685). In other words, the DAIM-model seems to have enhanced the learners' understanding of the relevance of IK and how its underlying scientific claims relate to that of school science (Kelly, Carlsen & Cunningham, 1993; Ogunniyi & Ogawa, 2008). The observations for the DAIM exposed learners are thus consistent with what Vygotsky (1978) would call transversing the zone of proximal development or as what Ogunniyi (1997) later had called an emergent cognitive contiguity.

The implication suggests the importance of ameliorating the distorted notion about IKS and school science in the extant literature (Aikenhead & Jegede, 1999). For instance, as Ogunniyi (1988, 2008) has alluded, dichotomy of IK and science only exist in the minds of teachers since learners themselves live happily in both worlds. Various other scholars (e.g., Gunstone & White, 2000; Hewson & Hewson, 2003; Marin, Solano & Jiminez, 2001) share this view.

B. Instructional viewpoint from learners to use DAIM in class

The unfamiliar practice of DAIM as a teaching and learning strategy came as a surprise to many learners who only started to like and enjoy the method after their understanding and familiarity was developed and increased in the process of their involvement with the research study. Most learners were confused by a new teaching practice that allows a form of argumentation, rather than a chalk and talk practice, during class sessions. This would indicate that argumentation practices are not commonly used by teachers, at least in this school, and likely not in others either. In considering the benefits of an argumentation-based approach in terms of aiding conceptual understanding of, and integrating, science and IKS in this case, the promotion of argumentation-based instruction should be investigated.

C. DAIM also addresses the shortcomings of alternative frameworks for scientific reasoning

What implications does dialogical argumentation have for the practice of science education and instruction? From a curricular perspective, one immediate implication is that, if individuals are to behave rationally and responsibly, they need to see judgments about data and evidence as being an assessment not only of the probability of the hypothesis being correct but also of it being wrong. Such evidence is essential to making an assessment of the Contiguity Argumentation Theory and Toulmin's Argumentation Pattern. Within the field of argumentation, Erduran and Jiminez (2007, p. 48) report that "a significant body of argumentation literature in science education has been based on Toulmin's work". From this is could be argued that dialogical argumentation could be used to provide a mathematical structure to Toulmin's model for argument. I would argue that this sort of argumentation instruction is likely to be particularly useful for students entering scientific research and practice. In this way, DAIM can help bring increased use of statistical reasoning into real-world applications.

D. DAIM can also be taught as a model for the reasoning processes of science.

Highlighting the importance of scientific reasoning, for instance, can improve awareness and identification of common pitfalls in logical reasoning in the classroom. Learners become more aware of the type of answers required to be given in tests and classroom discussions. Learners will consider whether a common answer can be supported by valid evidence and support to substantiate the claim in context. According to Kuhn (2009), for students to argue more effectively, clear instructions must be provided in class and thus educators require professional help and guidance in argumentation and ground rules must be established that guide and assist both the learners and the teacher participating the argument and that ensure they get the most out of the exercise (Kuhn, 2009).

E. Using own experience in classroom to design and enact policy of integrating science and IKS

It would be very difficult for teachers who are used to the traditional chalk and talk method of teaching to implement a dialogical instructional method in their classroom without any prior training in the DAIM instructional model. Thus, it was a huge challenge for me as the researcher to plan and design various lessons – using the DAIM model as teaching strategy - that coincide with the integration of science and IKS.

5.2.3 Discussion based on research question 3 (RSQ3)

RSQ3: What are the challenges teachers encounter in IKS-and-Science integrated Science classroom?

A. In-service teachers' (ISTs) construction of an argument

The argumentation-based instructional model was found to be effective to a certain extent in equipping the ISTs with the necessary argumentation skills that could enable them to take part in a meaningful discourse. The majority of the participating ISTs seemed to have the basic skills of constructing every day, socio-scientific and scientific argumentation. In the three tasks, they were able to: (1) provide evidence (data) to support their claims; (2) connect the evidence with the claim (warrant). The findings also showed that some of the ISTs constructed lower level arguments when engaged in argumentation on scientific scenarios, unlike when they engaged with day-to-day issues or socio-scientific argumentation. This finding is consistent with earlier studies in the area (e.g., Durant, Evans & Thomas, 1989; Xie & Mui SO, 2012). The latter studies indicated that in-service science teachers demonstrated low level of argumentation in scientific scenarios compared with their daily argumentation.

The findings further showed that the ISTs' ability to argue improved considerably as they went through many discursive activities, as indicated below.

- Some ISTs who did not offer evidence for their claims at the initial stage of the study were able to do so as the study progressed. However, only a few ISTs constructed arguments with rebuttals.

- Initially, both in the small groups and the whole class discussion, the participants tended to focus entirely on their own arguments and failed to attend critically to their opponents' arguments. Later on, most of the ISTs were able to listen to each other's arguments and to respond directly to each other's arguments so as to weaken their opponents' arguments. In other words, they demonstrated a greater skill in generating rebuttal.

- It was also observed that the group members who hold oppositional views made no attempt to dominate the discussion; rather, they provided appropriate evidence to justify their claims and attempted to use persuasive language to convince the group members who initially argued against the claim. As a result, some of the group members who initially argued against a particular claim were able to change their mind. The implication is that overtime the ISTs began to understand that opposition between the views of arguers during argumentation does not necessarily mean opposition between individuals.

- Compared to individual's arguments the collective arguments of the groups comprise of several claims and counter-claims supported by data and warrant. It is worth noting that some of the ISTs who were unable to construct arguments with rebuttals at individual level were able to generate arguments with rebuttals during the small and whole class discussion.

We can now conclude that there are too many IK practices according to different cultures making difficulties to choose which IK to use and which to leave out. IK is time-consuming; information on IK is often not documented or not readily available. Teachers lack models to emulate and appropriate teaching strategies to effectively handle science IK integration. The curriculum lays emphasis on scientific content knowledge coverage, leaving no room for IK. Some teachers believe that certain IK issues should not form part of the science curriculum. Some teachers have the perception that IK is outdated, degenerated, demeaning, and not in synch with modern or current thinking.

Still, the question at hand is: *If teachers themselves face such challenges, will learners be more motivated to desire the integration of science and IK, especially in a rapidly changing technological age?*

The multicultural debates are linked to other debates in science education aimed at inclusion, such as the constructivism approach, 'science for all', and SSI initiatives, which can improve the learning and achievement in science of a wider range of students. "However, the failure of science education research during these times was in not taking culture, language, 'race' or colonization as major factors in any of the projects" (McKinley, 2005, p. 230). This is despite that fact that a number of indigenous writers have argued for the importance of connecting school science education to the students' cultural background (Cajete 1995; Kawagley, 1995; Kawagley & Barnhardt 1999; McKinley, 1997). Making the connection to the cultural background can be done in two different ways, both of which are the foundations for place-based curriculum: 1) making science 'relevant' to the student, which usually involves teaching in culturally relevant contexts or everyday science, 2) using culturally responsive teaching or culturally based pedagogy (see Bishop & Glynn 1994; Ladson-Billings, 1995).

B. Teachers' views to compartmentalize two worldviews

It has been the experience of the researcher that the teaching strategy teachers have long used and with which they are familiar, is usually the old "chalk and talk" method of teaching. Many appear to have created a sort of comfort zone over the years, one in which they feel no need for change. If these teachers concede and agree to curriculum change, they have to learn new things and record and gather new resource materials. This can prove to be too much to adapt to at their age and stage in their careers. In cross-conversation with teachers it was not difficult to sense their unwillingness to adapt to the new curriculum and teaching strategy; there was also a sense that, for DAIM to be more or less successful, one needs to somehow reduce the fear of change that, according to the perception of the researcher, currently resides with most public school teachers (Spaull, 2013).

Challenges to implement DAIM in the classroom

Some of the challenges that emerged from the findings of the study include the need:

- To promote the dialogical instructional methodology amongst teacher colleagues
- To incorporate additional IKS lessons and interventions with learners who are educationally at risk of repeating a grade or being 'progressed'
- To undertake the necessary science/IKS interventions with gifted learners
- To acknowledge that the literacy and numeracy levels at many schools are low resulting in some learners, particularly those for whom English is not their mother tongue, not being able to read and comprehend. Most of the time instructions have to be read out to learners, and this has an adverse effect on the DAIM intervention in the classroom.

C. Potential benefits for others in the field of lessons learned from the planning and implementing of the DIAM

On reflection, when assessing the approach to instruction in a lesson period, I realized that the time constructs needed to be altered/adjusted so that learners could do more and be more active and the teacher reduce instructional/"teacher talk" time. During the research, it was discovered that the majority of learners do not complete assignments at home. Further qualitative research in the form of interviewing these learners indicated that they are faced with a lack of parental supervision, lack of research facilities, and overcrowded households. After much consideration, and in order to elicit better results and better performance, I ascertained that the instructional time should be reduced to 15 minutes and that time on task should increase to 45 minutes. What I discovered was that, in changing this instruction/time on task ratio, the learners automatically have more time to discover, rather than attempt to passively absorb, scientific concepts through a more hands-on approach during practical sessions. I have realised that grade 9 learners need more to handle equipment in an appropriate, useful and confident way. Learners are no longer actively busy during science lessons due to an overwhelming "talk and chalk" and "textbook" teaching approach.

From observations of the lessons in which DIAM was being implemented, I realized that the academic learning time when learners are engaged in individual activities should be extended to 60 minutes. One of the main reasons for suggesting this extension to the academic learning time would be to accommodate those learners who find it difficult to complete their assignments at home due to a lack of facilities and other challenges they face on a daily basis. By extending this time, learners could now comfortably make use of the school media centre to complete their individual assignments during the academic learning time frames. The school management team, in consultation with the school governing body, has decided to earmark money from the annual budget to pay a suitable parent to supervise and to distribute revision activities to those learners who are left without a teacher. This arrangement allows the other teachers to make full use of their contact time without being interrupted by the presence of learners from other grades within their class.

In conclusion, the assertion of the finding that learners held 'valid' or relatively good/accurate conceptions of indigenous weather prediction was based on the questionnaire which was designed and structured in such a way that it was possible to extract 'scientifically valid' conceptions of indigenous weather prediction from the learners' pre-test responses.

The report of results is to be seen in the context of the original questions and combines the descriptive data with the survey data. Where survey and descriptive data (pre-test) were noted, the CAT was applied to inform and describe the types of findings.

This questionnaire was administered two weeks after the survey questionnaire was completed. The same group that completed the survey completed the CoW-IK questionnaire.

5.3 Recommendations

Teaching strategies and classroom practices need to focus on improving learners' understanding and performance. Thus, from the findings, and reflections on this study, certain recommendations have emerged. The first is that teachers plan lessons that are high in the kind of IKS quality and relevance that provide learners with opportunities to engage actively and critically with indigenous knowledge, including disciplinary knowledge, with the aim of improving science problem-solving in the classroom. This would provide learners with a better, more developed cognitive mindset to learn, understand and internalise important science concepts and processes in-depth rather than superficially or from the textbook or chalkboard or teacher talk, and to use these in ways which explain meaning and process, rather than simply reciting or parroting 'correct' definitions of concepts.

Recommendations towards a DAIM supportive classroom environment

A dialogical instructional supportive pedagogy in science classrooms, where learners feel safe to take intellectual risks, is recommended. Using this teaching strategy enables learners to regulate their own academic behaviour and stay on task. Teacher and students are respectful towards each other while at the same time also engaging with the kind of argumentation that draws on the beliefs, values and ways of knowing of different cultures. The DAIM approach facilitates the participation of all students and the building of inclusive science classrooms, together with a connectedness to the world beyond the classroom. This would link school knowledge to learners' home and/or cultural knowledge and to awareness of events beyond the classroom setting, particularly those to do with climate change.

Recommendations towards Curriculum design and Development

For those teachers and curriculum designers contemplating introducing dialogical forms of instruction, it is recommended that teachers should work collaboratively with colleagues. Through a process of discussion and thorough examining of various dialogical instructional strategies, learning activities and curricular materials used in the classroom they could come to look at their and their colleagues' teaching in more structured and creative ways.

To enhance the implementation of CAPS, the following were recommended by the East Metro-Pole District, Western Cape province Social Sciences teachers in terms of integrating IKS with natural sciences:

1. Continuous teacher development targeted at improving natural science teachers' subject content knowledge and pedagogical content knowledge (PCK).

2. Supplying good quality resourced IKS textbooks, posters, and integrated IK-Science materials.

3. Continuous teacher development targeted at improving IKS-sciences teachers' practical knowledge and interpretation of socio-cultural value.

Recommendations towards teacher enrichment research

Experimental or action research from curriculum developers, educational researcher and also teachers can be a worthwhile endeavour for a number of reasons:

- Research and reflection allows teachers to gain confidence in their work by learning about themselves, their learners, their colleagues and their environment.
- The DAIM method requires a lot of time, sacrifice and energy from the teacher but its benefits favour more meaningful and effective classroom practice.

Departmental authorities should invest in developing at least one standard quality textbook per grade. In the course of my research, teachers indicated that the system has numerous textbooks recommended per grade, but none meets the standards required by CAPS and Umalusi. This coincides with findings by Nakedi (2014) who concluded that teachers' efforts to address and fulfil the NCS Natural Science learning outcomes were limited by the poor quality of textbooks. A high quality, informed and up-dated textbook in times of education reform can assist the teacher and learner in meeting the objectives of the new curriculum, especially where new content and new practical exposure to IKS have recently been added to the curriculum.

Recommendations towards designing STEM (Science, Technology, Engineering and Mathematics) activities which enhance learners' understanding of the use and importance benefits of indigenous knowledge systems and STEM

Schools need to invest in designing activities in the course of which learners are able to learn and interact with how weather and geography affects their communities and the wind, solar water energy resources. Learners could engage and experiment with scientific examples, such as solar energy to learn where photovoltaic power (solar panels), and wind energy using wind turbine on wind-farms have the greatest potential. Learners could also investigate various geographic regions in their community, around the nine provinces of South Africa, their climatic conditions and how these can influence solar-and wind energy potential to assist and contribute to the current electricity power-supply demand.

- Learners need to become familiar with the latest wind and solar technology and how to use renewal energy natural resources to tap into a sustainable energy supply.
- Classroom activities and lessons could range from a one period lesson up to a week of lessons, and learners could be assessed accordingly as a group or individually.

Activities could also include lessons where learners would learn about practical aspects of renewable energy, such as using the right type of materials in a home that conserves energy, together with an awareness of the importance of building-orientation and window sizing. Learners would then be able to engage in activities to measure temperature changes in several thermal storage samples. By the end of such a lesson unit learners would have been exposed to and would appreciate the need to plan construction using appropriate materials. They would learn that simple measures, such as landscaping and installing thermal storage, can make a considerable difference to energy consumption.

- Exposing learners to various activities that relate to career opportunities in the field of meteorological sciences, that are in line with the specific aims 3.2 as set out in the Department of Basic Education CAPS (2011) policy statement.
- Research on curriculum implementation should expand in such a way that it informs the design of the next curriculum (Penuel et al., 2009). Hence, it was not contradictory that some recommendations and suggestions that emerged from my interactions with participants in this study only seemed plausible in the context of the next curriculum change cycle.

These included:

1. Recommendations to introduce practical exposure through indigenous knowledge workshops;

2. Introducing practical experimental outdoor educational programmes for *STEM*, based on the idea to educate learners in all four specific disciplines (i.e:- science, technology, engineering and mathematics) – in an interdisciplinary and applied approach;

3. Separating Social Sciences into the two respective subjects: natural geography and indigenous geography (being aware that History may become a compulsory subject in 2030) (MTT, 2018, p. 133).

It is important to point out that CAPS (2011) emphasises that learners carry out individual experiments. This is a positive curricular initiative and idea, but policymakers have seemingly not sufficiently accounted for the extra demands this would have on natural sciences teachers' time and expertise.

Apart from their teaching duties, Natural Sciences teachers are burdened with tasks such as preparing equipment, solutions and reagents for practical geography lessons, in addition to rearranging materials and equipment (Barnea et al., 2010; Mizzi, 2013). These are tasks that in most cases teachers are under-prepared and/or under-trained.

Recommendations towards educational and organizational management:

As mentioned, the findings of the current study suggest a collaborative model: that a dialogical instructional model project be undertaken by a group of people on the staff rather than by each teacher working in isolation.

Another recommendation would be for teachers to engage and work on one problem at a time as identified from the pilot investigation. This could include, for example, the collaborative design of interactive (dialogical argumentative) lesson plans or class activities that focus on the immediate environment and surroundings of the school community. This would promote 'collegiality' amongst staff and learners and would be enhanced by emphasising the following characteristics to be cultivated by teachers: be committed to learners; plan well and thoroughly; respect and recognise learners (and their 'alternative' responses); identify learners' individual and common problems and provide relief through food, clothing, support; focus on solutions; focus on developing skills; focus and reflect on more effective management than was the case the previous day; promote accountability of both teachers and learners.

Recommendations on the use of local IKS in schools:

In my view, indigenous knowledge should be recognised as an important part of the lives of all citizens, but particularly of the poor. It is an integral part of the local ecosystem. IKS is a key element of the "social capital" of the poor; it is their main asset in the struggle for survival, to produce food, to provide for shelter or to achieve control of their own lives.

From my research and observation, I perceive indigenous knowledge to have the potential to provide problem-solving strategies for local communities and to help shape positive local visions and perceptions of environment and society. IKS is of particular relevance to the poor in the following sectors or strategies: midwifery and herbal medicine; agriculture; animal husbandry and ethnic veterinary medicine; use and management of natural resources; primary health care (PHC), preventive medicine and psychosocial care; community development; and poverty alleviation (Riffel, 2013).

I have a strong conviction of the importance of indigenous knowledge in our society. Respecting IK is an essential first step for development projects in order to provide opportunities for more creative and inspired innovation and adaptation of technologies, for adding to scientific knowledge, for increasing understanding between teachers and learners, for increasing the local capacity to experiment and innovate, and for empowering and affirming local communities, particularly the high poverty level communities'.

School interaction with elders in the community on the topic of IKS

The elders in the community could become involved in the promotion of IKS. They could be approached to lead and deliver traditional protocol. They would be given a small offering in exchange for their commitment to invest their time and energy in the work at hand. They could be invited to lead such gatherings as parent meetings, social functions, and fundraising events, with prayer and/or ceremony. Meetings and school gatherings traditionally begin with prayer and ceremony. I consider it entirely appropriate to ask this of community elders. It may not be what we are familiar with at school, but it is hoped that the school community would soon realize the benefits of IKS and of respecting the protocol and ceremonial practice of a cultural group and/or community.

Classroom interaction with elders in the community on the topic of IKS

The elders could also be asked to do classroom visits and be part of IKS activities and share their indigenous knowledge with the learners from a range of cultural groups. It has been my experience that the elders are well aware that any given group put together in a classroom situation is there for group members to learn from one another. Thus, in this context, investing indigenous wisdom and knowledge towards this endeavour would only benefit the learners – and the elders. In this context, it is envisaged that the elders would share what is acceptable to the community or cultural group, and give caution for what they view as sacred knowledge to be shared only in the context of ceremony.

The RNCS (Department of Education, 2002) and the CAPS (Department of Education, 2011) suggest the need to relate formal knowledge to informal knowledge, to close the gap between the knowledge learners acquire and develop at home and what they learn at school. In this regard the expectations inscribed in the RNCS and the CAPS (under 'Critical Outcomes') are for learners to be able to develop certain process skills that they need to solve the problems they encounter in their daily lives. These process skills call for the mobilization of critical thinking skills in classroom discourse (Onwu, 2009). However this presupposes that learners have the freedom and the opportunity for self-expression and for questioning in the classroom. This form of classroom interaction where learners are able to express their views without feeling intimidated or lacking in knowledge comes under the general umbrella of 'argumentation instruction', a teaching and learning approach that has been receiving increasing attention in both local and international literature since the beginning of the 21st century. In a study Stears and Malcolm (2005) conducted in the Cape Flats region of the Western Cape, South Africa they found that "relevance and participation go together: relevance encourages learners to participate in classroom processes more deeply, learning in their own ways and bringing together ideas, interests and experiences" (2005). Stears and Malcolm (2005) refer to previous studies which have identified a number of dimensions of relevance. In studies done in Australia, Linkson (1997) makes a plea for cultural appropriateness and Fleer (1997) for inclusion of multiple worldviews and social and political aspects of science. Peacock (1995) and Terwel (1999) advocate for linking classroom knowledge to children's everyday experiences, and Goodenough (2001) for accommodation of multiple intelligences and learning styles (Stears & Malcolm, 2005).

5.4 Contribution to Knowledge

The main focus of the study was to investigate what kind of indigenous knowledge (IK) could be *socially* and *culturally* relevant in mediating learning of meteorological science concepts to Grade 9 learners. Evidently, it emerged that a combination of IKS and DAIM has several potentially beneficial implications for classroom pedagogy.

The findings of this study revealed that: Firstly, the socio-cultural background of learners has a influence on their conceptions of weather prediction and there was a significant difference between boy's and girls' pre-test conceptions about the existence of indigenous knowledge systems within the *community* they live in. For instance, from the learners' excerpts, it emerged that the girls presented predominantly rural experiences as opposed to those of the boys which were predominantly from urban settings. Secondly, those E-group learners exposed to the DAIM intervention shifted from being predominantly equipollent to the school science to emergent stances and they found a way of connecting their IK to the school science. The DAIM model which allowed argumentation to occur amongst learners seemed to have enhanced their understanding of the relevance of IK and how its underlying scientific claims relate to that of school science. Thirdly, the argumentation-based instructional model was found to be effective to a certain extent in equipping the in-service teachers with the necessary argumentation skills that could enable them to take part in a meaningful discourse.

Overall the findings of this study make a significant contribution to knowledge in four areas. Firstly, methodologically in illustrating the use of the DAIM as an instructional or pedagogical strategy in fostering argumentation in meteorological science classrooms. Secondly, its insights into the mobilisation and integration of indigenous knowledge in order to enable border crossing in meteorological science classrooms. Thirdly, the study makes a valuable contribution in relation to classroom practices and how to empower science teachers with knowledge and skills on how to use DAIM to integrate indigenous knowledge in their science classrooms. Fourthly, its contributions could help to inform science teachers on how to tap into the cultural heritage or knowledge from the community in order to design culturally relevant or sensitive pedagogies central to which is the recognition of learners' diverse socio-cultural backgrounds.

5.5 Future Research

5.5.1 Factors that promoted or hindered the use of an argumentation-based instructional model in science classrooms?

The study also identified factors that promoted and hindered the ISTs from using argumentation-based instructional model to implement DAIM and IK in science classroom. It was found that the effect of the argumentation-based intervention training programme and reflective workshop sessions were the major factors that promoted ISTs to use DAIM to implement IKS in the science classroom. The major factors that hindered ISTs from using DAIM in science classroom are: student-related, teacher-related, curriculum–related, stakeholders-related, learning environment and nature of the teacher education programmes.

The findings of this study have implications for policy, curriculum development and instructional practices.

5.5.2 Directions for further studies

Possible directions for future research that emerged out of this study are put forward. While this study seems to show the positive effect of argumentation-based intervention training programme on in-service teachers' ability to implement learner-centred curriculum in science classrooms, continued empirical investigation with other cohort of in-service teachers is a critical next step. It is anticipated that the next step will reveal areas of unexpected promise and difficulty. The encouraging outcomes of this study illustrate the need to further study the effect of argumentation-based instructional model in other school subjects as this area of research is relatively uncharted. As this study has not linked the effect of argumentation-based instructional model to learners outcome, further studies are required to examine the effect of this model on South African learners': (a) conceptual understanding of science and (b) critical thinking and problem solving skills. The importance of dialogical argumentation in science teaching illustrates the need to further develop strategies for learners who have low self-esteem and/or who encounter difficulties in socializing with their peers.

The results of this study seem to reveal that in-service teachers' ability to employ argumentation-based instructional model in science classroom is influenced by their ability to construct quality arguments, a finding that can be unpacked further in future studies to examine how engagement in argumentation discourse can improve in-service teachers' ability to teach argumentation lesson successfully. Studies that examine the correlation between teachers' understanding of argumentation and their ability to demonstrate complex arguments in their classroom are also recommended. Future studies directed toward the development of a learning progression for teaching science as argument which trace teachers' longitudinal development are also recommended. Little is known about this area of research in argumentation. Studies that examine the effect of the learning environment in the development of the social norms of scientific argumentation are also recommended.

There is a general consensus among educators that teachers largely teach the way they were taught (Ogunniyi, 1997). In agreement with this assertion, the findings of this study showed that some ISTs who had teaching experience before were observed to use more of teacher-centred approach in their teaching even after their exposure to the intervention programme. We all know how difficult it is for teachers to change their practices especially if the change requires the acquisition of new skills. Therefore, more research is needed to define strategies that will reach teachers not using learner-centred approach and how factors such as previous teaching experience affect teachers' responses to professional development.

5.6 Limitations and Delimitations of the study

Constraints within the study

In addition to the difficulties of conducting this type of study in a public school setting, the concept of dialogical argumentation was new to all the learners both in the research population and the sample, and the process of argumentation needed to be explained to them in detail. The majority of the learners thought of argumentation as a means of conflict and seemed to have been conditioned to believe that argumentation amongst individuals normally ends up in verbal or physical confrontation. Thus, the biggest challenge was to get learners to listen and respect each others' viewpoints and claims.

Location

As was described in detail in Chapter 3, the area in which the study was conducted is located in a previously disadvantaged community of the Helderberg Region. From the daily activities in the school and community it was observed that unemployment, poverty, crime and gangster activity remain amongst the challenges this community is facing daily. Some learners come to school without money and often with empty stomachs and no lunch packs for the day; this made them uneasy about, and unmotivated towards, the whole process of the research investigation which normally takes time and commitment from all involved. Clearly, the socio-economic setting affects the external and internal environments of the learners in this area, and that in turn affects the classroom environment, students' learning resources, and, most importantly in terms of the aims of the study, learners' attitudes to learning. These attitudes are illustrated by their unfamiliarity with an argumentation-based instruction method, with many learners assuming this format usually leads to confrontation. Thus locality factors need to be considered when contemplating and planning to introduce a new teaching method such as the DAIM approach.

Two different samples of the same population

The two schools involved in the study are situated in the same area of the sampled population and this could possibly lead to the contamination of data collected. The two sampled groups of experimental and controlled groups at each of the schools, and made up of girls and boys, came from the same community surrounding both the schools. Although the data was secured by means of intervention stage sessions and close follow-up pre-post-test evaluation test dates to prevent possible data being, disseminated or shared, or even talked over by, or discussed between, different group participants, the possible data contamination could be flagged. Thus, high on the research agenda for the current study (and for future studies) was an attempt to secure all data and to come up with any ideas to curb such leakages. This possibility of data contamination made the researcher aware that research of this kind could set in motion "talking about the study" by learners who participated in the intervention discussions, and IK related means to weather predictions due to the nature of the interest in this among those involved

End of year school term

The pre-test data was collected between August and September in the third term of the school calendar, almost near the end of the academic year. The initial plan was to conduct the study early in the first and second school terms. Following protocol, and after several attempts to contact the WCED (Western Cape Education Department) research department, the department finally granted the permission (appendix 1) for the research study, on the condition that the research study be concluded within the 3rd term period.

The study did not interrupt the academic flow or timetable of the school. In the third term, most public schools are busy with lesson revision and preparing their learners for the final examinations in the fourth term. Access to additional class observation visits, interviews with teachers, and even assistance from staff members was very difficult to arrange because of teachers' academic workload and commitments to complete their syllabus, which was a valid and acceptable reason. Most of the interventions and post-test data collections took place after school hours to accommodate for the time losses and unnecessary disruptions during class times. The excitement of the learners involved in the study wore off towards the end, as evidenced by two learners one from (E) group and the other one from the (C) group who opted out at the post-test stage because they felt they were wasting valuable time after school. I feel that this third term was not the right time to undertake the study because of the many constraints which hampered the finalisation of the study. I would suggest that earlier terms in the year would allow ample time for the implementation of a quasi-experimental design research study.

Duration of Intervention

The intervention took place after the September school holidays in 2016. As a non-teaching staff member of the participating school only pre-arranged meetings after school hours or early mornings between assembly time with the group could be scheduled with the researcher. Thus, due to time constraints, the intervention was only spread over a period of 4 weeks. The original and ideal plan was to spread the intervention over an 8-week period so that learners could draw conclusive experience from the argumentation sessions and group-workshops presented. The intervention period was also interrupted by rigorous administration and curriculum duties that sometimes led to the cancellation of intervention meetings scheduled for after school.

A possible positive outcome of the after-school intervention meetings was that the sampled learners could focus directly on the intervention process at hand without any external distractions from other learners. The participating educator was always present and keen to assist with the intervention phase, and this also helped to build a better "teacher-learner relationship" between the researcher and the learners, particularly because none of the learners were known to the researcher or vice-versa. It also takes time to build mutual – and collaborative - relationships on common grounds especially in the field of educational research.

Hegemony of the Language of learning and teaching

Most of the learners who participated in the study were Afrikaans home language speakers. English is their second language at school and they are also officially referred to, and classified according to the Language in Education Policy (DoE, 1997) categories, by teachers as first additional language (FAL) speakers. All the materials and instruments used in the study were printed in English. This was a major setback for the research because not all of the sampled learners could express their ideas properly or coherently in the English language, nor access the questions in the questionnaire and the tests. The questionnaires was translated into Afrikaans to speed up the process. In small and larger group feedback sessions most learners chose to express their opinions and beliefs in their mother tongue Afrikaans, but again, in trying to answer the questionnaire using English, they sometimes used the wrong phrases to accurately or fully express their views.

5.7 Conclusion

At the school serving as the research site, Geography is not a favourite subject of learners, partly because of the lack of resources at the school. Most of the learners' current knowledge on weather and the environment is derived from school knowledge, and very little knowledge gleaned from an indigenous knowledge perspective. In fact, some learners were completely unfamiliar with the concept of IKS. Some had in fact never encountered the term IKS. Given this significant knowledge gap, I would recommend teaching strategies be initiated that showcase the importance of tapping into indigenous knowledge for easier and more relevant consumption and application on the part of learners of geographical concepts.

In summary, it is my view, based on experience, observation, and the findings of the current research, that indigenous knowledge systems (IKS) are important for both local communities and the global community. Thus, I would argue that school science curriculum developers and research partners need to recognize the role of IKS, to understand its workings in the context of local communities, and systematically integrate into the development programs they design the most effective, useful, and promising of such practices. The impact and sustainability of international practices could be enhanced if they are adapted to, and include, local conditions and indigenous practices. Yet, IKS remains an underutilized resource in the global socio-cultural and economic development process. Special efforts by government institutions are therefore needed to understand, document and disseminate IKS for preservation, transfer or adoption and adaptation to the benefit of all South African citizens.

By helping to share IKS within and across communities the global communities can learn substantially about the local conditions that affect those communities. IKS should complement, rather than compete with, global knowledge systems in the implementation of projects such as sustainable resource protection and preservation. By first investigating what local communities know and possess in terms of indigenous practices, global partners could, in more informed and effective ways, help improve upon and integrate these practices by including international experiences in other parts of the world. Moreover, this process has the potential to contribute to more meaningful cross-cultural understanding and to the promotion of socio-cultural awareness and enrichment. Above all, investing in the exchange of indigenous knowledge and its integration into the development process can help to reduce poverty.

If we continue to muddle with the education system it might fail, however, if we leave the system as it is there will be no improvement in our country. As stated above there are various challenges which educators and the school environment has to deal with on a daily basis. Some challenges have a direct impact on the learners and educators and others indirect. Moreover, some of these recommendations and implementations are manageable and others are not. This should, however, not make us weary as to dealing with these issues at hand. The process of ameliorating these challenges lies in the implementation process and the willingness of all included stakeholders (government, policy makers, curriculum developers, educators, principals, management, governing body, etc.). If we ignore these issues we will continue to produce an educational sector where teachers will be faced with a suicidal workload and lack the professional autonomy and flexibility. All will be well if we stand together to change and give IK a fare chance within the classroom space in which educators try to provide quality education for all.

With this research investigation, it is my hope that it will contribute effectively in teaching modern science education in South Africa, in the Western Cape Province in general.

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Appendix A: University of the Western Cape – Ethical Clearance
(Registration Number:15/3/1)

UNIVERSITY *of the* WESTERN CAPE

OFFICE OF THE DEAN
DEPARTMENT OF RESEARCH DEVELOPMENT

07 April 2015

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape approved the methodology and ethics of the following research project by:
Mr AD Riffel (Education)

Research Project:	The inclusion of Indigenous Knowledge (IK) in the teaching and learning of Meteorological concepts in Grade 9 using Dialogical Argumentation Instructional Model (DAIM).
Registration no:	15/3/1

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

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

Private Bag X17, Bellville 7535, South Africa
T: +27 21 959 2988/2948 . F: +27 21 959 3170
E: pjosias@uwc.ac.za
www.uwc.ac.za

A place of quality,
a place to grow, from hope
to action through knowledge

Note: The initial title in the early stages of the study was as on this page. However, as the study evolved the title was refined and registered as on the title page

Appendix B - Western Cape Education Department – Research Approval Letter

Western Cape Government
Education

Directorate: Research

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20150319-45241
ENQUIRIES: Dr A T Wyngaard

Mr Alvin Riffel
15 Le Grange Street
Rusthof
Strand
7140

Dear Mr Alvin Riffel

RESEARCH PROPOSAL: SOCIAL AND CULTURAL RELEVANCE OF ASPECTS OF INDIGENOUS KNOWLEDGE SYSTEMS (IKS), METEOROLOGICAL LITERACY AND METEOROLOGICAL SCIENCE CONCEPTIONS

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **20 April 2015 till 27 May 2015**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 19 March 2015

Lower Parliament Street, Cape Town, 8001
tel: +27 21 467 9272 fax: 0865902282
Safe Schools: 0800 45 46 47

Private Bag X9114, Cape Town, 8000
Employment and salary enquiries: 0861 92 33 22
www.westerncape.gov.za

Appendix C - Letter to Western Cape Education Department

The Western Cape Education Department
……………………………............ (Address)
……………………………............
……………………………............
……………………………...........
……………………………...........
……………………………...........

Dear Sir/Madam

Request to carry out research in school

I herewith would like to apply for permission to perform a research study at your school. I am a student at the University of the Western Cape in the process of completing my PhD. Degree. So I wish to ask your permission to conduct my research in one of your schools in the Western Cape. My research title is: **Social and Cultural relevance of aspects of Indigenous knowledge systems (IKS), Meteorological Literacy and Meteorological Science Conceptions.**

The purpose of my research is to look at those aspects of Indigenous Knowledge (IK) that could be socially and culturally relevant in the Western Cape, South Africa for teaching meteorological science concepts in a grade 9. Emphasis is placed on how a group of learners relate socially and culturally to selected meteorological concepts and how they interpret them in the context of the current South African school curriculum.
I will make an effort to create minimal disruption to teaching and learning during my time at the school.
Regular progress report will be made available to you if you wish to view them.
If, at any time you would like me to provide deeper explanation or clarify any uncertainties, I will make myself available to do so. Thank you in advance for your consideration and support.

Yours sincerely

……………………….....
Alvin Daniel Riffel
(Doctoral Candidate / Principal Researcher)
University of the Western Cape

Faculty of Education
Contact details:
Cell: 082 640 0707
Email: alvinriffel@yahoo.com

....
Dr Melanie Luckay
(Doctoral Supervisor in Charge)
University of the Western Cape

Faculty of Education
Supervisor contact details:
Tel: 082 560 8309
Email: mluckay@uwc.ac.za

Appendix D - Letter to Principal

The Principal
……………………………............ (Address)
……………………………............
……………………………............
……………………………...........
……………………………...........
……………………………...........

Dear Sir/Madam

<u>Request to carry out research in your school</u>

I herewith would like to apply for permission to perform a research study at your school. I am a student at the University of the Western Cape in the process of completing my PhD. Degree. So I hereby request permission to do my field work, class room and teaching observation in Grade 9 Social Science (Geography) class as a data gathering and pilot exercise for my research study at your school. My research title is: **Social and Cultural relevance of aspects of Indigenous knowledge systems (IKS), Meteorological Literacy and Meteorological Science Conceptions**

The purpose of my research is to look at those aspects of Indigenous Knowledge (IK) that could be socially and culturally relevant in the Western Cape, South Africa for teaching meteorological science concepts in a grade 9. Emphasis is placed on how a group of learners relate socially and culturally to selected meteorological concepts and how they interpret them in the context of the current South African school curriculum.
I will make an effort to create minimal disruption to teaching and learning during my time at the school.

Regular progress report will be made available to you if you wish to view them.

If, at any time you would like me to provide deeper explanation or clarify any uncertainties, I will make myself available to do so. Thank you in advance for your consideration and support.

Yours sincerely

…………………………....
Alvin Daniel Riffel
(Doctoral Candidate / Principal Researcher)
University of the Western Cape
Faculty of Education
Contact details:
Cell: 082 640 0707
Email: alvinriffel@yahoo.com

....
Dr Melanie Luckay
(Doctoral Supervisor in Charge)
University of the Western Cape
Faculty of Education
Supervisor contact details:
Tel: 082 560 8309
Email: mluckay@uwc.ac.za

Appendix E - Letter to Educators (Letter will also be translated to Afrikaans)

Dear Educator

Request for participation in research

I am a student at the University of the Western Cape in the process of completing my PhD. Degree. So I wish to ask your permission to participate in my research. My research title is: **Social and Cultural relevance of aspects of Indigenous knowledge systems (IKS), Meteorological Literacy and Meteorological Science Conceptions.**

The purpose of my research is to look at those aspects of Indigenous Knowledge (IK) that could be socially and culturally relevant in the Western Cape, South Africa for teaching meteorological science concepts in a grade 9. Emphasis is placed on how a group of learners relate socially and culturally to selected meteorological concepts and how they interpret them in the context of the current South African school curriculum.
I will make an effort to create minimal disruption to teaching and learning during my time at the school.

I promise to report information that will not reveal anything of a personal or compromising nature to you and regular progress reports will be made available to you if you wish to view them. Your participation in this project will not be forced and you are allowed to withdraw at any point in time.

If, at any time you would like me to provide deeper explanation or clarify any uncertainties, I will make myself available to do so. Thank you in advance for your consideration and support.

Yours sincerely

…………………………......
Alvin Daniel Riffel
(Doctoral Candidate / Principal Researcher)
University of the Western Cape
Faculty of Education
Contact details:
Cell: 082 640 0707
Email: alvinriffel@yahoo.com

....
Dr Melanie Luckay
(Doctoral Supervisor in Charge)
University of the Western Cape
Faculty of Education
Supervisor contact details:
Tel: 082 560 8309
Email: mluckay@uwc.ac.za

Consent:

I have read and understand the information provided to me and agree/ disagree to participate in the research project.

Name and Surname: .... Date: ....

Signed: ....

Appendix F - Letter to Parents or Guardians (Letter will also be translated to Afrikaans)

Dear Parent / Guardian

<u>Request for participation in research</u>

I am a student at the University of the Western Cape in the process of completing my PhD. Degree. So I wish to ask your consent for your child to participate in my research, which will involve lesson observation and focus group discussions. My research title is: **Social and Cultural relevance of aspects of Indigenous knowledge systems (IKS), Meteorological Literacy and Meteorological Science Conceptions.**

The purpose of my research is to look at those aspects of Indigenous Knowledge (IK) that could be socially and culturally relevant in the Western Cape, South Africa for teaching meteorological science concepts in a grade 9. Emphasis is placed on how a group of learners relate socially and culturally to selected meteorological concepts and how they interpret them in the context of the current South African school curriculum.

I promise to report information that will not reveal anything of a personal or compromising nature to your child. Your child's participation in this project will not be forced and he or she is allowed to withdraw at any point in time.

If, at any time you would like me to provide deeper explanation or clarify any uncertainties, I will make myself available to do so. Thank you in advance for your consideration and support.

Yours sincerely

…………………………......
Alvin Daniel Riffel
(Doctoral Candidate / Principal Researcher)
University of the Western Cape
Faculty of Education
Contact details:
Cell: 082 640 0707
Email: alvinriffel@yahoo.com

....
Dr Melanie Luckay
(Doctoral Supervisor in Charge)
University of the Western Cape
Faculty of Education
Supervisor contact details:
Tel: 082 560 8309
Email: mluckay@uwc.ac.za

Consent:

I have read and understand the information provided to me and give my consent for my child to participate in the research project.

Name and Surname: .... Date: ....

Signed: ....

Appendix G - Confidentiality form for learners

Declaration of confidentiality

Dear learners

The information discussed in the groups must remain confidential and cannot be shared outside of this group.

Below please read and signed the form in which you agree to keep the information shared during the discussions confidential.

Yours sincerely

…………………………....

Alvin Daniel Riffel
(Doctoral Candidate / Principal Researcher)
University of the Western Cape
Faculty of Education
Contact details:
Cell: 082 640 0707
Email: alvinriffel@yahoo.com

……………………………………………………………………………………………………

School:..	Grade: ....
I, ... promise that all information shared in this group will remain between the group and will be kept confidential.	
Signed:	Date: ....

Appendix H - Informed Consent Form

This certify that I, ______________________________________, hereby agree to participate as a volunteer in a research project by

____, under supervision of

____

The research and my part in the project have been adequately explained and defined to me, and I understand the explanation. The procedures of this project and their risks and discomforts have been described.

- I understand that I am free to not answer specific items or questions in the interview or questionnaire.
- I understand that any data or answer to questions will remain confidential with regards to my identity.
- I understand that the general results of the study will be made available to me, if required.
- I understand that no other intervention or administrative decisions will result from my participation in this study.
- I FURTHER UNDERSTAND THAT I AM FREE TO WITHDRAW MY CONSENT AND TERMINATE MY PARTICIPATION AT ANY TIME.

_______________________(Date)   _______________________(Subject's Signature)

____

(Subject's address, optional: provide if you wish results sent)

The witness, whose signature appears below, attests to this.

______________________ (Witness)   ________________________ (Researcher)

______________________ (Date)

Principal Reseacher : Alvin Daniël Riffel
-Contact Details -
Address: 15 Le Grange Street, Strand, 7140
Tel: (021) 853 7503 /   Cel: 082 640 0707
Fax: (021) 853 7503 / E-mail: alvinriffel@yahoo.com

Appendix I - General information sheet for WCED, principal, teachers and parents

INFORMATION SHEET:

The following sheet provides information on the research as outlined in the letter.

Who will conduct the research?

The research will be conducted by Alvin Riffel, a PhD (doctoral) student at the University of the Western Cape (UWC).

Title of the research?

Social and Cultural relevance of aspects of Indigenous Knowledge Systems (IKS), Meteorological Literacy and Meteorological Science Conceptions

What is the aim of the research?

To investigate what kind of Indigenous Knowledge in the Western Cape, South Africa could be socially and culturally relevant in teaching meteorological science concepts to grade 9 learners, using a dialogical argumentation-based instructional model (DIAM).

Who will be asked to take part in the research?

Teacher participants will be chosen based on the following: a) Natural Science/ Social Science, (geography) teachers, b) senior phase grade 9 class teachers, c) the sample is intended to include two intact grade 9 class groups consisting of between *20* to *25* learners for the experimental-control group design.

What will participants be asked to do if they took part?

The researcher would need to gain access to teachers' classes and observe at least three of lessons of each teacher in their specialized subject. In addition the researcher would like to conduct semi-structured interviews after the observation of all three lessons. The learners will complete a pre-post tests, the experimental group will receive intervention lessons based on IKS. Both experimental and control groups will be interviewed in focus-groups. Each observation will be video-taped and each interview will be audio-recorded.

What happens to the data collected?

The data collected will be reported in the students' thesis. In addition, the student will aim to have the results published in accredited educational journals. The results will also be made available to the school and other relevant schools, as well as the Western Cape Education Department.

How is confidentiality maintained?

The researcher promises confidentiality of the information the participants reveal and anonymity of the teachers' and learners' identities.

What happens if the participants do not want to take part or change their mind?

Participants in the research will not be forced and participants are also free to withdraw from the research at any point in time.

Where will the research be conducted?

The research will be conducted in the chosen school.

Will the outcomes of the research be published?

The researcher will aim to have the outcomes of the research published by accredited journals.

This information is compiled for research purpose only by the principal researcher. For a more detailed description related to the above please contact:

Alvin Daniel Riffel

(Doctoral Candidate / Principal Researcher)

University of the Western Cape

Faculty of Education

Contact details:

Cell: 082 640 0707

Email: alvinriffel@yahoo.com

Appendix J: Tenets of the NOIK framework in relation to the tenets of the NOS framework

Tenet no.	NOIK	Tenet no.	NOS
1	*Empirical and metaphysical NOIK* • Nature is real, partly or generally tested and observed, • needs-based experimentation. • The universe is orderly, metaphysical and partly predictable (Agrawal, 1995; Bohensky & Maru, 2011: Le Grange, 2007, Ogunniyi, 2004)	1	*Empirical NOS* • Nature is real, observable and testable. • The universe is orderly and predictable.
2	*Resilient yet tentative NOIK* • Indigenous knowledge has withstood the test of time, but is constantly changing as tradition; • It is fluid and transformative—linked to people's experiences. • The elders' repository of ways of knowing is truth and not to be challenged (Barnhardt, 2008; Bohensky & Maru, 2011; Senanayake, 2006)	2	*Tentative NOS* • Science is subject to change and not absolute and certain. • It is challengeable by all.
3	*Inferential yet intuitive NOIK* • Facts are both tested and experimental observationsmade. • Events have both natural and unnatural causes; • Metaphysical dimensions are important (Le Grange, 2007; Ogunniyi, 2004; Senanayake, 2006)	3	*Inferential NOS* • There is a clear distinction between observations made of nature and deductions (inferences) made from observations to explain the causes. • All events have natural causes.
4	*Creative and mythical NOIK* • Observations and experimenting are not the only sources of ways of knowing. • Human creativity, imagination, metaphors and myths also play a role (Barnhardt, 2008; De Beer & van Wyk, 2011)	4	*Creative NOS* • Observations and experiments are not the only sources of scientific knowledge. • Human creativity and imagination also play a role.
5	*Subjectivity of NOIK* • Indigenous ways of knowing are based on cosmology and interwoven with culture and the spiritual. • The elders can be influenced by prior ways of knowing and beliefs (Aikenhead & Ogawa, 2007; Ogunniyi, 2004)	5	*Subjectivity (theory-laden) of NOS* • Scientists strive to be objective and culture free, but as human beings they are subjective and influenced by theoretical and disciplinary commitments, and by prior knowledge and beliefs.

6	*Social, collaboration and cultural NOIK* • Indigenous knowledge is situated in cultural tradition and within a certain historical-political context. • It is the consequences of activities connected to everyday life in the natural environment of a group of people. • It does not focus on the individual, but on the group and sharing. • It is locally rooted and ecologically based. • It is generated at a specific place by people of that place. • It is orally transmitted. • Generalisations are relative within a certain context and can be shared amongst communities and beyond (Agrawal, 1995; Barnhardt, 2008; Bohensky &Maru, 2011).	6	*Social and cultural NOS* • Scientist try to be objective, but science is a human endeavour and is therefore affected by a social and cultural milieu. • Scientists do sometimes work individually. • Science is generated at a specific place and thus local, but generalised scientific laws and theories have universal applications.
7	*Wisdom in action and NOIK* • Indigenous knowledge is generated by practical engagements in everyday life through trial and error experiences. • Repetition, imitation and ceremonies are methods to aid retention and reinforce ideas. • New ideas are rigorously tested in the 'laboratory of survival' (Senanayake, 2006, p. 87; Aikenhead & Ogawa, 2007; Barnhardt, 2008; De Beer & van Wyk, 2011).	7	*Methods and NOS* • Science knowledge is not generated by a single step-by-step universal method. • Scientists use a variety of methods to solve problems and test theories. These methods and tests are usually done in laboratories.
8	*Functional application and NOIK* • Indigenous knowledge is concerned with what and why things happen in nature, but also with what ought to happen. • Emphasis is on functional application and skills. • Indigenous knowledge is concerned with the everyday lives of people rather than facts, theories and laws (Agrawal, 1995; Aikenhead & Ogawa, 2007).	8	*Theories and laws and NOS* • Scientists use theories and laws to explain what, why and how things happen in nature. • A scientific law describes what happens, while a theory explains why and how things happen. • Scientific laws are causal, rational and logic.
9	*Holistic approach of indigenous knowledge* • Indigenous knowledge is 'a conglomeration of knowledge systems' (Ogunniyi, 2007a, p.965) including science, religion, psychology and other fields. • Problems are solved in a holistic manner addressing all the smaller parts with no boundaries with the metaphysical world (Agrawal, 1995; Senanayake, 2006).	9	*Reductionist approach of NOS* • Complex phenomena can be broken down into small parts and analysed. The part to whole method is used.

Adapted from source (Cronje et al., p. 323, 2015)

Appendix K: Views of Indigenous Knowledge Questionnaire (VIKQ)

Views on Indigenous Knowledge Questionnaire (VIKQ)

Instructions:

- *Please answer each of the following questions. Include relevant examples whenever possible.*
- *There are no 'right' or 'wrong' answers to the questions. We are only interested in* ***your opinion*** *on a number of issues regarding indigenous knowledge.*

1. In your view what is indigenous (or traditional) knowledge?
What makes indigenous knowledge different from other types of knowledge systems (such as Western knowledge)?

2. Practitioners of indigenous science (e.g. elders, herbalist, traditional healers) observe nature to generate knowledge. Do they do experiments and tests in order to verify or validate this knowledge?

- If yes, explain how they test or validate their knowledge.
- If no, explain why not.

3. Practitioners of indigenous knowledge observe nature and give explanations about their observations.
Elders in a community can, for example, explain where lightning comes from. Do the elders always use natural causes to explain their observations such as lightning, or do they sometimes include supernatural causes in their explanations?

- If they only use natural causes, explain why and give examples of some of the causes.
- If they sometimes use supernatural causes, explain why and give examples of some of the causes.

4. Indigenous knowledge is transferred from one generation to the next over many decades and centuries. Does this knowledge stay the same or does it change over time?

- If yes, explain why it stays the same.
- If no, explain the causes of such changes.

5. *Hoodia gordinii* is a plant that was used by Khoi-San hunters to suppress their hunger and Thirst when they went on hunting expeditions. How **do you think** the Khoi-San people came to know that this particular plant has these properties?

6. Sustainable development is an emerging concept that includes topics such as hunger, poverty and underdevelopment. Globally governments and organisations struggle to find solutions for these important issues. **Do you think** indigenous knowledge can be used to alleviate some of these problems?

- If you say yes, please explain why and how indigenous knowledge can be used to solve these problems.
- If you say no, please explain why it cannot be used to solve these problems.

7. An athlete regularly completing in marathons struggles with pain in his legs during the last part of
a marathon and can sometimes not complete a marathon due to this. The athlete decides to consult a traditional healer to determine why his legs pain during the last part of a marathon.

- What methods **do you think** the traditional healer will apply to diagnose the problem when consulting with the athlete?
- What possible treatment or advice **do you think** he will give the athlete?

8. Myths are stories that are told in different cultures by elders from one generation to the other. Do you think myths and rituals play any important role in indigenous knowledge systems? Explain you answer with examples if possible.

9. Some claim that indigenous knowledge is infused with social and cultural values. That is, indigenous knowledge reflects the social and political values, philosophical assumptions and intellectual norms of the specific culture in which it is practised. Indigenous knowledge is thus generated locally and can only be used in a specific area. I cannot be used universally in other contexts of globally to solve different problems.

- Do you believe that indigenous knowledge reflects the social and cultural values of a specific community? Explain with the use of examples how indigenous knowledge reflects the social and cultural values of a local community.
- Do you believe that indigenous knowledge can only be used in a specific area or do you believe it can be used in other areas or globally to solve problems? Explain your answer with examples.

10. Indigenous knowledge is passed from generation to the other by elders. The elders are deemed very important and some people believe their ways of knowing (knowledge) is truth and cannot be challenged. Does this mean that current practitioners of indigenous knowledge must use this knowledge exactly as it was passed on to them, or can they use their creativity and imagination to modify the indigenous knowledge to solve current problems?

- If you say yes and believe that indigenous knowledge practitioners cannot change this knowledge, explain why. Use examples if possible.
- If you believe that indigenous knowledge practitioners can change and modify their knowledge, explain why. Use examples if possible.

(Adapted from Cronje et.al, 2015, Ogunniyi 2012)

Appendix L: Rubric for answering the VIKQ questionnaire

Nr	Question (Q)	Informed IK view (I) = 2	Partially informed IK view (PI) = 1	Uninformed IK view (UI) =0
1	*Geography is interesting*	Answer yes with an acceptable reason / example	Answer yes without explanation or with reason that is not acceptable Answer no with acceptable explanation	Not sure or no
2	*Using my IK to learn geography helps me understand the weather better*	Yes it reflects social and cultural values plus explanation / example. Believe it is universal/ transferrable/ partially transferrable with suitable explanation	Yes reflects social and cultural values plus explanation/ example. Does not believe it can be transferred with no explanation	No to both sides of the question or unsuitable explanation
3	*I can use what I learn in geography class at home and in my community*	Comprehensive suitable explanation including at least two examples relating to everyday life needs or trial and error methods	Short suitable explanation including at least one example relating to everyday life needs or trial and error methods	Not sure or unsuitable explanation
4	*I believe more in my IK than geography knowledge to understand the weather*	Answer yes and no or yes, but, and explains the resilience of indigenous knowledge but that indigenous knowledge can be modified as needs of society changes	Answers just yes with correct explanation of why believe more in indigenous knowledge or no with correct explanation of why believe in geography knowledge	Answer yes or not sure without any explanation
5	*I'm only interested in geography to pass my exams*	Yes with suitable explanation / example	Yes with no explanation or unsuitable explanation	Not sure or no
6	*There is a relationship between geography and weather patterns*	Answer yes with explanation and/ or example	Answer yes without suitable explanation / example	Not sure or unsuitable explanation
7	*Lightning and bad weather are caused by witches and traditional doctors*	Can include supernatural to explain causes. Gives example of possible unnatural causes	Can include supernatural to explain causes. Does not give examples of possible unnatural causes or gives irrelevant explanation	Answer yes or not sure without any explanation
8	*It is not necessary to protect yourself from thunderstorm weather because it cannot kill you*	Mentions at least two of the anticipated answers or two other examples of indigenous knowledge views/ beliefs	Mentions at least one of the anticipated answers or one other examples of indigenous knowledge views/ beliefs	Not sure or no
9	*Geography explains the effects of weather better*	Yes with suitable explanation and/ or example	Yes and partially provide suitable explanation or example	Not sure or no
10	*When cold fronts appear in the WC we should be aware of bad weather patterns and heavy rain*	Provide one holistic answer related to cold fronts and its related effects	Provides either method / answer to explain understanding of cold fronts and its related effects	Not sure or unsuitable explanation

Weighting of code on results of Conceptions of Weather (CoW) questionnaire				
Q = Questions	N/A = not answered	UI = Uninformed view (0)	PI = Partially informed view (1)	I = Informed view (2)

Appendix M: Linking CoW with the NOIK framework and CAT

Tenet no.	Explanation of tenet	Related CoW question	CAT Cognitive states (1-5)	Core components related to the tenet
1	That indigenous knowledge is empirical and metaphysically based	1, 3, 9, 6	1, 2, 5	Observing nature, doing experiments and explaining observations
2	That indigenous knowledge is resilient yet tentative	1, 2, 6	1, 3	Change over time, can be modified
3	That indigenous knowledge is inferential yet intuitive	1, 4, 7, 2	1, 4, 5	Generating knowledge, explaining observation, including supernatural causes
4	That indigenous knowledge is creative and mythical	1, 7, 9,	4, 5	Alleviating problems, myths, rituals, creativity and imagination.
5	That indigenous knowledge is subjective	1, 8, 6,	2, 4	Social and cultural values, contextual
6	That indigenous knowledge is social, collaborative and cultural	1, 7, 5	1, 5	Orally transmitted to new generations, social and cultural values
7	That indigenous knowledge is wisdom in action	1, 9, 2	1, 2	Trial and error, laboratory of survival
8	That indigenous knowledge is applicable and functional	1, 4,10	2, 3,	Practical application, addressing needs
9	That indigenous knowledge is holistic by nature	1, 7, 8	2, 5	Psychomatic origin of disease, blurred boundaries with metaphysical, data interpreter

CAT cognitive states: Dominant = 1; Suppressed = 2; Assimilatory = 3; Emergent = 4; Equipollent = 5

Appendix N: Ogunniyi Five Cognitive states of the Contiguity Argumentation Theory (CAT)

Cognitive States	**Description**
1. Dominant	A powerful idea explains and predicts facts and events effectively and convincingly or resonates with an acceptable social norm that affords an individual a sense of identity e.g. a scientific explanation of lightning in terms of static electricity as opposed to the explanation proffered for the same phenomenon within an indigenous worldview.
2. Suppressed	An idea becomes suppressed in the face more valid, predictive, empirically testable evidence, or established social norms e.g. the scientific explanation of the cause of a disease may be suppressed in the face of cultural beliefs about possible diabolical motives of enemies behind the disease.
3. Assimilatory	A less powerful idea might be assimilated into a more powerful one in terms of the of the persuasiveness or adaptability of the dominant idea to a given context e.g. the indigenous idea of not leaning against a metal pole, tree or wall which may have arisen from experience can easily be assimilated into the scientific concept of lightning as an electrical phenomenon.
4. Emergent	There may be circumstances where no prior idea exists and a new one has to be acquired or developed e.g. a considerable amount of scientific concepts such as atoms, molecules, magnetism, conservation of matter, laws of motion, etc. have usually been learnt from school science.
5. Equipollent	When two competing ideas have comparably equal intellectual force, the ideas tend to co-exist without necessarily resulting in a conflict e.g. the theory of evolution versus creationism.

Source: Ogunniyi (1997, 2007); Ogunniyi & Hewson (2008). *Adapted from Langenhoven (2015).*

Appendix O

QUESTIONNAIRE: LEARNER'S CONCEPTIONS ON WEATHER RELATED CONCEPTS

Code: .... Grade:..............

This questionnaire is about your conceptions and understanding on weather related concepts. There are no right or wrong answers, feel free to express your views. The information you provide will solely be used for research purposes and will not be disclosed to anyone.

SECTION A: PERSONAL INFORMATION

Code:	.Grade:					
Gender	Male					
Age	10-12 yrs	13-15 yrs	16-18yrs	19-21 yrs	Other (Specify)	
Religion	Christian	Moslem	Indian	Hindu	Judaism	Other

SECTION B: Personal views about (geography) or social science

Please indicate by a cross(X) your feelings about science. Give reasons for each answer you give.

1. Geography is interesting.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

2. Using my indigenous knowledge to learn geography helps me to understand weather better.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

3. I can use what I learn in a geography class at home and in my community.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

....

4. I believe more in my indigenous knowledge than geography knowledge to understand the weather.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...

....

5. I'm only interested in geography to pass my exams.

Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐

Reason...
....

6. There is a relationship between geography and weather patterns.
Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐
Reason...
....
Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

7. Lightning and bad weather (like heavy rain and strong winds) are caused by witches and traditional doctors.
Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐
Reason...
....
Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View

8. It is not necessary to protect yourself from thunderstorm weather, because it cannot kill you.
Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐
Reason...
....
Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

9. Geography explains the effects of weather better.
Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐
Reason...
....
Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

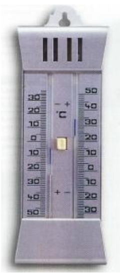
10. When cold fronts appear in the Western Cape we should be aware of bad weather patterns and heavy rain.
Strongly Agree ☐ Agree ☐ Disagree ☐ Strongly Disagree ☐
Reason...
....
Source of information: Science ☐ Religion ☐ Personal View ☐ Cultural View ☐

Appendix P: Meteorological Literacy (MLT) -Test

Code: ....   Grade:....................

Know your weather instruments.

Although the most accurate predictions come from meteorologist, anyone can make local weather predictions by watching the sky and using simple equipment.

	Weather Instrument	Name	Measures	Units
A.		Barometer	Air Pressure	Millibar (mb) Hecto Pascal (hP)
B.		**Min-Max Thermometer**	Minimum and Maximum Temperature	Degrees Celsius
C.				

		Rain gauge	Rain fall	Millimetres (mm)
D.		Hygrometer	Relative Humidity	Percent (%)
E.		Anemometer	Wind speed	Kilometres per hour
F.		**Compass**	Direction	Degrees

Activity 1: *Weather Instruments*

1) Which of the instruments shown above would best measure each of the following conditions. Give reasons for your answers:

________________________________ a) a 20mm rain fall on a specific day.

Give reasons:

____

____

______________________________ b) a period of hot, humid weather

Give reasons:

____

____

______________________________ c) a gentle land breeze

Give reasons:

____

____

______________________________ d) that can point out the direction of an item

Give reasons:

____

____

2) Which instrument would give each of the following readings?

______________________________ a) a reading of 14 kilometres per hour (k/h) / knots

______________________________ b) a reading of 53 (%) percentage

______________________________ c) a reading of 3 (mm) millimetres

_____________________________ c) a northerly (0^{o}) direction

Activity 2: Tick off the word (words) that will make each sentence a true statement.

1) When air is cooled near the earth's surface or when warm, moist air moves over cool surface, ___________ is formed.

snow	Fog	lightning

2) Air pressure is measured in _________________.

degrees	percent	centimetres

3) A ____________________ is used to measure air pressure.

thermometer	barometer	hygrometer

4) Air temperature is measured in ________________.

degrees	percent	centimetres

5) A ____________________is a wind flow that occurs during night time hours.

land breeze	water breeze	calm

6) If rain is forecast, the barometer pressure is ______________ .

rising	falling	steady

7) High pressure is normally associated with _______________.

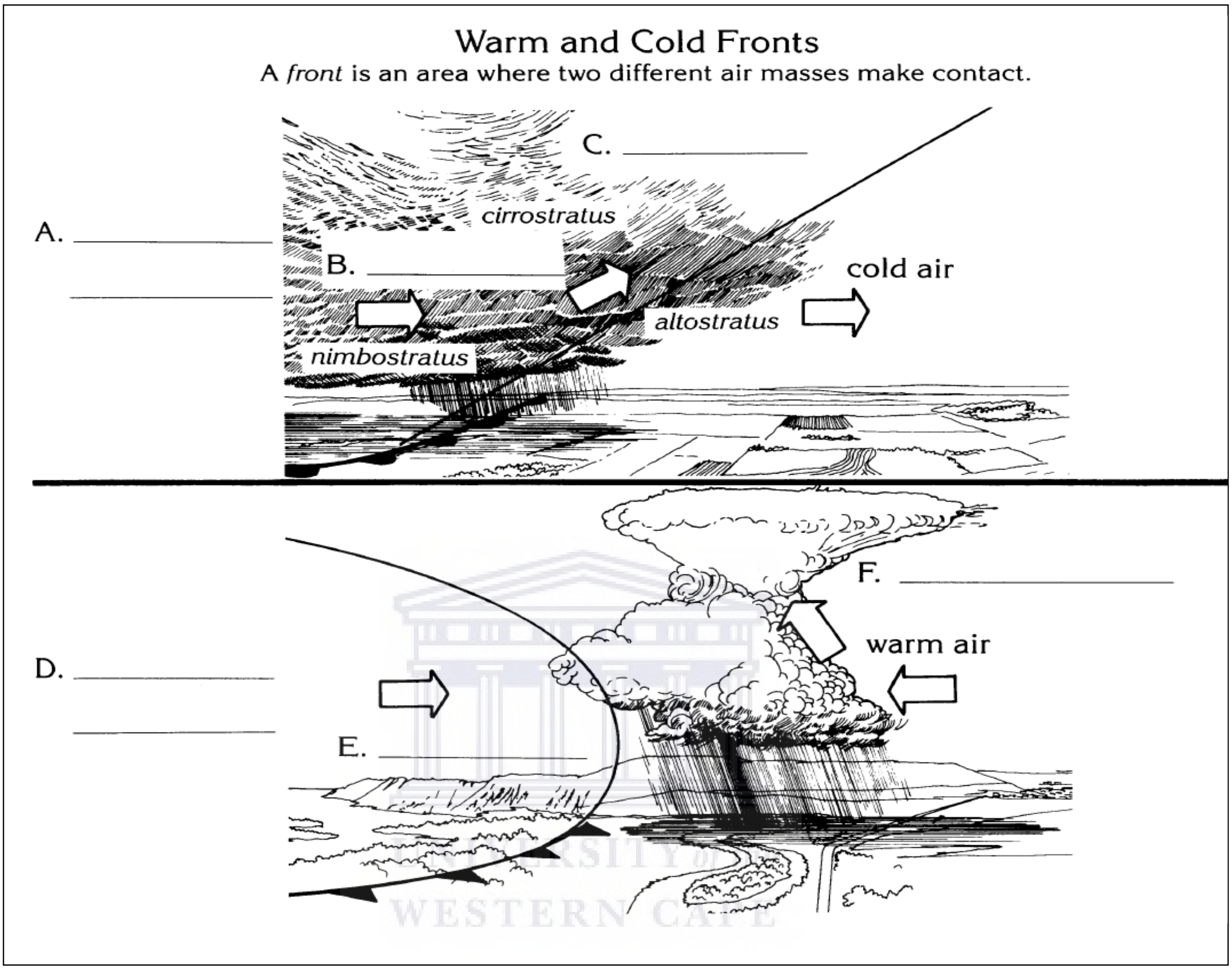
good weather	bad weather	freezing weather

8) Cold air masses are _______________ warm air masses.

lighter than	the same weight	heavier than

Activity 3: Geography Conceptual Knowledge

Question: Complete the diagram and fill in answers A to F using the list below.



Use the list of words below and label each of the following on lines A-F in the diagram above:

a cold front **a warm front**

cold air mass ain a cold front **warm air mass in a warm front**

cumulonimbus clouds **cirrus clouds**

1) Write <u>warm front</u> if the phrase describes a warm front; write <u>cold front</u> if the phrase describes a cold fronts.

_______________________ 1.1) air masses with a gentle slope over surface of earth

_______________________ 1.2) formation of stratus type clouds

_______________________ 1.3) fast moving, heavy air mass

_______________________ 1.4) produces small violet, short periods of rain.

Activity 4: Indigenous Knowledge Weather Forecasting Questions

Read the statement and underline the most appropriate answer and explain reasons for your answer:

You have just started your summer vacation. You are at a campsite with your family and you can't wait to start having fun. Your parents know you have been studying weather in class, so they have asked you to help decide what to do each day, based on your weather predictions. You don't have access to meteorological reports, so you must base your decisions on the indigenous knowledge-based weather predictors you learned about in class.

Day 1

You wake up early in the morning and notice that there is dew on the grass. Your parents say that means there is lots of moisture in the air and there will be rain. What should you do?

a. Plan a day of indoor activities.

b. Plan for a day outdoors.

Explain your choice: ....

....

....

Day 2

You have discovered a beehive near your camp. You go to investigate it again this morning. You see that there is a lot of activity, with bees flying in and out of the hive. You come back to your family and tell them that this indicates:

a. They should have a good day for outdoor activities.

b. They should stay indoors today.

Explain your choice: ....

....

....

Day 3

You had a wonderful day yesterday with swimming, hiking, and a campfire at night. At the campfire, you noticed the stars were very clear and bright. You also noticed that the smoke was not rising very quickly from the fire. With these observations, you announce to your family that tomorrow is a good day to:

a. Spend another day at the beach.

b. Plan for a day of indoor activities.

Explain your choice: ....

....

....

Day 4

Today you wake up and notice high clouds overhead. You see that the birds on the ground tend to be facing west. It had rained all day yesterday and most of the night. Your parents look at the clouds and say that it is going to be a bad day and we should go for a road trip. You:

a. Agree another day stuck inside is the only other option.

b. Say the day will be alright and a good day to go fishing.

Explain your choice:
....

....

....

Day 5

Last night you had another campfire. The wind suddenly started to blow from the east and you saw that the moon had a halo effect around it. You also noticed that the leaves on the trees were turning upside down as you headed to bed. You told your parents that this meant there was going to be rain. They said that it was too bad, for tomorrow was your last day. They said you should all pack up in the morning and head home early. You said:

a. Yes, we should head home early.

b. No, this weather would be gone by morning.

Explain your choice: ....

....

....

Appendix Q: Lesson Plans and Assessment tools

Activity 1 : 45 Min

Indicators of Early Spring
1. Animals:

Indicators of the Length of Winter
1. Animals:

Indicators of Storms and cold fronts
1. Trees & Birds:
2. Moon:

Indicators of Wind
1. Sunset and sunrise:
2. Birds:
3. Direction:
4. Sundogs:

Activity 2: 45 Min
Cultural Weather Sayings take home research

Learners where send home with a task to collect as many possible weather saying that is still active in the community. This data was use to discussed various cultural weather sayings

Activity 3: 45 Min
Weather Instruments and weather data collection
- Learners where exposed to various weather instruments and the usage for weather data collection

Activity 4: 45 Min
IKS – Weather forecast application
The learner where exposed to a weather forecast scenario and groups where allowed to predict weather based on IKS knowledge

Activity 5: 45 Min
Knowledge Intergration and career choices in weather related work place

Activity 6: 45 Min
Weather Journal Handout
Personal Home Task: Your task is to make your own record of the weather for one week.

Activity 7: 45 Min
Weather Journal discussion session– Small and large Group discussion
Possible feedback from learner experiences and ideas

Activity 8: 45 Min
Peers and group assessment were done on all work that was covered in the process of the intervention stage. This gave learners the time to do self reflection on their own as well as their peers work. Assessment of weather journal were according to the rubric provide (Appendix R)

1.1 Structure of classroom lessons

Lesson 1 (Day 1) – Introduction
Explain to learners that identifying the seasonal cycles and weather patterns that were important to indigenous peoples. They observed the moon and animal behaviours to determine how much food should be prepared and stored for the winter months. Refining one's sensory perceptions helped to establish a knowledge base of the local environment and to prepare adequately for the weather. Seasonality provided the time framework for communal and personal activities.

Learners will make notes on the following terms:
• *Weather* - the day-to-day environmental conditions in a location.
• *Climate* - the weather conditions of an area averaged over many years.

Learners will then explore these concepts by discussing the following questions:
1. When you wake up in the morning and you think about going outside, what are you thinking about - weather or climate? How does this affect your day?

2. When you plan what you are going to do during the Easter holiday, are you thinking about weather or climate?

3. If you plan to travel to the mountains during Easter, are you thinking about weather or climate? Would you have the same plans if you stayed at home?

4. List some occupations that are weather dependent and some that are climate dependent.

Lesson 2 (Day 2) – Cultural Weather Sayings Research

Learners will now conduct their own weather research. A day in the library or computer lab is recommended. Learners can spend the day finding answers to the guided questions and are encouraged to find new or alternate sources.

After the day of research, learners are asked to supplement their information at home.
Ask learners to share their research with their family and friends, and ask them to share any other information (home knowledge) they might have.
(See **Appendix R** for a learner worksheet entitled **Cultural Weather Research** and an answer key containing possible responses to the worksheet questions.)

Listed below are some websites that have provided enough information to provide answers to the learners research questions:

- http://www.weathersayings.com
- http://www.metoffice.com
- http://www.kidsweather.com
- http://www.erh.noaa.gov
- http://weatherstories.ssec.wisc.edu

Lesson 3 (Day 3) – Cultural Weather Sayings Sharing

This day is designed for the learners to share their research results.

Learners will have the opportunity, either in small groups or through a teacher-directed discussion (dialogical argumentation), to share their information and to ask for clarification.

When learners are satisfied they have a complete weather sayings resource, learners can complete the summary activity.

This activity is an opportunity for learners to apply the cultural weather sayings they have researched. Learners are given possible scenarios for a typical summer situation.

Each learner is asked to choose a course of action for the upcoming day's activity. He/she must choose and then explain his/her choice, including what cultural knowledge has been used to make the decision. When learners have presented their choices individually, they may form small groups to discuss their choices.
(See **Appendix R** for a Weather Forecasting Performance Task learner handout)

Lesson 4 (Day 4) – Weather Forecasting Journal

This activity is to be completed as a performance task to show learners' understanding and application of cultural sayings.

This journal assignment can be completed immediately after the introduction activities or it can wait until learners have learned more about modern forecasting techniques.

This task takes place over the course of five days as a homework project. It involves the learners in weather observation and data collection.
Learners collected personal weather data (temperatures, wind, clouds, animals, etc.), as well as the meteorological forecast for the day. Learners are encouraged to add in weather observations as the day progresses. They are also required to write a summary at the end of the day, discussing how the predictions worked, missed, and what observations may have been omitted. An appropriate format to be used in the journal each day should be discussed. This will ensure that all the observations and analysis will be completed on a daily basis.

2. ASSESSMENT

IKS – Weather Forecast Application

Weather Forecasting Application Answer Key

Day 1

You wake up early in the morning and notice that there is dew on the grass. Your parents say that means there is lots of moisture in the air and there will be rain. What should you do?

a. Plan a day of indoor activities.

b. **Plan for a day outdoors**.

Explain your choice:

Because cultural knowledge says: "Dew on the grass, rain won't come to pass."

Day 2

You have discovered a beehive near your camp. You go to investigate it again this morning. You see that there is a lot of activity, with bees flying in and out of the hive. You come back to your family and tell them that this indicates:

a. **They should have a good day for outdoor activities**.

b. They should stay indoors today.

Explain your choice:

Because oral history says: "Animals act strange with a weather change."

Because cultural knowledge says: "If bees stay at home, rain will soon come; If they fly away, fine will be the day."

Day 3

You had a wonderful day yesterday with swimming, hiking, and a campfire at night. At the campfire, you noticed the stars were very clear and bright. You also noticed that the smoke was not rising very quickly from the fire. With these observations, you announce to your family that tomorrow is a good day to:

a. Spend another day at the beach.

b. **Plan for a day of indoor activities**.

Explain your choice:

Because oral history says: "East wind means storm approaching."

Because cultural knowledge says: "Chimney smoke descends, our nice weather ends." "When stars shine clear and bright, we will have a very cold night."

Day 4

Today you wake up and notice high clouds overhead. You see that the birds on the ground tend to be facing west. It had rained all day yesterday and most of the night. Your parents look at the clouds and say that it is going to be a bad day and we should go for a road trip. You:

a. Agree another day stuck inside is the only other option.

b. **Say the day will be alright and a good day to go fishing**.

Explain your choice:

Because oral history says: "Birds show wind direction. West wind change in weather and sun approaching."

Because cultural knowledge says: "The higher the clouds, the better the weather." "When the wind blows from the west, fish bite best; when it blows from the east, fish bite least."

Day 5

Last night you had another campfire. The wind suddenly started to blow from the east and you saw that the moon had a halo effect around it. You also noticed that the leaves on the trees were turning upside down as you headed to bed. You told your parents that this meant there was going to be rain. They said that it was too bad, for tomorrow was your last day. They said you should all pack up in the morning and head home early. You said:

a. Yes, we should head home early.

b. **No, this weather would be gone by morning**.

Explain your choice:

Because oral history says: "When leaves show their undersides, rain is coming." Because cultural knowledge says: "A ring around the sun or moon means rain or snow is coming soon." "Storms that come up fast never last."

3 Weather Journal Assessment

Assessment on the learner weather journal where based on the rubric as indicated in table

TABLE 3.1: Rubric for assessment of Weather Journal

Category	5	4	3	2	1
Journal Days	Five weather days observed.	Four weather days observed.	Three weather days observed.	Two weather days observed.	One weather days observed.
Signs	Recorded more than two weather signs each of the five days.	Recorded more than two signs for at least three days.	Recorded two or more signs for all days.	Recorded one weather sign for each day and two weather signs for three days.	Recorded one weather sign each day.
Use of cultural prediction	A cultural predictor was referenced in the forecast for all days, with multiple predictors used in three or more days.	A cultural predictor was referenced in the forecast for all days, with multiple predictors used in at least two days.	A cultural predictor was referenced in the forecast for four days	A cultural predictor was referenced in the forecast for three days.	A cultural predictor was referenced in the forecast for two days.
Media forecast	Reported the daily media weather and long-term forecast for all days.	Reported the daily media weather for all days, with the long-term forecast for at least three days.	Reported the daily media weather for all days.	Reported the daily media weather for at least three days.	Reported the daily media weather for one day.
Summary	There is a report of the actual weather compared to the personal and media forecasts, with suggestions of missed signs or confirmation of correct signs.	There is a report of the actual weather compared to the personal and media forecasts.	There is a report of the actual weather compared to the personal forecast, with suggestions of missed signs or confirmation of correct signs.	There is a report of the actual weather compared to the personal forecast.	There is a report of the actual weather for each day.
Full day of observatio	There are two days of all-	There is one day of all-day			

n	day observation. **(2 marks)**	observation. **(1 mark)**			

Appendix R: Convergent Design of Qualitative and Quantitative data and analysis

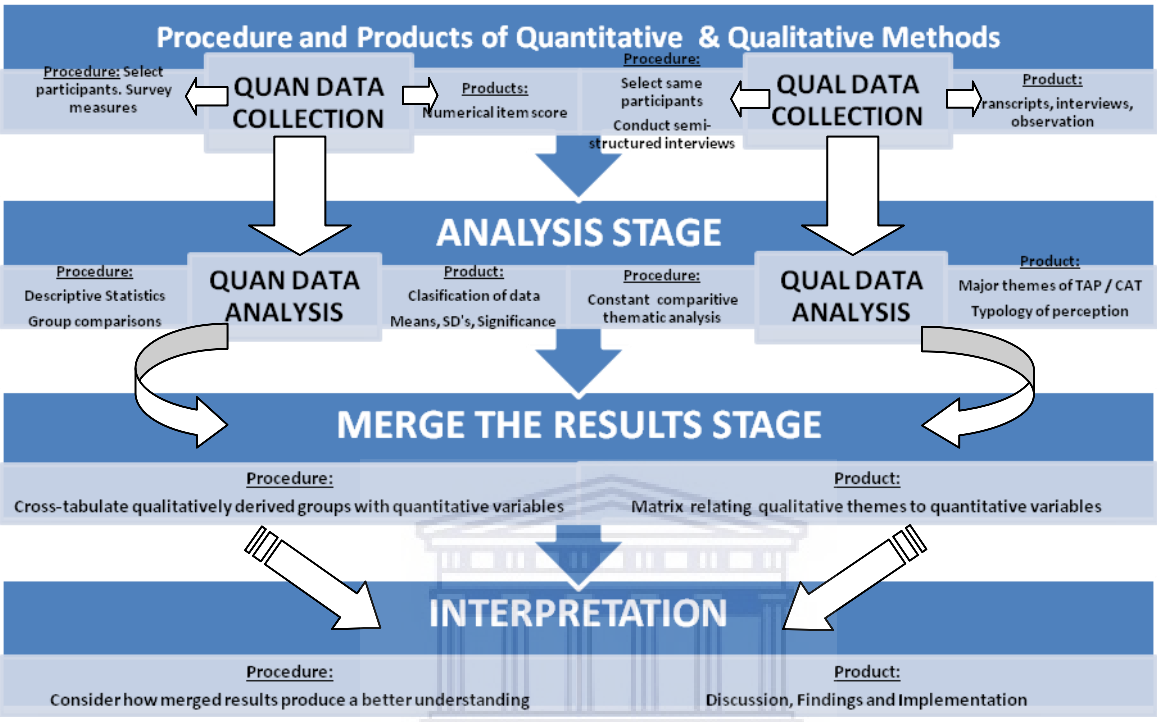


Figure: Convergent Design of Qualitative and Quantitative data and analysis

(Adapted from Wittink et al., 2006)

Appendix S: Strengths and Weaknesses of Quantitative Research Methods

Table 1:

Strengths (Creswell, 2002)

- Testing and validating already constructed theories about how (and to a lesser degree, why) phenomena occur.
- Testing hypotheses that are constructed before the data are collected. Can generalize research findings when the data are based on random samples of sufficient size.
- Can generalize a research finding when it has been replicated on many different populations and subpopulations.
- Useful for obtaining data that allow quantitative predictions to be made.
- The researcher may construct a situation that eliminates the confounding influences of many variables, allowing one to more credibly assess cause-and-effect relationships.
- Data collection using some quantitative methods is relatively quick (e.g., telephone interviews).
- Provide precise, quantitative, numerical data.
- Data analysis is relatively less time consuming (using statistical software).
- The research results are relatively independent of the researcher (e.g., effects size, statistical significance).
- It may have higher credibility with many people in power (e.g., administrators, politicians, people who fund programs).
- It is useful for studying large numbers of people.

Weaknesses

- The researcher's categories that are used may not reflect local constituencies' understandings.
- The researcher's theories that are used may not reflect local constituencies' understandings.
- The researcher may miss out on phenomena occurring because of the focus on theory or hypothesis testing rather than on theory or hypothesis generation (called the confirmation bias).
- Knowledge produced may be too abstract and general for direct application to specific local situations, contexts, and individual

(Adapted from Creswell, 2002)

Table 2: Strengths and Weaknesses of Qualitative Research Methods

Strengths	Weaknesses
• The data are based on the participants' own categories of meaning. • It is useful for studying a limited number of cases in depth. • It is useful for describing complex phenomena. • Provides individual case information. • Can conduct cross-case comparisons and analysis. • Provides understanding and description of people's personal experiences of phenomena (i.e., the "emic" or insider's viewpoint). • Can describe, in rich detail, phenomena as they are situated and embedded in local context. • The researcher identifies contextual and setting factors as they relate to the phenomenon of interest. • The researcher can study dynamic processes (i.e., documenting sequential patterns and changes). • The researcher can use the primary qualitative method of "grounded theory" to generate inductively a tentative but explanatory theory about a phenomenon. • Can determine how participants interpret "constructs" (e.g., self-esteem, IQ). • Data are usually collected in naturalistic settings in qualitative research. • Qualitative approaches are responsive to local situations, conditions, and stakeholders' needs. • Qualitative researchers are responsive to changes that occur during the conduct of a study (especially during extended fieldwork) and may shift the focus of their studies as a result. • Qualitative data in the words and categories of participants lend themselves to exploring how and why phenomena occur. • One can use an important case to demonstrate vividly a phenomenon to the readers of a report. • Determine idiographic causation (i.e., determination of causes of a particular event).	• Knowledge produced may not generalize to other people or other settings (i.e., findings may be unique to the relatively few people included in the research study). • It is difficult to make quantitative predictions. • It is more difficult to test hypotheses and theories. • It may have lower credibility with some administrators and commissioners of programs. • It generally takes more time to collect the data when compared to quantitative research. • Data analysis is often time consuming. • The results are more easily influenced by the researcher's personal biases and idiosyncrasies. (Adapted from Creswell, 2002)

Table 3: Strengths and Weaknesses of Mixed-Methods Research

Strengths	Weaknesses
• Words, pictures, and narrative can be used to add meaning to numbers. • Numbers can be used to add precision to words, pictures, and narrative. • Can provide quantitative and qualitative research strengths (i.e., see strengths listed in Tables 2 and 3). • Researcher can generate and test a grounded theory. • Can answer a broader and more complete range of research questions because the researcher is not confined to a single method or approach. • The specific mixed research designs discussed in this article have specific strengths and weaknesses that should be considered (e.g., in a two-stage sequential design, the Stage 1 results can be used to develop and inform the purpose and design of the Stage 2 component). • A researcher can use the strengths of an additional method to overcome the weaknesses in another method by using both in a research study. • Can provide stronger evidence for a conclusion through convergence and corroboration of findings. • Can add insight and understanding that might be missed when only a single method is used. • Can be used to increase the generalizability of the results. • Qualitative and quantitative research used together produce more complete knowledge necessary to inform theory and practice.	• Can be difficult for a single researcher to carry out both qualitative and quantitative research, especially if two or more approaches are expected to be used concurrently; it may require a research team. • Researcher has to learn about multiple methods and approaches and understand how to mix them appropriately. • Methodological purists contend that one should always work within either a qualitative or a quantitative paradigm. • More expensive. • More time consuming. • Some of the details of mixed research remain to be worked out fully by research methodologist (e.g., problems of paradigm mixing, how to qualitatively analyze quantitative data, how to interpret conflicting results). (Adapted from Creswell, 2002)

Appendix T: Social and Cultural Indigenous Knowledge Questionnaire (SCIKQ)

Name/ Code/ Initials: ……………………………

Bio Data

Language		Race		Province/ Place Originated From						Currently Living	
AFR		Colored		Western Cape		Limpopo		USA		Urban	
ENG		Black		Eastern Cape		Free State		ENG		Rural	
iXhoza		Indian		KZN		North West		ASIA		Homestead	
Venda		White		N/Cape				EUROPE		Farm	
Tshawane		Other		Gauteng						Flat	
Other				Mpumalanga				Other		Townhouse	

Educational Qualifications

Highest Secondary Education			Tertiary Education			(If Yes) Specify Tertiary Education	Level of Degree / Diploma			
High School	Y	N	Degree	Y	N		Diploma		PhD	
Private School	Y	N	Diploma	Y	N		B-Tech		PGCE	
Public School	Y	N	Technical Diploma	Y	N		B-Degree		Post- doctoral	
Rural School	Y	N	RPL	Y	N		B.Ed (Hons)			
Village School	Y	N	Tradesman	Y	N		Masters			

Teaching experience

School Teaching Practice				**School Teaching Experience**				**Years Teaching**	
Primary School		**High School**		**Primary School**		**High School**		0 (None)	
Foundation		Junior		Foundation		Junior		1-5	
Intermediate		Senior		Intermediate		Senior		7-10	
Junior		Matric		Junior		Matric		10-15	
								16-20	
								21-25	
								26-30	
								30-40	

General question

Have you ever had any encounter involving Indigenous Knowledge Systems (IKS)? **YES/ NO** (Please supply evidence below, if answer is YES)

Item / Questions

1. Have you heard about IKS (Indigenous Knowledge Systems) at school / university?	
Yes	No

2. In your view which of the following IKS (knowledge's) should be recognized at school

IK-Knowledge	**Yes**	**No**
Traditional Medicine		
Weather Prediction		
Traditional Healing		
Mythical/Spiritual Healing		
Environmental & Sustainable		
Agriculture knowledge		

3. What is your perception on the following IKS matters?	
Western Science vs Traditional Knowledge (Which do you prefer to teach / know more about)	Your view:
The role of IKS in formal curricula (Schools/ CAPS)	
Woman's role in IKS	
Government's role in IKS	
Traditional agriculture knowledge	
Traditional Medical practices	

4. According to your view about IKS—Who do you think will be more supportive on IKS *(Mark with an X this side)*	
A) Gender Males	
Females	

B) Race Coloured	
Indian	
Black	
White	
Other	

C) Tribal/ Informal urban areas or Provinces Eastern Cape	
Mpumalanga	
Limpopo	
KwaZulu-Natal	
Free State	
North West	
Gauteng	
Western Cape	
Northern Cape	

5. Do you agree to the following statement:

" Encouragingly, younger people tend to be just as interest in IKS as older age groups"	
Yes:	No:

6. What is your view on businesses/ brand companies that are exploiting the indigenous knowledge of communities?	
Example	
IKS	**Commercial**
A. Traditional Beer making Name: Umqombothi Beer Ingredients: Maize, Water & yeast (Sorghum malt) Alcohol content: <3% Tribes: Sotho, Zulu & Xhoza	**South African Breweries:** - Carling Black Label - Castle Milk Stout - Castle Lager - Amstel beer
Your view:	
B. Traditional Medicine Name: Aloe Vera/Wild garlic / ginger Ingredients: Natural Purpose: Healing/ Antibiotic/ Immune booster Tribes: African Tribes	**Pharmaceutical Companies** - Cosmetics - Pills / Antioxidants' - Slimming -
Your view:	