The effectiveness of an argumentation instructional model in enhancing pre-service science teachers' efficacy to implement a relevant science-indigenous knowledge curriculum in Western Cape classrooms

A full thesis submitted in fulfilment of the requirement for the degree Doctor of Philosophy

RESEARCHER: KEITH ROY LANGENHOVEN

Supervisor: Prof. M.B. Ogunniyi

Co-supervisor   Dr. C. Fakudze

School of Science and Mathematics Education (SSME)

Faculty of Education

The University of the Western Cape, Republic of South Africa

Key Words

Pre-service science teachers' efficacy; dialogical argumentation instructional model; nature of science; nature of indigenous knowledge systems; integrated science-indigenous knowledge systems; Toulmin Argumentation Pattern; Contiguity Argumentation Theory; Socio-cognitive Theory; Curriculum and Assessment Policy Statements

DECLARATION BY CANDIDATE

I KEITH ROY LANGENHOVEN hereby declare that this treatise/dissertation/thesis, **"The effectiveness of an argumentation instructional model in enhancing pre-service science teachers' efficacy to implement an integrated science-indigenous knowledge curriculum"** is my own work; that it has not been submitted before for any examinations or degree purposes, in another University or for another qualification.

KEITH ROY LANGENHOVEN

SIGNED: ……………………….………   **DATE: December, 2014**

ACKNOWLEDGEMENTS

This work is dedicated to my late parents, Joyce Langenhoven (Petersen) and Dennis Petersen, Granny Petersen and stepfather Richard Langenhoven and extended family, who made huge sacrifices on my behalf to ensure that education, propelled my life's journey. They taught me morals, values, appreciation, love for God and the simple things in life.

I would like to thank my Heavenly Father who sustained me throughout this journey and for the talent he has bestowed on me through love, grace, mercy and good health.

Thank you to my supervisor, Professor Meshach Ogunniyi, my mentor, father, counsellor and patron, who motivated, cajoled, prayed and cared. His vision is for all students in his care to achieve their dream of completing their studies. His favourite saying was **"If you say you want to dance, then get up and dance, don't sit on your behind and expect to dance."** Thank you for the prayers of petition by you and your wife. My appreciation is also extended to co-supervisor, Dr. Cynthia Fakudze, who taught me the finer points in the last stages of writing. Together they acted as midwives in nurturing me through the pangs of giving birth to this PHD. In the last stages of giving birth to this PHD, Dr. Femi Otulaja inspired with his analogies and encouragement during his weeklong visit.

My appreciation goes to the inspiring academics who supported the start of my academic journey: Professors. Svein Sjoberg, Cyril Julie, Monde Mbekwa, Lorna Holtman, Zubeda Desai (Dean), Vuyo Nomlomo, Juliana Smith and the rest of the staff members of the Education Faculty.

To the **Science and Indigenous Knowledge Systems Project** team, you have become my academic family as we engaged in earnest discussions on an intellectual level as well as at a social level. Here, with no selective favouritism, I wish to mention my dependable support base: Shafiek Dinie - colleague, friend and sounding board; Alvin Riffel – no job too big; Dr. Funmi Amosun – sage advisor; Chris Diwu – insightful; Florence February – reliable and

always concerned, and all the others (Lorraine, Daniel, Philip, Noluthando, Andrew, Frikkie, Cherie, Ngoni, Abiodun, Lynn, Dr. Rasekoalo; Dr. Femi Otulaja, Dr. Rita Kizito, Dr. Govender, Michelle van Heerden who had an influence in my academic life. God's richest blessings as you pursue your destinies.

Words cannot express the gratitude I have for my dear friend, colleague, editor, and motivator Ruth Stone who when darkness threatened provided sound advice, fresh perspectives and encouragement.

Then to the students and teachers of UWC (undergraduate and postgraduate) who contributed to our debates and discussions that shaped the dialogue in this thesis, much appreciation for your participation.

To my children Kim, Lyle & (Nadine), Erin & (Brandon) may you be warmed by this achievement and be inspired as it was done for you. Remain humble and respectful as you are and trust in God to bless and sustain you in your life's travels.

Last but not least I would like to express my sincere and loving gratitude to my lovely, friendly wife, Olivia, of 36 years of happily married life; for her friendship, patience, exuberant personality, unwavering love and for sacrificing her time and talent by working at an international school for the benefit of her family, throughout the completion of this degree. You are indeed blessed with a humble and loving spirit.

When Prof. Meshach Ogunniyi said the magic word PRINT, it was like music to my stressed soul knowing that one important journey in my life had reached its destiny and another was about to commence. I love you all.

THANK YOU

DEDICATION

I dedicate this work to my grandchildren Declan, Emerson and whosoever will follow. May you be inspired and always strive towards being custodians of all of Gods' creation during your sojourn on Earth. Make Pa proud!

"Children, obey your parents in the Lord, for this is right. Honour your father and mother that it may go well with you and that you may live long in the land"

Ephesians 6:1-2

ABSTRACT

The study investigated the impact of a dialogical argumentation instructional model (DAIM) as an intervention teaching strategy to assist pre-service science teachers to implement integrated science-indigenous knowledge (IK) lessons during their seven week block teaching practice at schools in the Western Cape. This imperative is found in Specific Aim 3 of the Curriculum and Assessment Policy Statement (CAPS) of the South African School Curriculum (Department of Basics Education, 2011).

The study focussed on the pre-post conceptions of pre-service science teachers' conceptions of the nature of science and the nature of indigenous knowledge. In addition the study examined pre-service teachers' sense of self-efficacy in deploying a dialogical argumentation instructional model to implement an integrated science-IK lesson.

The sample consisted of a cohort of thirty (30) Post-graduate Certificate of Education (PGCE) students training to teach at the Further Education and Training (FET) phase of school. They were a combined class enrolled for method in Natural Sciences, Life Sciences and Physical Sciences.

A mixed methods approach was used to generate quantitative and qualitative data using a series of questionnaires, reflective diaries, journals and focus group interviews. Transcripts provided a rich bank of data of which only exemplars were used to highlight trends and to illustrate how theoretical constructs were used as analytical tools.

The theoretical constructs used were Toulmin's (1958/2003) Argumentation Pattern (TAP), Ogunniyi's (1997) Contiguity Argumentation Theory (CAT) and Banduras' Social Cognitive Theory (1986). The findings showed that the pre-service teachers appeared to overestimate their sense of self-efficacy (i.e. the ease and comfort) in using DAIM to implement a science-IK curriculum at the pre-test than at the post-test. The study also identified important implications for policy, teacher training programmes, teaching practice, pre-service science teachers, learners and further research.

Furthermore, the pre-service reflective experiences indicated their increased awareness of the challenges and successes related to using dialogical argumentation to integrate a science-IK lesson.

The most important contribution of this study to an argumentation paradigm was the emergence of a visual model called the Pyramid Argumentation Model that succinctly connected the apparent disparate module units in a holistic way (To be discussed in follow-up reports).

The findings revealed numerous complexities as the participants navigated their own cosmologies of a scientific worldview and that of their indigenous knowledge worldview. Finally, the findings have not only corroborated the findings in earlier studies with respect to the merits and demerits of argumentation instruction but also identified various challenges that prospective and even practicing teachers might encounter in an attempt to make school science relevant to the sociocultural environment of learners especially those living in indigenous or traditional societies like the participants in this study.

TABLE OF CONTENTS

UNIVERSITY *of the*

WESTERN CAPE

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AIKS:	African Indigenous Knowledge Systems
ANA:	Annual National Assessments
C2005:	Curriculum 2005
CAPS:	Curriculum and Assessment Policy Statements
CAT:	Contiguity Argumentation Theory
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
ITK:	Indigenous Technology Knowledge
MOE:	Ministry of Education
MRD	Model if Reciprocal Determinism
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

OBE   Outcomes Based Education

PGCE: Post Graduate Certificate of Education

RDQ: Reflective Diary Questionnaire

RNCS: Revised National Curriculum Statements

ROSE: Relevance of Science Education

RPL: Recognition of Prior Learning

SIKSP: Science and Indigenous Knowledge Systems Project

SK: Science Knowledge

SSME   School of Science and Mathematics Education

STLP: Science and Technology Literacy Project

TAP: Toulmins Argumentation Pattern

TEK: Technology Environmental Knowledge

TIMSS: Trends in International Mathematics and Science Study

TOSRA: Test of Science Related Attitudes

UNESCO: United Nations Educational, Scientific and Cultural Organisation

CHAPTER 1

INTRODUCTION

1.1   Background

Chapter one provides a background to the development of post-apartheid science education policy in South Africa. The first democratically elected government construed the education system as a way to acknowledge and develop all the cultural groups in South Africa. One of the ways to achieve this goal was to introduce a culturally relevant curriculum which entailed the inclusion of Indigenous Knowledge (IK) in the school curriculum. In addition, part of this reform process also affirms the indigenous knowledge held by all indigenous communities across spheres of activity such as health, agriculture, tourism, media, science, economics and politics (Department of Science and Technology, 2004). In November 2004, the South African Indigenous Knowledge Systems Policy was adopted by Cabinet with a view to recognise, affirm, develop, promote and protect Indigenous Knowledge Systems (IKS) in South Africa (Department of Education, 2002; Department of Science & Technology, 2004).

In the development of the New Curriculum Statements (NCS) and the Curriculum and Assessment Policy Statements (CAPS) there exists 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.

After voluntary teacher severance packages in 1995 and 1996 the closure and subsequent merger of teacher training colleges with that of universities occurred. Further as a way to authenticate its political emancipation from the apartheid system of education a curriculum policy was formulated to enact an inclusive curriculum in the classroom. One of the learning outcomes of the new curriculum namely Learning Outcome 3 (LO3) was the inclusion of indigenous knowledge (IK) in school science in an attempt to make science more relevant to the socio-cultural environment of learners (Department of Education, 2002;

2004a, b & c) and the Curriculum and Assessment Policy (CAPS) (Department of Basic Education, 2011a, b & c).

The study was further inspired by the Science and Indigenous Knowledge Systems Project (SIKSP), a research project funded by the National Research Foundation (NRF) of South Africa with the express purpose of conducting research into the role that dialogical argumentation (DA) could play as an instructional teaching strategy to assist teachers to implement a science-IK curriculum in the science classroom. The SIKSP workshops provided advanced seminar lectures on research design, theoretical constructs and argumentation theory. I wish to trace and describe how the Dialogical Argumentation Instructional Model (DAIM) was developed and secondly to assess the experiences of pre-service science teachers when using this teaching strategy to implement science-IK lessons. Fridays were devoted to advanced seminars conducted by academic staff and Saturdays were devoted to SIKSP research activities such as science-IKS resource material development, preparing conference papers, trialling integrated science-IKS materials and developing argumentation-based instructional models.

My first encounter with IKS accrued when reading the Revised National Curriculum Statements (RNCS) in 1994 when Curriculum 2005 (C2005) was launched. In 2001 my role as a science methods lecturer in the School Of Science and Mathematics Education (SSME), University of the Western Cape (UWC) necessitated the interrogation of policy documents and the implementation of the IKS in science curricula. The Science and Indigenous Knowledge Systems Project (SIKSP) located in the School of Science and Mathematics Education (SSME) was launched in 2004. I participated in the SIKSP research group, located in the School of Science and Mathematics Education (SSME), University of the Western Cape (UWC) since 2004 to the present time. The group consisted of teacher researchers studying towards masters and doctoral degrees. Through this engagement with SIKSP colleagues I was inspired to write and present numerous papers at conferences, staff seminars, co-authored a science-IKS resource book 'Earth and Beyond' (unpublished), assisted in planning five science-IKS related conferences and organised science teacher workshops for the Western Cape Education Department (WCED) aimed at integrating science and indigenous knowledge through dialogical argumentation instruction as a teaching

strategy. This research is a systematic and a continuous undertaking seeks to assist science teachers to grapple with integrating an indigenous knowledge worldview in the science classroom.

In the next section I will provide a context to the purpose of the study and its' importance to South African education with special focus on the sample group of pre-service science teachers.

1.2   Contextualising the Background

The emergence of South Africa from an era of oppression by the Apartheid regime into a new democratic dispensation in 1994 is well documented in the extant literature (Bloch, 2009; Motala & Pampallis, 2001). Since Apartheid Education was used as an indoctrination mechanism to perpetuate racial superiority by the White minority, it was also the first government department to undergo rapid reform. However this reform did not proceed smoothly. According to Vally and Tleane (as cited in Motale & Pampallis, 2001) the process of educational reform in South Africa must be understood against the context of educational policies calling for a "privileged cost reduction and fiscal austerity measures linked to a voluntarily imposed structural adjustment". This sentiment resulted in the quality of teaching and learning being sacrificed under the presumption that equity would be obtained in education. Policies promoted the acknowledgement of socio-cultural contexts by affirming the role that indigenous knowledge systems could play in the new democracy as part of a Ten-point programme for the so-called "Education Roadmap" by "Enhancing pre-service and in-service teacher training (Bloch, 2009). This study does not focus on the economics of education policy imperatives but rather on empowering science teachers and more specifically pre-service science teachers to enable the implementation of science education policy in a way that improves teaching and learning in the science classroom. It seems the pre-service science teachers are strategically placed to introduce an inclusive science curriculum into their classrooms. An effective way to achieve this goal is by using argumentation-based pedagogical instrument. An argumentation-based pedagogy has been

3

promoted and used in a plethora of studies attesting to a favoured and effective classroom discourse (Osborne, Erduran & Simon, 2004).

IK is dynamic in nature, and changes its character as the needs of the participants change. It also gains vitality from being richly entrenched in people's lives. The transformation of education syllabi from a primarily content-driven approach to one of problem solving creates further impetus for the central recognition of IK. This seems to imply that appropriate methodologies for mobilising IK in various learning contexts be identified and used (Department of Science & Technology, 2004, p. 29).

The Department of National Education proceeded to design science curricula that included the sentiments expressed in the Indigenous Knowledge Systems Policy. The curriculum introduced in 1997 was called Curriculum 2005 (C2005) introduced in 1997 was an outcomes-based curriculum better known as OBE. The intention of introducing Curriculum 2005 was to transform the previously racially segregated schooling system to a democratic inclusive education system in line with the achievement of democracy in 1994. Prior to 1994 the schooling system was based on separate curricula and financing systems with disproportionate allocations being made along racial classification lines. Public schools were racially separated and funded disproportionally on a sliding scale of funding, where White schools (now Model C schools) received more funding than Black schools. Funding, infra-structure and resource provisioning was based on poverty indicators. One attempt by the democratically elected government is to level the playing fields by classifying schools according to poverty indicators, so that the poorer resourced schools received more funding than their wealthier Model C school counterpart. With the demise of Apartheid, schools opened their doors to all South African children resulting in multi-cultural classrooms requiring an integrated and transformative approach to teaching and learning.

To meet the demands of the multicultural contexts of the school environment and the changing needs of its curriculum the National Department of Education (NDOE) provided the following curriculum statements Revised National Curriculum Statements (RNCS) (Department of Education, 2002), National Curriculum Statements (NCS) (Department of Education, 2004) and the most recent Curriculum and Assessment Policy Statements (CAPS)

(DOE, 2011). All these curriculum statements acknowledged, in Specific Aim Three (3) `that science teachers should relate science and technology to learners' socio-cultural environment arguing that indigenous knowledge (IK) reflects the wisdom about the environment developed over centuries by the inhabitants of South Africa. Further that much of this valuable wisdom is believed to have been lost in the past 300 years of colonization and now needs to be rediscovered and utilized to improve the quality of life of all South Africans (Department of Education, 2002; Ogunniyi, 2007a).

The incorporation of IKS into school science curricula features internationally in countries such as Canada, the USA, Australia, New Zealand and the Middle East, many African countries, Far East and South American countries, but South Africa has an IKS Policy embedded in national curricula. There are nuances within the various science curricula that teachers should understand. For example the National Curriculum Statements (NCS) intended for Natural Sciences in the General Education and Training (GET) phase stipulates the acknowledgement of indigenous, technological and practices and the wisdom of people located for a long time in one place. The NCS Life Sciences refers to interrelationships between science, indigenous knowledge, technology, history, the environment and society. The NCS Physical Sciences refers to IKS embedded in African philosophical thinking and social practices as evolved over many years. These nuances however do not detract from the important fact that IKS requires acknowledgement and validation in science curricula in South Africa (Department of Education, 2002; 2004a, b & c).

Since its inception in 1997 the outcomes-based C2005 has faced many challenges and criticisms during its frequent revisions e.g. in 2000, 2002, 2009 and 2012. In 2012 the two national curriculum statements, RNCS for Grades R-9 and NCS for Grades 10-12 were combined to form one continuous policy document called CAPS. This curriculum is intended to be fully operational from grade R to grade 12 in 2014.

The reason for this curriculum review was based on an outcry from the public on the unwieldy nature of the 1997 outcomes-based education (OBE) policy and the difficulty teachers experienced with its' implementation. Jansen & Christie (1999), outspoken critics of outcomes-based policy, pointed out the need to simplify the curriculum in a way that would

5

make accessibility to the tenants of the curriculum by teachers and learners easier. The main tenants of CAPS provide for:

1. Curriculum and Assessment Policy Statements (CAPS) for all approved subjects school subjects, notably for science these are Natural Science, Life Sciences and Physical Sciences amongst others
2. National policy pertaining to the programme and promotion requirements for grades R-12
3. National protocol for assessment grades R-12.

In all the editions of the curriculum policies, the principle of promoting critical thinking in learners, the need to integrate IK with school science and to value and acknowledge the contribution of indigenous knowledge in support of interpreting and understanding science concepts, are prominent features. These ideas are captured in Specific Aim Three (3) of CAPS which asserts that:
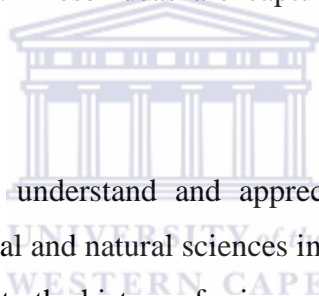
1. Learners should learn to understand and appreciate the history, importance and applications of life, physical and natural sciences in society.
2. Learners must be exposed to the history of science and indigenous knowledge systems from other times and other cultures.
3. Learners should understand the different cultural contexts in which indigenous knowledge systems developed.

The message is clear and the vision for the teaching and learning of science is expressed through the following sentiment expressed in education policy statements namely, that science should be taught in an integrated way in order to enhance the subject and to clarify the relationship between science and society inclusive of indigenous knowledge systems that relate to a specific topic, history of scientific discoveries and the applications of science to everyday life (Department of Education, 2002; 2004a, b &c; Department of Education, 2011a, b & c).

6

It will be argued that despite the good intentions of the new curriculum policy, science teachers in the school system experience immense challenges in implementing the integration of science and IK in a science lesson due to pedagogical incapacity, in the form of a suitable model for promoting science teaching and learning in a social constructivist classroom. As indicated earlier, some of the reasons adduced for these difficulties are an inadequate supply of trained teachers to give effect to implementation as well as an inadequate supply of resource materials and time-on-task strategies amongst many others (Ogunniyi, 2007 a & b; Onwu & Mosimege, 2004).

1.3   Rationale for the Study

The implementation of the new South African science curriculum policy which focused on the integration of canonical school science with indigenous knowledge (IK) posed huge challenges for many teachers. Teachers' outcry at the inception of the outcomes-based curriculum in 1997 was not unrelated to the fact that they were not directly involved in the development of the curriculum. It was a top-down type of curriculum implementation (Ogunniyi, 2004; 2007a & b; Ogunniyi & Hewson, 2008). Like any new curricular innovation in which teachers have not directly participated teachers were well aware of their inadequacies in terms of the knowledge and skills required to implement an inclusive science-IK curriculum. Another challenge posed by the curriculum was that science and IK are based on different epistemologies. Science is largely based on a mechanistic worldview while IK is embedded largely in an anthropomorphic worldview, an omnibus and contentious curriculum based on dissimilar worldviews (Ogunniyi, 1988). These concerns highlighted a need for including an alternative teaching strategy in the science methods programme that could support a learner centred approach to learning science and especially an integrated science-IK curriculum.

I found the research into argumentation discourses by the SIKSP research group valuable as a teaching and learning strategy to encourage teachers into implementing an integrated science-IK curriculum. I decided to investigate how pre-service science teachers

(30) would manage an argumentation instructional model introduced to them as a unit in the science method course.

An argument can be viewed as a type of communicative interaction. Within the last decade there has been an increased interest in determining the effectiveness or otherwise of argumentation in enhancing the students' understanding of scientific concepts (Ogunniyi & Hewson, 2008). Dialogical arguments are those that occur during discussion or debate and involve reasoning with premises that are supportive of their claims. According to Driver (as cited in Skoumios, 2009), dialogical argumentation occurs when different perspectives are being examined and the purpose is to reach agreement on acceptable claims or courses of actions.

Bricker and Bell (2008); Duschl et al, (2008); Osborne et al, (2003) contends that

"…in the field of science education, argumentation is a scientific practice endeavour which help young people learn scientific theories and concepts as well as ensuring how to engage in scientific discourse, learn about the workings of scientific enterprise and come to apply scientific concepts and practices to everyday decision making".

A Dialogical Argumentation Instructional Model (DAIM) as a pedagogical instructional strategy emerged during my involvement with the Science Indigenous Knowledge Systems Project (SIKSP) and evolved through experiences in the use of this tool in a pilot programme with in-service teachers who enrolled for an upgrading qualification programme on the Advanced Certificate Of Education (Science & Technology) from 2009-2011. The National Research Foundation's (NRF) sponsored the Science Indigenous Knowledge Systems Project (SIKSP) run by the School of Mathematics and Science Education at the University of the Western Cape supported a series of regular bi-monthly seminars and workshops run from 2006-2013. The primary purpose of SIKSP was to interrogate argumentation-based methods to assist science teachers to implement an indigenous knowledge science curriculum in schools.

A dialogical argumentation paradigm is one way of creating teaching and learning spaces where the opinions of learners are valued, thus allowing them to make meaning of science concepts. Learners acquire skills whereby they analyse, evaluate synthesis and apply knowledge acquired to new and unfamiliar contexts. The pre-service teacher should be placed in a position during their teacher training course to reflect on those processes that would enable them to implement strategies that encourage learner participation and inquiry.

These seminars and workshops were open to staff and post-graduate masters and doctoral students in science education. The DAIM with its' consequent modifications developed from this engagement. The results and evidence drawn from questionnaires, classroom observations and teacher reflective interviews suggests the suitable positioning of components of the model for organising, scaffolding and writing about science-IK ideas. This model also provides a functional and sustainable strategy method for motivating learners to read, write and talk about relevant science concepts and phenomena. In addition teachers and students found that using this model provided time for facilitation, space to promote discourses, enhanced concept development and interrogation of the relevance of the topic under discussion (Kwofie, 2009; Kwofie & Ogunniyi, 2011).

This agreement can also be seen as a form of cognitive harmonisation. Harmonisation is an attempt to reach a consensus on the issue being argued, which does not imply that participants agree on all points but that a level of understanding is achieved around the issue/s. Dialogical argumentation focuses on the interactions of individuals or groups attempting to convince one another of the acceptability and validity of alternative ideas. Through the argumentation, the learners articulate reasons for supporting a particular claim, attempt to persuade or convince their peers, express doubts, asks questions, relate alternate views, and point out what is new and/or what is not known (Skoumios, 2009; Diwu, 2011; Ogunniyi & Langenhoven, 2011).

In science, models are replicas of the actual object, which may be macroscopic or microscopic, for example, a model of a human heart. An instructional model replicates the way that scientists and philosophers communicate on controversial issues, with a view to

reaching a consensus or understanding of concepts and theories. Hence pre-service science teachers' engagement with the concept of visual modelling in science is also explored as a means to concretise scientific concepts.

The study is further intended to evaluate the effectiveness of the Dialogical Argumentation Instructional Model (DAIM) and the efficacy with which pre-service science teachers navigate their way in using DAIM to implement a science-IK curriculum. DAIM may fit effectively into the pedagogical space of the science classroom in a way that thinking, talking, sharing, learning, teaching, reflection, mediation and research creates spaces for understanding an integrated science-indigenous knowledge curriculum. Through facilitating the teaching and learning environment in a creative way, the science teacher may enable learners to enjoy a richer personal experience of the socio-scientific issues prevalent in society.

This study explores the understanding that pre-service science teachers have of a science-IK curriculum and there efficacy in using DAIM as a teaching strategy to implement a science-IK curriculum in their initial contact with science classes during their first teaching practice block..
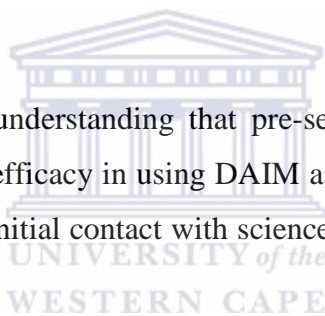
1.4   Problem Statement

This experience with DAIM prompted the need for further research into its' inclusion into science education method courses offered at tertiary level, particularly with initial science education graduate teachers who are faced with the challenge of implementing the CAPS imperatives at the start of their teaching career in the GET Senior Phase (grade 7-9) as well as the FET (grades 10-12). CAPS captured the holistic approach to science teaching as follows:

> "...all of Specific Aim 3 (Science in Society) can be integrated into Specific Aim 1 (Knowing) or Specific Aim 2 (Doing) in such a way that learners can make links with related topics that help them to achieve a deeper understanding of the nature of and connectedness to everyday life" (Department of Education, 2011).

Most of South African science teachers have been schooled to teach the formal eurocentric science curriculum rather than an inclusive science-IK curriculum. As a result of this teachers are experiencing difficulties in their attempts to implement the new science curriculum (Keane, 2008; Aldous & Rogan, 2009; Hewson & Ogunniyi, 2011). Teachers identified some of these challenges as time (periods are too short); lack of suitable materials for integrating science and indigenous knowledge; an exam driven curriculum; science-IK topics are assessed minimally if at all; curriculum advisors have inadequate or incorrect interpretation of policy imperatives; the training of in-service teachers relating to science-IKS directives is inadequate.

The philosophy framed by the CAPS document points to an inclusive paradigm promoting different ways of knowing, accommodating different ways of learning through using localised everyday content (Lubben, 2011). Likewise, the new curriculum recognises indigenous knowledge (IK) as a valued aspect of human experience which can enrich learners overall scientific literacy. In this regard a learner would not see school science as antipodal or separated or inimical to his/her daily experiences or cultural values and modes of operation (Ogunniyi, 2011). Many science textbooks include IK as enrichment or an addition or as an appendage to be romanticised or eulogised about as and when class time allows. This problem is exacerbated by teachers limited knowledge about IKS and the limited access to suitable teaching resources.

Despite the merits of the new curriculum's top-down approach in which the new curriculum was implemented has caused great disaffection among teachers. Hence, at the inception of the new curriculum teachers were confused about how to actualise the goals projected for this curriculum. Teachers resorted to their own interpretation of implementation by using strategies ranging from a total neglect of the philosophy of the new curriculum to compartmentalization of science to rudimentary attempts to integrate the two systems of thought. Despite what has been done to make teachers more favourably disposed to the new curriculum, most revert to a positivist way of teaching and learning science, whereby a pure

scientific methodology is used, neglecting the rich socio-cultural context from which the learner may come (Ogunniyi, 2007b).

The basic assumption of this study is if pre-service and in-service teachers are given the necessary exposure to instructional models they could interpret and implement the tenets of the new curriculum successfully in their classroom. Pre-service teachers at tertiary institutions in South Africa to obtain a teacher qualification along two access routes.

The **first** access route for teacher qualification follows after learners complete twelve years of basic education and obtain a matriculation exemption certificate or its' equivalent. Adults from the workplace may also be admitted after submitting a portfolio of work through a programme called Recognition of Prior Learning (RPL). This category of learner may enrol for the five year (foundation) or four year bachelor of education (BED) (senior primary) programme directed at training teachers for grades 7-9 of the General Education and Training (GET) band. The five year foundation BED allows weaker learners two years to complete the first year of BED, and time for them to orientate into academic studies.

The **second** access route to becoming a licensed teacher begins after a three or four year degree programme or national diploma of education where a minimum of 360 credits is an entrance qualification to the one year Post Graduate Certificate of Education (PGCE), required for teaching at the Further Education and Training (FET) phase of schooling. The Bachelor of Science (BSC.) And Bachelor of Arts (BA) are examples of such qualifying degrees, provided two school subjects are taken up to at least second year level. These teachers are referred to as pre-service teachers or beginning teachers, because they have minimal or no teaching experience. However unqualified in-service teachers with a degree may also find themselves needing to obtain this PGCE teaching qualification before qualifying for permanent employment by the department of education.

DAIM is seen as one such instructional model which could assist teachers to move from a teacher centred classroom to a learner centred classroom. It is my opinion that pre-service student teachers in science disciplines like natural sciences, life sciences, physical sciences and technology are strategically positioned to effectively provide an indigenous science

curriculum after being exposed to an intervention programme. This can be accomplished through demonstrating and modelling the theory underpinning modules such as the nature of science; nature of indigenous knowledge systems; nature of visual modelling and dialogical argumentation instructional model. By incorporating these units of study in the method of sciences module pre-service science teachers are primed for implementing an indigenous science curriculum (Ogunniyi, 2011).

This research provides valuable guidelines for making meaningful connections between science and societal, technological, environmental and indigenous knowledge as a socio-cultural way of dealing with the world (Lazarus, 2004).

1.5   Purpose of the Study

The central concern of this study focuses on how efficaciously pre-service science teachers can use DAIM to implement an integrated science-IK curriculum. More specifically, the study aimed at:

1. Creating awareness of pre-service science teachers about the importance of an integrated science-IK curriculum.
2. Exploring pre-service science teachers' self-efficacy (i.e. ease and comfort) in using a Dialogical Argumentation Instructional Model (DAIM) to implement an integrated science-IK curriculum.
3. Reflecting on pre-service science teachers' experiences in using DAIM as a teaching strategy to implement an integrated science-IK curriculum in science classes.

1.6   Research questions

In the pursuance of the above aims answers were sought to the following questions:
1. What are the pre-service science teachers' pre-post conceptions of NOS and NOIKS?
2. What are the pre-service science teachers' views of an integrated science-IK curriculum before and after being exposed to DAIM?
3. What are the pre-service science teachers' pre-post conceptions of an integrated science-IK curriculum?

4. What are the pre-service science teachers' practical experiences during the teaching practice when attempting to use DAIM to implement integrated science-IK lessons?

1.7   Theoretical Underpinnings of the Study

South African education policy planners recognise that indigenous knowledge meet the challenge of recognising the contribution that culturally diverse learners bring to the science class and as such is in line with attaining social justice and in line with international trends on promoting a socio-cultural curriculum. Ukpokodu (2003), questions pre-service teachers' lack of multicultural literacy in her Social Studies method course. She uses critical pedagogy in her teaching because it is inquiry based and interactive, emphasising a dialogue in which teacher and learners explore and reflect on issues of a socio-cultural nature. This approach finds resonance with the dialogical argumentation discourse being applied as a method with pre-service teachers in science methods courses in South Africa. Also the remarks by Gutman (1995), on the recognition that *American* society consisting of many cultures have particular resonance with the multicultural nature of the South African society, where eleven languages out of several others are officially recognised by the South African government. Gutman stresses further that "It is both morally wrong and empirically false to teach students as if it were otherwise" (p. 30).

The following brief introduction to the theoretical framework is intended to contextualise the socio-constructivist paradigm on which the study is based. The three theories are Toulmin's (1958) Argumentation Pattern (TAP), Ogunniyi's (1997) Contiguity Argumentation Theory (CAT) and Bandura's (1977) Social Cognitive Theory. Toulmin's Argumentation Pattern (TAP) and Ogunniyi's Contiguity Argumentation Theory (CAT) are used as theoretical constructs and tools of analysis to understand and interpret the views and perceptions of pre-service teachers on the integration of science and indigenous knowledge lessons in the school curriculum in South Africa. TAP is not strictly speaking a theory but a philosophical analysis of argumentation discourse. This will be explained in Chapter 2. Bandura's (1977) Social Cognitive Theory is used to explicate pre-service science teacher efficacy in implementing DAIM as pedagogy for teaching integrated science-IK lessons.

Where TAP provides an understanding of the dynamics of logical argumentation, CAT allows for self-evaluation of the present mental state with regard to a set of mental cognitive states brought about through thoughtful consideration of beliefs and culture. Ideas flow in and out of these cognitive states through experiential exposures of one or other form.

TAP and CAT is used extensively as both a theoretical and analytical tool by researchers in the Science and Indigenous Knowledge Systems Project (SIKSP) since 2001. In addition argumentation is used as a teaching and learning strategy to create spaces for dialogue in science classes. Further elucidation can be found in the literature review Chapter Two.

1.7.1 Toulmin's Argumentation Pattern (TAP).

Stephen Toulmin was an English philosopher who in 1958 authored a book called *Uses of Argument* in which he spelt out his argumentation theory TAP. Toulmin postulated the elements of an argument as consisting of the claim, evidence, warrant, backing, qualifier and rebuttals. The claim is the main idea that is being contested. So, during a lesson on IK and physical phenomena (such as lightning), a learner might postulate from his/her IK that a big bird in the sky causes lightning and thunder. In order to discern the claim, the question to be asked is, 'What are we trying to prove or disprove'?

Next, Toulmin says for a claim to be valid it must be *supported* by data or evidence. Warrant denotes the link between the claims. The warrant helps the claimant to justify his/her assertion. For instance in the case of the claim of a bird causing lightning, the arguer may claim that a friend has actually seen the bird. But to justify the claim the opponent might want to make a personal observation than purely a claim based on a persons' public one. Of course the problem of justification of metaphysical belief is not amenable to experimental observations. However interesting as the subject may be, it is beyond the scope of this study.

There are three further parts to TAP, namely *qualifiers, rebuttals* and *backings.* These three additional parts of TAP do not appear in every argument and can, to all intents and purposes, be left out of the argumentation pattern when used by the teacher in the classroom.

A rebuttal can be explained as a rejection of the claim or if an alternative view is offered then it is simply identified as a counter-claim. It is unlikely that every claim will meet with general approval from the learners in the class.

TAP is particularly useful for science teachers because through this method of discussion learners are exposed to the power of logic. In addition TAP is used as an analytical lens to judge the level of an individual or groups argument.

1.7.2 Ogunniyis' Contiguity Argumentation Theory (CAT)

CAT attempts to examine both rational and non-rational arguments which are commonly evident in discourses. When a controversy is about ethics, cultural beliefs and values, TAP is greatly limited, for example, should people of different socio-economic status pay the same rate of electricity? Should animals be kept in the zoo? Should women be circumcised? Is the death sentence justified? And so on. While TAP can explain effectively the rational arguments involved it might be greatly limited in dealing with the affective arguments involved in the issues listed. CAT on the other hand does not attempt to declare a verdict of what is valid or not but attempts to show various categories of mental states involved in declaring a stance. The stance may be based on scientific, religious, cultural arguments or a mixture of these or both can exist. CAT confines arguments mainly for the purpose knowledge building or   which culminates in a specific stance.

CAT is found to be a suitable theory to explain contrasting cosmologies or different thought systems such as science and indigenous knowledge held by pre-service teachers as they grapple with attaining an understanding of the cognitive shifts between cultures (Moyo & Ogunniyi, 2013; Siseho et al, 2013). The study used CAT to determine whether a transformation in pre-service teachers' views and practices are possible after a one semester intervention programme that orientated them into the socio-culturally sensitive instruction in science and indigenous knowledge and the reality of integrating them through argumentation as pedagogy (Amosun, Ogunniyi & Riffel, 2013). 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

16

cognitive state. The five cognitive states are given as: Dominant; Suppressed; Assimilatory; Emergent; Equipollent and is discussed in Chapter 2: Literature Review.

1.7.3 Bandura's Social Cognitive Theory

Bandura who was well known as a behaviourist psychologist in the 1970's has over the years leaned towards a cognitivist paradigm. In order to develop a strong sense of peoples self-efficacy Bandura suggests three types of modelling, namely, social modelling, where people see others like themselves being successful,; mastery where people achieve goals and overcome failures and social persuasion, when people are persuaded by others that they can succeed.

Tschannen-Moran & Hoy (2001) regards mastery experiences by the teacher as an indicator of capability, whereby the task to be accomplished is analysed and they assess their competence in relation to it. Hence the context of the teaching situation and the specific content are important influences for judging their efficacy levels. Bandura (1997) is of the view that self-efficacy beliefs established during early learning as in the case of future beginning teachers, once developed, are resistant to change.

Teacher efficacy belief is a judgement of a teacher's capabilities to bring about desired outcomes of learner engagement and learning in relation to outcomes such as achievement, motivation, and the teachers' own efficiency in planning and organisation of the teaching moment. Teachers are also opened to new ideas and willing to experiment with new methods to improve their learners understanding in an uncritical and empathetic way. Furthermore teachers exhibit a greater enthusiasm for teaching (Tschannen-Moran & Hoy, 2001).

1.8 A Dialogical Argumentation Instructional Model (DAIM) as a Conceptual Framework

The study used the concept of 'argumentation' as a conduit for pre-service teachers to create a teaching and learning environment that could efficaciously be used to teach an indigenised science curriculum. In line with Social Cognitive Theory, a Dialogical Argumentation Instructional Model (DAIM) was used to induct pre-service teachers into an intellectual discussion space through selected cognitive tasks requiring sequential engagement at the individual (intra-argumentation), small groups (inter-argumentation) and whole group (trans-argumentation) levels of discourse with the goal of reaching consensus or conceptual understanding (cognitive harmonisation) where possible (Langenhoven, 2009; Kwofie, 2009; Diwu, 2010; Afonso & Ogunniyi, 2011; Kwofie & Ogunniyi, 2011; Langenhoven & Ogunniyi, 2011; Diwu et al, 2011). The concept of argumentation as related to the DAIM is further explicated in the literature review discussed in Chapter Two.

In a review of international trends in promoting a learner centred approach, the National Science Education Standards (NSES), Australia view scientific inquiry "as an integral component for restructuring science education". There is a call for learners to work collaboratively, investigating research questions in small groups and moving beyond the walls of the classroom (Drayton & Falk, 2001).

There are three elements particular to a constructivist instructional learning theory: (a) A learners prior knowledge – what a learner knows or believes interacts with a new conception to which the learner is exposed; (b) learners construct meaning through interactions with others, with materials, by observation and exploration of interesting and challenging activities; and (c) learners should construct understanding around core concepts and big ideas (Brooks & Brooks, 1999; Haney & McArthur, 2002). An instructional process such as Dialogical Argumentation Instructional Model (DAIM) enables learners to talk about their ideas and express their understandings and belief with a view to deepening science conceptual understanding (Ogunniyi, 2007b).

Bleicher & Lindgren (2005) concluded that the time and effort required to teach a science methods course incorporating hands-on experiences, extensive discussion, explanation and extensions in order to reinforce science concepts, make connections to other science ideas as well as to the everyday world, supports the need for engaging in dialogical argumentation pedagogies. A social constructivist orientated classroom provides the teacher facilitator with insights into how learners are thinking and understanding. It allows the voices of learners to be heard thus giving teachers an opportunity to identify their levels of understanding or misunderstanding.

1.9   Significance of the Study

The National Curriculum Statements (NCS) policy for grades R-12 supported by the Curriculum and Assessment Policy Statements (CAPS) advocate the integration of IKS in all school curricula at the GET Phase. The study explores the effectiveness of using a dialogical instructional model as a pedagogical strategy that would enable pre-service teachers studying at a South African urban university to use a discourse approach that would equip them to teach topics of a socio-science nature in an integrated way.

Comparative research trends are discussed with a view to transforming and/or improving curriculum design, materials development and instructional model implementation for pre-service teachers by implementing a dialogical argumentation instructional model that would enable them to effectively teach integrated science-IKS lessons. The study may reveal whether a dedicated pre-service teacher training intervention programme inclusive of dialogical argumentation and visual modelling enhances their efficacy in teaching integrated science-IKS based lessons. The research findings may lead to recommendations that may benefit science curriculum planners, science curriculum advisors and science teachers in realising an integrated science-IKS curriculum in the formal schooling system (Foulds, 2003).

Any meaningful curriculum change and innovation must start with the teacher. It is hoped that the study will show that by using a defined pedagogical model such as dialogical

argumentation, a pre-service science teacher can create a meaningful teaching and learning environment for teaching integrated science-indigenous knowledge lessons.

A study by Newton et al, (1999) argues for the promotion of curriculum change and a pedagogy that moves away from the mechanistic exam driven curriculum to one that is relevant and equips new science teachers with the skills necessary for applying social constructivist principles pedagogy such as dialogical argumentation. The value of advocating this pedagogy is to practice the ability to sift, sort, and interrogate information and to assess its implication and significance to society's well-being. Newton et al, (1999) are of the view that existing curricula are in danger of becoming irrelevant both to society and to in the new millennia. Schools, it is argued, should provide opportunities to young people to develop skills of listening, arguing, making a case and accepting the greater wisdom or force of an alternative view and 'who are capable of making considered decisions' and 'making considered choices' on controversial issues of a socio-scientific nature.

Boulter & Gilbert (1995) supports the argument that a technocratic orientation to science education is leading to a repressive pedagogy that emphasises rote learning at the expense of deeper understanding. The perception is that few science teachers have so far developed the skills necessary to include argumentation in their repertoire.

With these sentiments in mind, this study could be significant in that the process and the efficacy of dialogical argumentation is interrogated in order to assess the viability of implementing alternative pedagogical approaches, such as this to science education.

This study lends itself to the possibility of fostering the development of a spirit of Ubuntu in pre-service science teachers. They are seen to have the potential to act as key teachers as they communicate the skill of argument to learners by using DAIM as a teaching method supported by visual modelling of such as DAIM and Bandura's Model of Reciprocal Determinism.

1.10   Delimitation of the study

1. The study used a purposive sample of thirty (30) graduate student teachers enrolled for the Post Graduate Certificate of Education (PGCE) intended to provide a recognised qualification for teaching at school, within the General Education and Training Senior Primary (GET-SP) phase (grades 7-9) and/or Further Education and Training (FET) phase (grades 10-12). These student teachers acquired content knowledge in their undergraduate degree by studying a selection of science related modules up to at least second year in various science related fields such as Life Sciences, Biotechnology, Chemistry, Physics, Microbiology, Biodiversity and Conservation, Agricultural Sciences, Earth Sciences, Environmental Studies, Physiology, Human Anatomy, Bio-informatics, Sports Science and Health Related Sciences. Entrance qualifications required them to have at least studied to 2nd year level in at least two of these areas. The basic areas that should be covered in the undergraduate degree in order to teach school subjects would be physics, chemistry, botany, zoology and physiology. This is rarely the case and many students would experience gaps in their content knowledge. These gaps are generally filled through experiential on the job learning. Hence the content background is not homogenous which may factor in on their efficacy.

2. The majority of the students, twenty six (26) or 87% had no teaching experience, whist four (4) or 13% had taught in schools as unqualified teachers. In addition the level of teaching experience of the thirty (30) students in the sample varied and this may add complexity to the analysis of the study. Two (2) come from the workplace environment, four (4) have advanced degrees, and four (4) have tutoring experience at tertiary level.

3. Orientation lectures, practical activities and demonstration lessons based on using DAIM to teach an integrated science-IK lesson were presented. These lectures took place over a series of fourteen contact sessions of three hours duration during the first semester of 2012. A total time of 42 hours were expended on the training session.

4. The lectures were supported by hard-copy and e-learning readings on the Nature of Science (NOS), the Nature of Indigenous Knowledge Systems (NOIKS), the Dialogical Argumentation Instructional Model (DAIM) and the Nature of Visual

Modelling (NOVM). Interactive sessions included demonstration lessons, power-point lesson summaries, video material on integrated science-IK lessons, e-learning readings included (a two volume package-**Volume 1**: Nature of Science and **Volume II:** Nature of Indigenous Knowledge Systems): Trial runs of groups teaching integrated science-IK micro-lessons using DAIM as pedagogy to their peers were an integral part of the interaction, as well as classroom observations, followed by classroom observation and reflections of selected samples of pre-service science student teachers lessons during teaching practice block.

1.11   Limitations of the study

1. Since the study is delimited to science student teachers enrolled in science education method courses such as natural sciences, life sciences and physical sciences the results cannot be generalized to other method courses in the faculty or any other education faculties. In order to maintain a viable class size all students attended a combined methods class where generic topics were discussed followed by tasks and assignments in their respective selected method areas of specialisation. The advantage being that science knowledge can be seen holistically and integrated instead of fragmented and disparate, and students' science knowledge gaps can be identified and conceptually addressed.

2. The forty-two hours allocated for the orientation of these student teachers into systematic learning procedures for implementing the Dialogical Argumentation Instructional Model is hardly enough for assessing its' application use in the classroom as it was limited to a seven week stint of teaching practice.

3. Furthermore time allocation for classroom observation is constrained by school environmental factors such as time-on-task schedules, syllabus requirements, tests, annual national assessments (ANA), principal and subject teacher's goodwill, learners' attitudes, discipline and student teacher's limited management skills. A further limitation is the placement of student teachers with large class groups, in under-resourced schools and in schools that display disciplinary problems.

4. The high absenteeism amongst teachers at the host schools sometimes resulted in student teachers having to teach and supervise classes, thereby neglecting the preparation of their own scheduled lessons.

5. Advantages in some schools were the cultural mix of learners who could share indigenous beliefs during discussion time. This form of enculturation is supported by; Aikenhead (2003); Lazarus (2004); Liphoto et al, (2008) and Ogunniyi (1995) who argue for maximising this pluralistic cultural mix by using a pluralistic teaching approach that favours a science- indigenous knowledge mix for engaging co-existing alternative worldviews in teaching methodologies.

6. Classroom observations and focus group interview reports were based on the observation and responses of ten (10) student teachers. These students were randomly selected using equity criteria such as gender (male & female) and language (English, Afrikaans and isiXhosa which are the Languages spoken in Western Cape Schools, where the study was conducted.

7. The lingua franca of the university is English and a small percentage of the pre-service students may experience difficulty with translations, but in the main English formed one of the bilingual languages required for the Bilingual Language Endorsement Certificate. The language combinations would then be English/Afrikaans; English/isiXhosa; English/Indigenous or Foreign Language.

8. Despite these limitations it is hoped that the findings would prove informative and useful in promoting attempts to equip pre-service science student teachers with relevant ideas on how to teach an integrated science – indigenous knowledge curriculum compliant with the South African National Curriculum Statements (Science) and the Curriculum and Assessment Policy Statements (CAPS).

1.12   Operational Definition of Terms

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

1.12.1 Contiguity Argumentation Theory (CAT)

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

1.12.2 Dialogical Argumentation Instructional Model (DAIM)

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, 2009).

1.12.3 Efficacy

Efficacy may be defined as the ability to implement a course of activity in an efficient, competent and confident way. *Efficacy* has to do with how a teacher feels about his or her ability to do their job. Gordon (2006) says that, "Teacher efficacy is sometimes considered to be an indicator or prediction of teaching effectiveness" (p. 5). A more contemporary word for efficacy could be *confidence.* If a teacher feels confident that he or she can teach using the dialogical argumentation model then … that teacher would be described as being highly efficacious (Cubukcu, 2008). *Self-efficacy* will be manifested in a teacher's esteem and ability to effect positive change in the classroom. Self-efficacy is evident in the response a person gives when asked, 'How well can you perform that task'? Highly efficacious teachers face their tasks with a great degree of optimism and are very confident in their ability to do that job well. They also have the ability to persist in the most difficult situations, remain level headed, and turn those difficult situations around with successful results. When *teacher efficacy* is used in this study, it refers to the level of success in implementing the dialogical argumentation instructional model.

1.12.4 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; Fasokun et al, 2005;).

1.12.5 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).

1.12.6 Nature of Indigenous Knowledge Systems (NOIKS)

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

1.12.7 Pre-service science teachers

These are under-graduate or post-graduate student teachers in an initial teacher training programme such as the undergraduate Bachelor of Education (BED) or Post Graduate Certificate of Education (PGCE) with little or no teaching experience (Education Labour Relations Council, 2003).

1.12.8 Relevant science

Relevant science is science that makes sense of lived experiences and can be applied (used) in everyday living. The ability to be literate in the discourse of science, for example reading, writing and talking science as well as understanding and seeing the relevance and interactions between science, technology, society and the environment (England et al, 2008).

1.12.9 Nature of Science (NOS)

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

1.12.10 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).

1.12.11 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).

1.12.12 Western Cape Province Classrooms

Western Cape Province classrooms refer 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 speaking learners. The language of instruction is dependent on the language preference of the geographic area in which the school is located and is determined by the School Governing Body.

1.13   Overview of Chapters

Chapter 1: Background

This chapter provides a rationale for conducting this study with pre-service science teachers located at a university in the Western Cape, South Africa. A pedagogy using argumentation could assist teachers to implement an integrated science-indigenous knowledge systems curriculum as prescribed in the Curriculum and Assessment Policy Statements (CAPS), South Africa. A historical perspective is given of the development of education policy before and after democracy in 1994. The chapter is focussed on the purpose

of the study, research questions, theories underpinning the study, as well as an introduction to the Dialogical Argumentation Instructional Model (DAIM).

Chapter 2: Literature Review

In Chapter Two a literature review is undertaken with a view to probing available literature that focus on three main discussion areas, namely (1) integrating science and indigenous knowledge as postulated in the CAPS (2) dialogical argumentation pedagogy and (3) efficacy of pre-service science teachers in implementing an integrated science-indigenous knowledge curriculum. The structure of this dissertation is organized around the conceptual framework of Toulmin's Argumentation Pattern (TAP), Ogunniyi's Contiguity Argumentation Theory (CAT) and Bandura's Social Cognitive Theory. A discussion of how DAIM evolved and developed within the Science and Indigenous Knowledge Systems (SIKSP) workshops and seminars is described. Papers related to topics on the integration of science-IK curriculum which have been presented at conferences and published in journals are also reviewed.

Chapter 3: Methodology

This chapter considers the processes of collecting data from the purposive sample thus providing evidence in support of interpretations and analysis of responses to the research questions. Instrumentation used to gather information particularly in relation to the scope of the study is discussed. A rationale is provided for choosing a   flexible research design approach (Robson, 2002) and the selection of case studies.

Chapter 4: Results and Findings

The data generated in this study is presented and discussed. The discussion and findings are considered with the references to the literature study in Chapter Two in order to interpret the process that occurred during the teaching of argumentation and its purpose for implementing integrated science-Indigenous Knowledge lessons by pre-service science teachers in science classrooms.

Chapter 5: Recommendations and Conclusion

In this chapter I make recommendations for further development and research related to argumentation instructional models, classroom practice, policy imperatives, material and resource development and method of science course development. Conclusions are drawn on the study and its contribution knowledge.

UNIVERSITY *of the*

WESTERN CAPE

CHAPTER 2
LITERATURE REVIEW

2.1   Introduction

This chapter reviews the extant literature on the issue of integrating science with indigenous knowledge with school science. First it explores the literature on the nature of Science (NOS), Nature of Indigenous Knowledge Systems (NOIKS) and the Nature of Science Indigenous Knowledge Systems (NOSIKS) curriculum as enunciated in the new South African Revised Curriculum Statement (RNCS) and the Curriculum and Assessment Policy Statement (CAPS). Secondly the chapter seeks to justify why an argumentation framework is considered most apposite for engendering the integration of the two systems of thought namely, science and IKS. However before treating these issues it is apposite to explore briefly the relevance of an inclusive science education in the new South Africa. The dramatic socio-political changes that have taken place in South Africa since the first democratic election in 1994 have affected all facets of society including the education.

2.2   Background

In the Manifesto on Values, Education and Democracy (2001) it is stated that: "an education system does not exist to simply serve a market, important as that may be for economic growth and material prosperity. Its primary purpose must be to enrich the individual, and by extension then, the broader society." In 2001 the late Professor Asmal Kader, as Minister of Education, made a call for "respecting and understanding oral traditions, the role they play and the skills they impart". Part of this understanding must be that respect be shown for the oral traditions of all cultures, African, Western or otherwise (Department of Education, 2001). The influence of myths, traditions and modern youth culture produce the dilemma of making choices (Ogunniyi, 1987; Ogunniyi, 1988; Cordero, 2001). One would hope that these are informed choices and that the educational community is in a position to confront this daily challenge.

29

This advocacy for accepting the cultures and traditions and experiences of different communities promotes the idea of Ubuntu by fostering a harmonious living relationship between fellow men, between man and nature for a sustainable future in employment, food security, environment and essential needs. Van Driel et al, (2001) recognises the complex nature of teaching which accounts for the knowledge held by teachers as an integrated set of knowledge, conceptions, beliefs and values brought to bear on the context of the teaching and learning environment. This implies that science education and a science curriculum design can and should contribute to a culture of science literacy. Onwu et al, (2005) posited that whilst scientific literacy is an important science education goal with the integration of science and indigenous knowledge a sub-set of science literacy and multi-cultural science education, there appears to be no consensus on what it is that should be done to assist teachers and learners achieve science/indigenous knowledge integration. The question of how education must direct itself to "the preparation of the child for responsible life in a free society, in the spirit of understanding, peace, tolerance, equality of sex and friendship among all peoples, ethnic, national and religious groups and persons of indigenous origin".
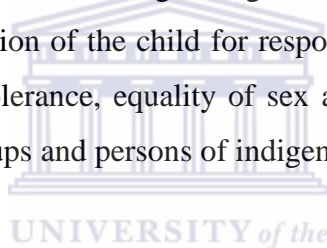
2.3 Historical overview of Science Indigenous Knowledge Systems Project (SIKSP)

As mentioned in Chapter 1 the driving force underscoring the research in this study is the SIKSP. This historical summary of SIKSP aims and activities provide a further rationale for this study. The information is provided by the SIKSP project director Professor. M.B. Ogunniyi.

2.3.1 The aims of the project

- In-depth access to IKS in nine provinces & to integrating the knowledge gained implementing a science-IKS in the classroom.

- Develop an integrated of online repository of archived IKS which will serve as a clearing house for IKS information query, archived by researchers from all the provinces

- Develop a comprehensive catalogue of IKS studies in all the provinces

- Develop a website to provide an active forum for researchers working on IKS.

- Develop IKS-embedded instructional materials that provide high quality contextualized scientific material covering relevant topics of the CAPS from the Foundation to the FET phase and combine IKS-embedded instructional tools with the requisite assessment materials that can act as benchmarks of quality, and exemplars for teaching.

- Pilot Science-IKS integrated materials in the classroom and evaluate their efficacy.

- Build up a community of practice in an area where research capacity is very low.

- Equip Master's, doctoral and post-doctoral students with research skills in an authentic South African context.

- Initiate and conduct multi-disciplinary research as an integral component of the institutional intervention initiative in IKS education at school level in accordance with the National IKS policy

2.3.2   Moving forward on integrating science and IKS

- In 2006 we ran the first conference on SIKSP with most participants coming from South African institutions.

- The second conference on SIKSP was run in 2009. At that conference participants came from South Africa and abroad (including Prof. M. Ogawa from Japan).

- In 2010, we led a national effort in developing the Science-IKS innovation materials. The SIKSP, is thus a product of this attempt to develop a co-ordinated national platform for the integrating science and IKS using a phased approach, beginning with five provinces in the first national phase, and extending the activities to the rest of the

31

country once all structures were set in place and taking into consideration the lessons learned from the first phase.

- In 2011, the SIKSP undertook the third international SIKSP conference with over 40 participants from various African countries, Europe and North America. In 2011 we added two sister projects namely, the National IKS Project (NIKSP) and the South African/ Mozambican Systematic Analysis Project (SAMIKSP).

- The fourth international SIKSP conference took place in October 2013, with around 50 participants and the establishment of the African Association for the Study of Indigenous Knowledge Systems (AASIKS)

- In July 2014, the first ever science teacher training workshop "Creating teaching and learning spaces for an integrated science-IKS curriculum' was conducted in the Western Cape.

- A vast amount of data have been collected through the three projects is awaiting analysis for publication considerations.

- It is apposite to state that since the inception of the project over 50 papers have been published in refereed journals and conference proceedings and more than 10 Masters and doctoral degrees have been completed.

2.3.3   Findings so far

- The initial results of the first three phases -2004-2007, 2008-2010 and 2011 - 2013) of the project indicate the following:

- Participating teachers had become more aware of the appropriate context to use the scientific or IKS worldviews than was the case before the onset of the project. Also, their experience on the project seemed to have greatly enhanced their sense of social identity (Ogunniyi, 2006; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008; Ramorogo & Ogunniyi, 2010).

- Participating teachers found it easier to integrate science learning outcomes 1-3 and thus made science and mathematics more relevant to the daily living contexts of their learners. (Ogunniyi, 2004; 2005).

- Participating teachers have not only acquired higher degrees and research capacity they have become more confident to teach indigenous knowledge which has direct relevance to school science and the life worlds of their learners (Ogunniyi, 2007a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008)

- The interface of IKS and argumentation by teachers reportedly produced learners who were more critical and able to support their observations and views. The results were even more striking with learners in the Foundation Phase (Ogunniyi, 2004; 2007a & b; Ogunniyi & Hewson, 2008).

2.4   Science curricula

Curriculum defines what counts as valid knowledge (Bernstein, 2002). Valid knowledge transmitted to learners forms an integral part of the curriculum and is the curriculum. The word 'content' refers to this valid knowledge that is found in the curriculum. IKS as stipulated in the NCS (National Curriculum Statement) and Curriculum and Assessment Policy Statement (CAPS) in South Africa and is expanded upon and explained in Specific Aim 3: Science, society and the environment. This component brings with it, the addressing of cultural concerns of the general population of our country as well as learners respect for their society constituted of local communities, "…the content of the curricula is largely devoid of any meaningful cultural context." (Ogunniyi, 1989, p. 826) states in support of IKS that our present position with regards to cultural context inclusion in the NCS is a valuable step in the right direction. Meaningful cultural context is included by curriculum designers in NCS and CAPS through recognition given to the diverse cultures present in South African society. Ogunniyi (1989) continues to note, "There seems to be an urgent need to design science curricula that foster among learners the acquisition of valid knowledge, but at the same time are sensitive to their value system".

Learners may or may not have been exposed to IK in their own cultures but have failed to recognise its value. The exposure of rural South African youth living in urban areas to modern day trappings and technologies (modernity) is huge and many may have lost their connections to their cultural heritage life experiences. However, in rural environments notions of IK will be stronger since many rural communities are dependent on IKS for survival because of a lack of basic resource needs such as clean running water, electricity and waste removal. Alternatively urban South African youth have an alternate experience of the nature of indigenous knowledge and may view this practice as primitive or "uncultured" and may never encounter IKS practices

2.4.1 Relevance in the science curriculum

In November 2002, about 9 000 Grade 8 learners from South African public schools participated in the Trends in International Mathematics and Science Study (TIMSS) 2003. TIMSS set out to measure learner achievement in mathematics and science, as well as learner beliefs and attitudes towards these subjects at a national and international level. In addition the study also investigated curricular intentions and classroom environments. The South African report on TIMSS 2003 was completed and published by Human Sciences Research Council in 2006 and the findings had implications for policy, practices and research. South Africa is ranked with the weakest group along with Lebanon, Philippines, Botswana and Ghana. It was also placed lower than the international average scale score.

1. South Africa also had the widest variation of science achievement scores which suggested that there were some learners who performed very poorly and others who performed very well.
2. South Africa was one of the countries where there was no gender difference in performance.
3. The Western Cape Province and Northern Cape Province are regarded as top performers with Eastern Cape and Limpopo as poorer performing provinces in South Africa.

4. Learners at schools serviced by a high poverty community performed poorly compared to those at schools serviced by a low poverty community.

5. It was reported that in science, learners performed better in the chemistry domain, while performance was weakest in physics and earth science.

The TIMSS 2003 report provided this look at South African learner achievement in Science but lacked insight into the learners' contextual viewpoint of science and technology as experienced in the classroom and in their everyday life (Martin et al, 2004).

Woolnough (as cited by, Jenkins, 2001, p.40) argues that:

One of the problems about constructivism, and other theories of learning, is not that they get the answers wrong but that they ask the wrong questions! They seek to answer the question 'how do pupils learn'? What we ought to be asking is 'what makes pupils want to learn'?

The assumption in general is that, the attitude of South African learners towards science is positive as they have self-confidence and enjoy and value the subjects. This may only be a socially desirable response and we need to probe further to determine the 'real' attitudes of learners. The evidence suggests that schools that are economically disadvantaged score less than those schools where learners are not disadvantaged and that explanations for weak learner achievements cannot be provided by a single factor – it is a combination of a number of variables (Reddy, 2006).

Sjoberg (2000) in an article entitled 'The disenchantment with science' argues for a rethinking of current science teaching and curricular. He advocates a science education curriculum that is related to key values in a democracy such as respect for arguments and evidence, as well as a critical and rational basic attitude. The work of Kolstø (2000) looks at topics and ways of dealing with socio-scientific issues and proposes research projects probing not only pupils knowledge and views on science in social contexts but also into its' applicability to complex real-life problems. What is needed is for people in the developing world to believe more in themselves and to develop systems, programs, and practices that are

authentic and contextually relevant and not to uncritically follow the dormant order (Gray, 1999, p. 267).

Langenhoven (2006) argues that in South Africa the positive attitudes by learners towards science and mathematics do not translate into high achievement scores as evidenced in the TIMMS study conducted in 2003 (Reddy, 2006) where grade 8 learners from South Africa were ranked consistently in the bottom three countries well below the average international benchmark score on science related items. In further support the ROSE survey conducted in 2006 with grade 9 learners in the Western Cape, South Africa, showed these learners have a high positive interest in learning science. This interest is similarly displayed by learners in both socio-economic school areas classified as low poverty and high poverty.

It is my contention that pre-service teachers are strategically positioned to engage with discussions and implementation strategies of a pedagogical process that promote constructive dialogical argumentation around such discourses, and are able to bring relevance to an otherwise content and examination driven science curricula.

2.5   The Nature of Science (NOS)

South African education policy documents require pre-service science teachers to have a solid grounding in the basic tenants of science. These tenants are facts, principles, theories, laws and processes in addition to science process skills (observing, comparing, measuring, recording, sorting, classifying, interpreting, predicting, hypothesising, investigating communicating etc.) necessary for scientific inquiry (DOE, 2002; 2003). Science is normally subjected to certain methods of inquiry and is regarded as a human enterprise. For this reason one should have some understandings and skills associated with the development of scientific knowledge in terms of its cultural, political, historical, economic and societal role, its philosophy, status and significance (Dekkers & Nbisi, 2003). South Africa has further chosen to integrate traditional knowledge systems and indigenous technologies in order to address the imbalances of the past and hopefully develop economic enterprises that optimise the rich indigenous heritage for example Rooibos tea (a detoxifying

health drink harvested from the leaves of *Calicotome villosa* – an indigenous *fynbos* plant) and the *Hoodia gordonii* an indigenous succulent plant (extracts used for slimming). These plants used for centuries by indigenous people (Khoi-San) have been exploited commercially without much benefits filtering down to them.

The extant literature extols the need for the nature of science (NOS) to be reflected in the science curriculum and more so for pre-service teachers who are expected to incorporate its' characteristics in science lessons. Driver, et al, (1996) provided five reasons for teaching NOS:

1. Utilitarian – in order to manage their daily encounters with diverse technological products.
2. Democratic – equip people with the necessary knowledge to make democratic decisions on socio-scientific issues.
3. Cultural – appreciation of science as a critical element in contemporary culture.
4. Moral – science contributes to ethical values.
5. Educational – to succeed in science NOS must be understood.

Ogunniyi and Pella (1980, p. 591) posits NOS as an elusive concept:

> The so-called 'nature of science' is a complex concept. It involves the processes whereby scientific information are gathered, analysed, synthesized and disseminated; the products or the linguistic structure by which regularities in nature are described, explained, predicted and upon which the meanings of scientific content depend; the written and unwritten ethical system and conventional codes of conduct guiding the scientific community in its methodological inquiry.

In a collaborative research on the Science and Technological Literacy Project (STLP) between South Africa and Zimbabwe from about 1997 to 2004, teachers and learners understanding of NOS and how NOS relates to the nature of other knowledge systems gained attention. The conclusion of this research pointed to the difficulty teachers had with coming to terms with science from a non-Western worldview that is notably culturally and traditionally determined. Their relativist view sat uncomfortably with their positivist view (Dekkers et al, 2005).

Bell et al, (2011) further reviews the continuing debate around whether NOS should be taught from a contextual viewpoint or an explicit viewpoint. They further define the three teaching strategies that emerged over the past four decades, these being, teaching NOS from the "historic approach" based on episodes from the history of science; the "implicit approach" which emphasises doing science and the "explicit approach" where the teacher intentionally focus learners attention on "so-called" authentic" science concepts such learning about atomic structure or pH values (p. 417). The work by Lederman et al, (2002) is also of immense importance in delineating the characterisation of NOS whereby a conceptual framework was developed for inclusion in various American education reform documents. Scientific knowledge in these documents is described as being:

1. Empirically based upon and/or derived from observations of the natural world.
2. Tentative and subject to change with new data and new perspectives on existing data.
3. Possessing inherent subjectivity based on theory.
4. Partly the product of human inference, imagination and creativity.

A further discussion centres around contextualisation and situational learning proffering the view that socio-scientific issues provide a potentially powerful context in which teachers can integrate instruction about science content and NOS in ways that help "students envision the connection that exists between global issues and themselves like global warming" for example (Driver et al, 2000; Sadler, 2004) .

In fact the South African science education reform policy documents (DOE, 2002; CAPS, 2011) suggests that by learning science through contextualisation and situational location learners may more easily integrate NOS concepts into their schema of thought knowing the authenticity or value of science (Scott et al, 2007). Driver et al, (2000); Kolstø, (2001) echoes the idea of integrating socio-scientific issues into science instruction as a means to empower learners in preparing them to become informed decision-makers.

2.6   The Nature of Indigenous Knowledge Systems (NOIKS)

The research literature is not unanimous about the concept of Indigenous Knowledge Systems (IKS) and Indigenous Knowledge (IK). Sillitoe (2002) noted that "…there is a large number of terms vying for prominence as the more correct label in this field, whatever it is, is symptomatic of the confusion as terms like 'local knowledge', 'traditional knowledge', 'folk science' etc. are bandied about. He also posits that whatever term is used to define Indigenous Knowledge must not only define it but also clear away misconceptions and justify its use.

One such definition defines indigenous knowledge broadly as the knowledge that an indigenous community accumulates over generations of living in a particular environment. This encompasses all forms of knowledge, technologies, know how skills and practices etc. which enable the community to achieve stable livelihoods in their environment (The United Nations Environment Programme, n.d.).

> "Indigenous knowledge is local knowledge-knowledge that is unique to a given culture or society. Indigenous knowledge contrasts with the international knowledge system generated by universities, research institutions and private firms. It is the basis for local decision-making in healthcare, agriculture, natural resources management, education and a host of other activities in rural communities" (Warren, 1991 in World bank Group Regions: Sub-Sahara).

Another definition given is "The term indigenous knowledge stands for an idea or system of thought peculiar to the so-called 'native' to a particular 'geographical location' or 'socio-cultural environment'. This implies that the knowledge has not been borrowed it has become so assimilated into the new culture that it is difficult if not impossible to identify its original character or foreignness (Sillitoe, 2002).

Indigenous knowledge is the knowledge that people in a given community has developed over time and continues to develop. It is based on experience, often tested over centuries of use, adapted to local culture in a dynamic and changing environment (UNESCO, 1996).

39

Nnazodie (2009)concurs with the views expressed by UNESCO when she notes that, "…indigenous knowledge is not owned and produced by one person alone, it is knowledge generated and owned by a community…indigenous knowledge is produced and developed by a group in a particular locality. Indigenous knowledge is practical in nature, reflecting everyday experiences of the people owning the knowledge. Indigenous knowledge is passed down orally from generation to generation. Indigenous knowledge is not produced by institutions such as schools and universities".

None of the selected definitions suggest any contradiction amongst many others. In fact several aspects occur repeatedly specifically related to Indigenous Knowledge and may be summarised as follows:

1. It is locally bound and indigenous to a specific area.
2. It is culture and context specific
3. It consists mainly of non-formal knowledge
4. It is orally transmitted and generally not documented
5. It is dynamic and adaptive
6. It is holistic in nature and closely related to the survival and subsistence for many people worldwide (UNESCO, 2011).

Fakudze (2004) reflects on indigenous knowledge as referring to the philosophies, indulgences and expertise developed by long resident societies in their interaction with their natural surroundings and other peoples. It is vital to a cultural complex that also encompasses education, language, systems of classification, resource use practices and social interactions highly embedded in a metaphysical framework. Dreyfus (1990) sees an urgent need to enhance the intergenerational transmission of indigenous knowledge, as a complement to mainstream education so that acknowledgement and value of IK is maintained going forward.

Ogunniyi (2007) endorses the specificity of indigenous knowledge when he posits that "IKS is a redemptive, holistic and transcendental view of human experiences with the cosmos." Allow me to draw on some examples to explain the concept of what is referred to by Ogunniyi and Ogawa (2008) as amalgamated cosmologies. IKS (Indigenous Knowledge

Systems) is a paradigm of how indigenous cultures perceived their world. Indigenous describes the people who were the first inhabitants of a geographical location land or country. They were born in that land, lived in that land, lived off the land and sustained the land for future generations of their offspring. Knowledge in the case of IKS is gained through getting in touch with the natural world. The indigenous peoples of the world have brought together many years of understanding and knowledge of the natural world as they have experienced it, through storytelling, dance and rock paintings. This sharing took place around camp fires and in private because some of this knowledge belonged to a particular family. Spiritual healing is an example of such knowledge. These rituals, knowledge and beliefs were in many cases a closely guarded secret. The indigenous community's survival depended on applied knowledge. People practiced and used their knowledge to heal the body, and feed their community. Their way of thinking had a socialist ideal. Value was put on the survival of the community. IKS involves belief systems that stretch beyond the physical world. It is extremely spiritual in context as in the use of traditional plant medicines with the inclusion of traditional dance. The spirit world has an effect on the body. Researchers on the life of Bushmen of the Kalahari (an identified indigenous group), has, barring an interest in medicinal plants, been almost exclusively centred upon a detailed analysis of 'trance cure dance' (Low, 2004).

There is always a possibility that these people would exhaust the things that they needed for survival, thus respect for all aspects of nature was paramount. Prayers and dances were done to show respect for all facets of nature. Thus, a spiritual flavour feel is engendered by the aboriginal peoples. They would speak to trees and call upon the ancestors for blessings. Therefore all things in nature are animate. Their understanding of existence is not linear but cyclical. The Indigenous peoples lived with this idea in mind. Khoi-san followed the migration (migration is a change in habitat) of animals in order to hunt them and provide food just enough for their immediate needs. These hunts were preceded and ended with ritualistic activities indicating that indigenous people had absolute respect for conserving the environment that sustained their lives and livelihoods. The Indigenous people of the world believed that man should co-exist with nature. As Battiste and Henderson (2000) noted "Harmony is seen as a dynamic and multidimensional balancing of interrelationships of (indigenous peoples) ecologies. Disturbing these interrelationships creates disharmony".

41

I wish to endorse the opinion expressed by Sillitoe (2002) that despite the debate surrounding the term "Indigenous Knowledge" this term construed in its post-modern and post-structured perspective refers to a living, changing and dynamic knowledge rather than a pre-logical system of thought…". It is my opinion that whereas 'Western science' tends towards proving phenomena in an empirical way, IKS allows for speculating about the unexplained events and faces the reality of dealing with a multi-cultural science class without denigrating their belief systems. The study explores pre-service science teachers' efficacy in using DAIM as a conduit to amalgamate the science-IK worldview.

2.6.1   The need for an integrated science-Indigenous Knowledge Systems curriculum

During the Apartheid era which ended in 1994, South Africans were racially classified according to the colour of their skin by the then white Afrikaner minority and anyone of mixed ancestry was classified as 'coloured'. This stratification of non-equality in order of privilege was 'White, Coloured, Indian, Black". Ethnicity goes beyond colour and includes differentiation on the basis of criteria such as languages, tribes and culture. A case in point is xenophobia where black immigrants are attacked by individuals from predominantly indigenous black South African communities. It is important that teachers should recognise that all indigenous people on planet Earth world have their own view of the world which has continued throughout the ages: "Indigenous peoples throughout the world have sustained their unique worldviews and knowledge systems for millennia" (Aikenhead & Ogawa, 2007).

Indigenous peoples throughout the world have sustained their unique worldviews and associated knowledge systems for millennia, even while undergoing major social upheavals as a result of transformative forces beyond their control. Many of the core values, beliefs, and practices associated with those worldviews have survived and are beginning to be recognized as being just as valid for today's generations as they were for generations past. The depth of Indigenous knowledge rooted in the long inhabitation of a particular place offers lessons that can benefit everyone, from educator to scientist, as we search for a more satisfying and

sustainable way to live on this planet (Barnhardt & Kawagley, 2005). Differences and similarities between a Western worldview and an Indigenous worldview are identified and reflected by various authors as indicated in the following tables. These tables provide a useful guide to understanding the relationship and perceptions held on the nature of science and the nature of indigenous knowledge systems (Fleer, 1999; Lertzman, 2002; Dowie, 2003; Mason et al, 2012; Zinyeka, 2013; Barcelos, 2013).

Table 2.l Characteristics of Western vs. Indigenous Worldviews (Fleer, 1999)

Western worldview	Indigenous worldview
Materialistic	Spiritual
Reductionist	Holistic
Rational	Intuitive
De-contextualized	Contextualised
Individual	Communal
Competitive	Cooperative
Explains mystery	Celebrates mystery
Time is linear	Time is circular
Seeks power over nature and people	Seeks to coexist with nature and people
Knowledge production for the sake of it, to progress society	Knowledge production for specific cultural outcomes, to maintain society

Table 2.2 Differences between modern science worldviews and IKS worldviews

DIFFERENCES

Modern Science worldviews	Indigenous Knowledge Systems worldviews
Knowledge is presumed to be the most accurate approximation (Zinyeka, 2013)	Any knowledge is presumed to be true (Zinyeka, 2013)
Knowledge Is secular (Mason et al., 2012)	Knowledge is secular but also sacred (Mason et al., 2012)
Teaching occurs through various didactical approaches (Barcelos, 2013)	Teaching occurs through story telling (Barcelos, 2013)
Learnt through formal education (Zinyeka, 2013)	Learnt through practical experiences (Zinyeka, 2013)
Most science knowledge is documented (Mason et al., 2012)	Most indigenous knowledge is visible or oral (Barcelos, 2013)
Knowledge is critical and based on subsets of the entire system (Mason et al., 2012)	The knowledge is integrated and based on the entire system (Mason et al., 2012)
Knowledge is based on models or hypotheses (Barcelos, 2013), hence based on intellect (Mason et al., 2012)	Knowledge is based on intuition and environmental pattern observations (Barcelos, 2013)
Considers a reductionist worldview (Zinyeka, 2013)	Considers a holistic worldview (Zinyeka, 2013)
Knowledge is always objective (Zinyeka, 2013)	Knowledge is subjective to the geographical location it originates from (Zinyeka, 2013)
Follows a positivist paradigm (Barcelos, 2013)	Follows an experiential paradigm (Barcelos, 2013)
Is rapidly acquired (Mason et al., 2012)	Is acquired through lengthy processes (Mason, 2012)
Based on prediction and experimentation (Dowie, 2003)	Is based on the long-term wisdom from a community (Barcelos, 2013)
The first approximations are based on linear modelling (Zinyeka, 2013)	The models are based on naturally occurring cycles within the community (Zinyeka, 2013)

Hypotheses, laws and theories are used for explanation (Barcelos, 2013).	Examples, parables and anecdotes are used for explanations (Barcelos, 2013)
Excludes supernatural and only includes natural occurrences (Zinyeka, 2013)	Includes natural and supernatural aspects (Zinyeka, 2013)
Is clinical and is free of values (Mason et al., 2012)	Is spiritually based and maintains social values (Mason et al., 2012)
Is regarded as concrete (Mason et al, 2012)	Considered to be more abstract (Mason et al, 2012)
Is exclusive in structure and discovery (Mason et al, 2012)	Is inclusive of a variety of ideas (Mason et al, 2012)

Table 2.3 Similarities between modern science worldviews and IKS worldviews

SIMILARITIES

- Observations can serve as a guide from which conclusions can be drawn (Dowie, 2003

- Has realistic implications, relevant to the lives of individuals (Dowie, 2003)

- Both systems are empirically based (Lertzman, 2002)

- Both systems are dynamic (Lertzman, 2002)

- They are both considered as permissible manners of knowing (Lertzman, 2002)

From the tables above one can infer that a modern (Western) science worldview dominated the design of science curricula for schools in South Africa during the apartheid years with strong emphasis on a positivist paradigm, reductionist, decontextualized and free of values (Fleer, 1999; Zinyeka, 2013). On the other hand an IKS worldview is seen as being inclusive of values such as holistic, communal and spiritual (Mason et al, 2012; Zinyeka, 2013). Both the modern science (MS) worldview and indigenous knowledge (IK) worldview are obtained through observations, impacts on individuals lives and are dynamic and changing (Dowie, 2003; Lertzman, 2002). Although distinct differences exist between the two worldviews, I wish to concur with Lertzman (2002) who is of the opinion that both are considered as permissible ways of knowing. With the advent of democracy in 1994, a

restructuring of science curricula took place with a view to providing a contextual flavour to knowledge by considering aspects such as history, culture, technology and indigenous knowledge amongst others. Recognition of these differences and similarities were taken into account by policy makers and curriculum designers for inclusion in post-apartheid science curricula. In this way the relationship and contribution of indigenous knowledge worldview to science world knowledge was acknowledged.

Corsiglia & Snively (2001) argues that IKS offers knowledge that Western modern science has not yet learned to produce. They contend further that the current environmental crisis largely caused by scientific and technological activities has forced many scientists to pay increased attention to how the situation can be ameliorated through traditional environmental knowledge.

2.6.2   Research reviews on an integrated science-IKS curriculum

A study conducted by Onwu (2009) with in-service science teachers on the implementation of a science-IKS curriculum identified and highlighted the challenges and difficulties involved in providing an operational definition of indigenous knowledge for inclusion in the science curriculum. Some suggested building integrated curricula around socio-cultural and environmental issues. In this instance the topic would come first and the science taught evolves from the topic.

Ogunniyi (2012, pp. 7- 9) highlighted the controversial philosophy of wanting to integrate two world views, that of the 'scientific worldview' seen as distinctly different from an 'indigenous worldview'. He further provides the following quote by Idowu (1967, p.3) in support of this view:

> The 'scientific method' has brought a blessing to scholarship in that it has served the salutatory purpose of minimizing the amount of emotion which usually gets mixed up with what should be an objective study, it has led to more careful verification of data, and created also an urge to accuracy in the documentation of observed or verified facts….There are certain things which this method strictly defined, cannot probe. And there are things which are to be reached and known through the appropriate apparatus of the human faculties.

Warren (1991) is of the opinion that an IKS worldview serves as the basis for local-level decision making in agriculture, health care, food preparation, education, natural-resource management, and a host of other activities in rural communities.

Other terms used for Indigenous Knowledge Systems are:

1. indigenous knowledge (IK),

2. indigenous technical knowledge (ITK),

3. ethno-ecology,

4. local knowledge,

5. folk knowledge,

6. traditional knowledge,

7. traditional environmental (or ecological) knowledge (TEK),

8. people's science,

9. African Indigenous Knowledge Systems (AIKS),

10. Indigenized science

Whatever term is used, the concept of achieving harmonization between human activity belief and lived experiences with nature is central to understanding the connectedness between science and IKS.

In the cognitive process of individuals three worldviews attempt to align themselves with each other through seeking points of contiguity (i.e. to seek regions in the thought systems concepts or ideas that share common elements in order to accommodate, reconcile and adapt them to each other) in order to make sense. The three basic worldviews in a learners' cognitive structures are identified as (1) Traditional beliefs (indigenous knowledge); (2) Common sense (intuitive knowledge) and (3) Science. These basic worldviews are located in the cultural, scholastic and life worlds of the teachers and learners lived environments. Ogunniyi's Contiguity Argumentation Theory (Ogunniyi, 2002) is used in this study as a tool of analysis to determine points of contiguity in the responses of teachers and learners to some of the research questions.

Without understanding the realities of exclusivist, segregationist philosophy and practice of the South African apartheid past it would be difficult to justify an inclusive science curriculum. The fact that the apartheid system of education denigrated and negated other cultural beliefs, knowledge systems and associated values to the background of euro-centric ways of knowing and interpreting human experiences. The consequences of this have been the dehumanization and bastardization of the non-European worldviews and value systems as well as loss of socio-cultural identities of the ruled – likewise the ruled became wood cutters and fetchers of water so to speak (Ogunniyi, 2007a & b). Inclusive science education, therefore, is broad and the focus of the study is on professional practice in relation to the implementation of the science-IK curriculum among prospective science teachers. The new curriculum has been an attempt by the Department of Education to combat discriminatory practices and attitudes that prevailed under apartheid so as to create the spirit of Ubuntu (relatedness, togetherness, community practice among all South African citizens regardless of race, colour and creed (Ogunniyi, 2007a & b).

Three reasons are provided in Curriculum 2005 (C2005) policy statements for justifying the integration of science and indigenous knowledge (IK). The reasons given are:

1. IK reflect the wisdom about the environment developed over the centuries by the inhabitants of South Africa;

2. Much of this valuable wisdom believed to have been lost due to colonisation need to be rediscovered and utilized to improve the quality of life of all South Africans; and

3. Modern/Western science tends to denigrate valuable experiences arising from IK.

South African teachers who are tasked with the responsibility of implementing an integrated science-IKS curriculum have been schooled mainly within the framework of modern science. It is my contention that pre-service teachers at Universities and Colleges are agents for implementing education policy imperatives in a dynamic and pro-active way by introducing units into the science method modules that promote an integrated science-IKS curriculum. Loggenberg (2012) in his study on electrostatics concludes that the use of scientific argumentation as a teaching strategy, as well as the integration of IKS into science

classrooms enhances the teaching and learning of scientific concepts. Furthermore dialogical argumentation could be a useful teaching and instructional pedagogy that create spaces for reading, writing and aural engagement. The following discussion will attempt to contextualise the Nature of Science and Indigenous Knowledge Systems (NOSIKS).

2.7   The Nature of IKS in the Science Curriculum

In this section I explore the Nature of IKS (Indigenous Knowledge Systems), the rationale for IKS to be included in the current science curriculum, the challenges and successes experienced as well as the concerns and reservations expressed by pre-service science teachers on the implementation of a science-IKS curriculum. Furthermore I will draw on reviewed and published articles to support this exploration.

2.7.1   Rationale for an integrated science-IKS curriculum

IKS it is seen as a knowledge system that constantly evolves over time and adapts to changes in nature and to the processes which force the change. Indigenous people identify with this idea of change. In respect to the South African context we perceive indigenous people to mean those that are mostly rural dwellers in particular geographical locations and have well defined cultural traditions. If IKS is taught in various institutions it could bring about a respect for indigenous people and a respect for the knowledge that they have developed over time. Our government prides itself on its democratic constitution which through its' IKS Policy (DST, 2004) promotes the inclusion of indigenous knowledge as an inherent part of the economy since communities can generate an income from endeavours such as establishing places of interest for tourists and in turn improve employment opportunities. They could also be remunerated for their knowledge when huge corporations utilise their IK on medicinal plants to manufacture medicines and other herbal-based remedies. These pursuits raise the issues of intellectual property rights, ethics and laws protecting the rights of indigenous communities. IK should be explored by both teachers and learners alike.

Tinnaluck (2004) postulates that "Western science and indigenous knowledge systems represent different knowledge systems because of their respective backgrounds and values, organising principles, habits of mind, skills and procedures, and how knowledge is used. The real challenge is to find mutual recognition and respect to work together in a complimentary manner…" (p.71). He further notes that" in such recognition, modern science and indigenous knowledge should be viewed as two systems of knowledge that can supplement, rather than compete with each other, or…they can work together intelligently." Scholars like Hoppers (2002) and Jegede & Aikenhead (1999) supports the integration of indigenous knowledge in the school curriculum as a positive acknowledgement of the contribution made by indigenous peoples to the fabric of society and humanity.

In the latest South African Curriculum and Policy Statements (CAPS, 2011) IKS is included under Specific Aim 3 and more specifically Specific Aim 3.2: Relationship of Indigenous Knowledge to Natural Sciences (Life Sciences and Physical Sciences) and reads:

Examples that are selected (and that should, as far as possible, reflect different South African cultural groupings) links directly to specific areas *like IKS* in the *Natural Sciences*, *Life Sciences and Physical Sciences* subject content. *The nation needs some healing after 40 years of discriminatory Apartheid practices and even after 20 years of democracy*. The knowledge of different cultures through *integrating IKS in* the curriculum could go a long way to repairing the damage (DOE, 2003).

Le Grange (2007) explains that successful and effective integration of indigenous knowledge in science learning can only be achieved if teachers understand what integration of indigenous knowledge means and have the ability to integrate indigenous knowledge in their practice. Various reasons have been forwarded as to why teachers are not implementing this policy. Rogan (2004) offers the following reasons: (a) the pedagogy of teachers have not changed much since the inception of Curriculum 2005 (C2005); (b) teachers have a wrong conception of what learner-centeredness is and (c) teachers lack innovation and initiative in classroom teaching leading to a dichotomous perception between seeing curriculum as intention and seeing curriculum as practice. A major drawback or impediment in implementing indigenous knowledge in the classroom is perhaps a misconception or

50

misinterpretation of what constitutes indigenous knowledge. Most teachers understanding are limited to what is read in a textbook. Teachers rely heavily on textbooks and other resources approved by the Department of Education for materials and science resources. A lesson on fossils for instance, in a grade 7 textbook had the intention of showing integration of indigenous knowledge and Western/modern science. However on closer inspection of the content textbook focussed on positivist science concepts with scant mention of the IK. Teachers' limited understanding of indigenous practices also contributes to the limited or in some instances non-implementation of Specific Aim 3.

Ocholla (2006) posits that indigenous knowledge was marginalised by the negative and derisive manner in which it was often referred to: 'primitive', 'backward', 'outdated', 'archaic', 'barbaric'. He also notes that the demeaning reference did not create space for indigenous knowledge's integration with other forms of knowledge, commonly referred to as 'western, 'modern', 'scientific' knowledge.

A serious problem confronting the integration of IK and Western science is the pedagogy employed in the classrooms. The teaching strategies that teachers employ appear not to provide a suitable pedagogical scaffolding framework for interrogating an integrated science-IKS type lesson. This could be attributed to the fact that many science teachers were schooled in the Apartheid era with its strong emphasis on Christian National Education (CNE). CNE was the ideology responsible for the transmission of Eurocentric values and cultures based on objective knowledge with assessment mainly implemented through rote learning and 'pen-and-pencil' examinations.

Teachers tend to view IK as an add-on to the notion of Western Science. The NCS and CAPS never intended IK to be in opposition to Western Science but rather to be shown as an alternative means of knowing and explaining scientific concepts. In a reflective diary report a teacher responded as follows 'seeing the IK in science and the science in IK' after attending one of the SIKSP workshops (Amosun & Ogunniyi, 2013). It is clear that what the curriculum intended and what actually happens in the classroom is different. Of concern is teachers' perception that IK is irrelevant and unscientific. One should remember that the science teachers' basic science foundations are rooted in empiricism. What cannot be

51

observed, measured and explained why events happen in nature, cannot be accepted as science. Teachers tend to reinforce this worldview on learners in their teaching and learning strategies with total disregard for learners' own cultural backgrounds. With the advent of democracy in 1994, South African schools have become more and more multicultural, which means many of the learners do not share the same Eurocentric worldview as those held by the teacher. Ogunniyi (1995) posits that "…science teachers play a key role in science instruction. They determine the success of the curriculum and consciously or unconsciously shape the nature of the information they convey to the students".

It is vital that science and IKS not be dichotomized and seen as separate knowledge systems. Compartmentalizing of science content knowledge creates a lot of redundancy where learners might think that one concept only applies in one context and not the other, hence also making t difficult for both teachers and learners to recognise the science in their everyday lives and experiences. The integration of Dialogical Argumentation into IKS together with an open mind about the characteristics, values and assumptions of the nature of Science and the use of visual objects and aids are a winning recipe to achieve optimal learner cognitive understanding and appreciation of science as a world (Diwu & Ogunniyi, 2011).

IKS has a long history with recent documentation by historians, archaeologists, anthropologists and scientists. The IK (Indigenous Knowledge) is a source of knowledge that has kept man alive for millennia in the sense that it contributed to sustainable living and development (MacDonald, 2013). It covers a world of diversity of the human race. IK is as diverse as the people who have kept it alive for all this time. Indigenous South Africans, like the rest of post-colonial Africa, are struggling to redefine their identity amid centuries of stolen history and denigration of indigenous culture. Hodson & Hodson (1998) argues for a shift from a naïve constructivist view of teaching and learning science towards a social constructivist view anchored in the Vygotskian notion of education as enculturation. The idea being that learning science, learning about science and learning to do science for oneself requires an understanding of and an ability to use appropriately a set of culturally defined methods for conducting inquiries and a set of conventions and mode of discourse for presenting results. In order to introduce learners to learning experiences teachers should have a sound knowledge of scientific knowledge and scientific methods, inclusive of the historical,

its social, economic and environmental impact as well as the social, moral and ethical issues for the individual and society.

The ANC government voted into power in 1994 has adopted the philosophy of Ubuntu by promoting the integration of indigenous knowledge systems into mainstream economic activities as a way of asserting African identity and bringing about African renaissance. They argue that only a holistic view of IKS implementation stands a chance of success, by acknowledging also that some sections of society are vigorously campaigning against such implementation especially in education. For example, where there are voices arguing for a positivist approach to science education, totally removing IKS from the curriculum and returning to the "Western" education system as a "way of improving results." The silent assumption is that education incorporating IKS is either sub-standard or does not contribute any value to the economic development of the country. This perception runs contrary to current views about sustainable development. MacDonald (2013) argues for consideration to be given to sustainability as pedagogic practice with acknowledgment of the contribution of IK and socio-cultural activities. Carter (2008) and Glasson et al. (2010) supports this notion that science be seen through the "lens of culture" and indigenous knowledge.   Since IKS is located in the context of a curriculum and has a suggested content component linked to the science curriculum as envisaged by curriculum designers of NCS and CAPS, an attempt at defining the terms 'curriculum' and 'content' is appropriate at this stage of discussion.

2.7.2   The educational benefits of integrating IKS into formal schooling.

According to Semali and Kincheloe (1999), IK has taken centre stage in educational and development discourse. The promotion of Western Science at the expense of (IK) has been criticised, resulting in new calls for recognition thereof. By including IK, the particular social identity of the learner is acknowledged. De Beer and Whitelock (2009) posits that by acknowledging the learners' particular culture, science education can turn learning into a more positive experience for those resistant to studying Modern Westernised science. Learners will begin to value their own knowledge and be able to link it to other knowledge

systems. Integrating IK into the formal school curriculum suggests that academic knowledge will be given equal place in the academic arena, "In this way, academic knowledge becomes a more integrated body of knowledge, embracing different forms of knowledge and thought" (Nnazodie, 2009).

IK integration into the curriculum may enable learners to recognise and learn from other groups lying outside dominant Western scientific cultures and who have made important contributions to fields such as agriculture, medicine and environmental management (Naidoo, 2007). The inclusion of IK may have the effect that learners will no longer see Western Science as being too abstract and irrelevant to their everyday life experiences. The educational benefit of integrating western science and IK is that learners would be able to use one body of knowledge to explain the other. In this way the two knowledge systems can complement each other. Kwofie (2009) agrees with this view of integrating IK and Western Science, "…since school science is based on Western models of education, educators must be well equipped to effectively implement a science-IK curriculum using DAIM as pedagogy". To incorporate IK into science discourses implies that teachers need to be well informed about the concepts and practices of IK and how they can be integrated with Western Science. Nnazodie (2009) postulates that teachers must become researchers on IK and through this research, teachers will become familiar with the knowledge of the learners and develop better ways of integrating this knowledge in their lessons. Ogunniyi, (2009) is also of the view that an argumentation framework is best suited "to meet the demands of equitably by bringing two distinct knowledge corpuses together i.e. science and IKS".

2.8   Theoretical frameworks used in this study

Theoretical and conceptual frameworks are considered to provide a guide for conducting the study and guiding the process of material development, instrumentation, implementation, analysis of data and drawing conclusions. Aikenhead (1996) conceptualises cultural border crossing as a transition between a student's life world and school science, thus moving between two worldviews which the student may or may not interpret as being

difficult. The teacher should be in a position to understand how the student manages this transition in his/schema of thought. The theories of TAP, CAT and Socio Cognitive theory provides a guide to mapping the scope of this integrated science-IK perspective, what is referred to by Aikenhead as a "culturally responsive curriculum".

2.8.1 Toulmin's Argumentation Pattern (TAP)

The use of TAP as a theoretical framework provides a basis for analysing the arguments that arise within group-work settings during lessons in the classrooms. Simon (2008, p. 279) has found that the "more elements of TAP present in the dialogue, the better the quality of argumentation. Claims supported by grounds including data, warrants and backings were deemed to represent more complex hence more sophisticated arguments." Within the same study it was also found that when rebuttals were given, it enhanced the process of justification and elaboration of evidence. Various levels of argumentation will therefore exist within classroom discourse. The study used Ogunniyi's table on levels of argument based on Toulmin's TAP levels of argument (2009, p. 5) to rate the levels of argument in the group discussions especially data gathered from Stage 3: Group Task and Stage 6: Cognitive Harmonisation of DAIM (see Table 2.1). The application was done during the pre-service teacher training intervention programme as well as at the teacher implementation stage in the classroom in order to process the levels at which learners argue. It can also be argued that pre-service teachers responses to questions and statements can also be analysed using TAP in order to determine whether the argument or claim is supported by grounds inclusive of data, warrants and backings. In this case the levels would need modification. For example Level 0 would read, 'Only an argument/claim is made; Level 1 would read: 'Argument involves a simple claim/counterclaim/rebuttal with grounds (data or evidence)'; Level 2 reads 'Argument involves claims/counterclaim/rebuttal with grounds (data and evidence)'; Level 3 could read, 'Argument involves claim/counterclaim/rebuttal with grounds (data, evidence and warrants)' and so on.

Table 2.4 Levels of TAP's arguments in classroom discourse

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

Source: Ogunniyi (2009, p. 5)

Toulmin's Argumentation Pattern is can be used by teachers to enhance their learners' understanding of scientific arguments in the nature of science since it lends itself to a deductive-inductive classroom discourse which focuses on scientifically valid arguments.

Furthermore, the coordinator of the argumentation session assists the whole group to establish the level of argumentation reached using TAP as well as the types of arguments used by the participants. In terms of TAP the more the number of rebuttals used by the arguers, the better the quality of the argument (Erduran et al, 2004; Osborne, et al, 2004; Simon et al, 2006). In terms of CAT the quality of the arguments is to what extent an arguer has evinced an argument that is appropriate for a given context (Ogunniyi, 2011a & b).

However, TAP is positivist in nature in that it can be used when there are claims, counter-claims and rebuttals supported by evidence and lends itself to scientific methods, it is inappropriate when indigenous knowledge is considered, because of its metaphysical understanding of a given phenomenon. This metaphysical aspect is encapsulated in beliefs, religion, myths and other occurrences for which there may not be a plausible scientific explanation for that specific context. Therefore, in order to analyse IK within a similar framework the study will make use of the Contiguity Argumentation Theory (CAT). "CAT deals with both logical,

scientifically valid arguments as well as non-logical metaphysical arguments which form part of IK (Ogunniyi, 2009).

2.8.2 Contiguity Argumentation Theory (CAT)

The Contiguity Argumentation Theory (CAT), rooted in the Contiguity Theory, is a learning theory traceable to the Aristotelian Contiguity Theory. CAT asserts that two distinct coexisting thought systems such as science and IKS tend to readily couple with, or recall each other to create an optimum cognitive state. This type of association is a theory of the structure and organisation of the mind which asserts that every mental life is explicable by the combination and recombination of these simple, discrete components in conformity with the laws of association of ideas (Cross & Price, 1966). According to Dreyfus (1990) students must therefore be able to negotiate the meanings across the two distinct thought systems of the different worldviews in order to integrate them. The five cognitive categories of CAT reflect the ways in which an arguer or arguers could make cognitive shifts in response to contextual changes. Essentially CAT consists of five dynamic cognitive states in which arguers evaluate and adapt to different experiences in a given context.

The five cognitive categories of CAT can be used as an analytical tool by researchers to explain views held by teachers on science-IKS worldviews. One of which would express most closely the participants present mental or cognitive state. The five CAT categories with descriptions (Ogunniyi, 2002; 2007a; 2007b) are listed in Table 5.

Table 2.5 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.

(Ogunniy, 1997, 2002; Ogunniyi & Hewson, 2008)

Whereas TAP provides an understanding of the dynamics of logical argumentation, CAT allows self-evaluation of the present mental state with regard to a set of mental

cognitive states brought about through thoughtful consideration of beliefs and culture. Ideas flow in and out of these cognitive states through experiential exposures of one or other form (Ogunniyi, 2004). Each of the cognitive states mentioned in table 5 above exist in a dynamic state of flux and can change from one form to another depending on the arousal context (Ogunniyi, 2004; 2007a & b; Ogunniyi & Hewson, 2008; Ogunniyi & Ogawa, 2008).

Ogunniyi's Contiguity Argumentation Theory will be used as an analytical lens to analyse the qualitative data collected. The CAT is rooted in the Aristotelian Contiguity Theory which asserts that one or two states of mind tends to readily couple with each other to form an optimum cognitive state. A fundamental assumption of the CAT is that claims and counter claims on any subject matter or across fields (such as science and IKS) can only be justified if both systems of thought are initially accorded the same status until one is found to be inappropriate for a given context (Ogunniyi & Hewson, 2008; Ogunniyi, 2007a; 2009; Afonso & Ogunniyi, 2011).

This theory resonates with that of Jegedes' (1995) theory of collateral learning, where he identifies four types, namely, (1) parallel collateral learning occurs when learners acquire and maintain opposing schemata about a concept or idea, for instance when indigenous learners first make contact with school science, they allow the new information to coexist in their schemata while attempting to make sense of it. (2) Simultaneous collateral learning occurs when they hold information simultaneously from two different world views in relation to a new concept being learned. (3) dependent collateral learning occurs when one worldview is held while restructuring another worldview which may be rejected or accepted either way. (4) secured collateral learning occurs over a period of time when for instance the learner clings to an indigenous worldview while resolving the dissonance created by modern science explanations about a concept as in the case of the causal effect of a lightning strike (sent to harm or a natural occurrence). I would argue that beginning teachers would be required to navigate this terrain in the science classroom in a way that is non-threatening to the learner. It is also my experience that pre-service teachers also encounter these cognitive challenges. I will attempt to show that through the reflective interviews, pre-service teachers experience similar difficulties which influences their efficaciousness in implementing an integrated science-IKS curriculum. Le Grange (2008) views science teaching and learning as a

negotiated process and not absolutely based on empirical verification or falsification. This stance helps the teacher and learner to work with both disparate knowledge traditions in a equitable way.

2.8.3 Bandura's Social Cognitive Theory

Bandura (1986) based his Social Cognitive Theory on the 1961 Bobo Doll study, where an adult woman was shown being aggressive to a Bobo doll, hitting and shouting aggressive words. The video made of this action was shown to a group of children. The children were allowed to play with the same Bobo doll. They began imitating the model and used similar aggressive behaviour. He summarises his findings by providing three functionaries of the role of a model.

1.   Modelled behaviours serve as cues to initiate similar behaviour in others.
2. They serve to strengthen or weaken the learner's existing restraints against the performance of a modelled behaviour.
3. They're used to demonstrate new patterns of behaviour.

In a comprehensive study by Smolleck & Mongan (2011) on self-efficacy beliefs of pre-service teachers in planning inquiry based learning experiences during their student teaching experience it was noted that more research is required to better understand the connection between self-efficacy and the teaching of science as inquiry as well as the ability to apply this knowledge to classroom practice in the constructivist classroom where a social exchange of ideas occurs between teacher and learner and learner and learner. In this way meanings of knowledge that arise from dialogue are shared. The approach takes account of learner's prior understandings.

Bandura's (2000) Social Cognitive Theory postulates a triadic model visualised as an equilateral triangle with interplay between the internal psychological factors of the Person (P) and the external observable factors of Environment (E) and Behaviour (B). His idea of people observing the actions and behaviour of others provides an efficient method for social learning because it generates new and creative thought. Though the three factors do not make equal

60

contribution to the overall context nevertheless each plays an important role in determining the way people live, behave or respond to the challenges they encounter in their daily lives. In Bandura's model, Person (P) refers to cognition, self-efficacy, motives and personality. Environment (E) is comprised of the situation, roles, models and relationships. Behaviour (B) refers to things like complexity, sustainability, skills, enthusiasm and commitment. He further distinguishes two main dimensions, that of personal self-efficacy and outcome expectancy. These two dimensions are said to work together in influencing behaviour (see figure 1).
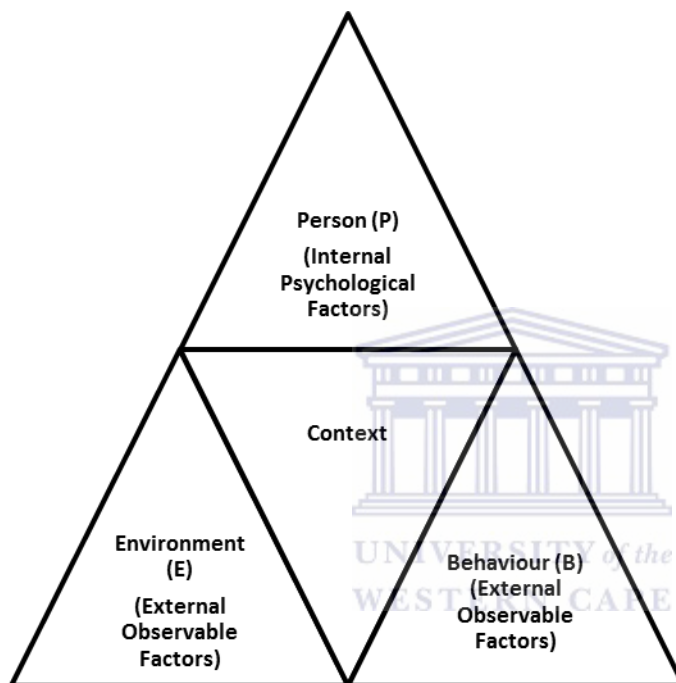
Figure 2.1 Bandura's (1977; 1986) Model of Reciprocal Determinism

Teacher efficacy and teaching effectiveness

Efficacy in the context of this research can be defined as the ease and comfort that a pre-service teacher may experience in implementing a Dialogical Argumentation Instructional Model (DAIM) when teaching an integrated science-indigenous knowledge lesson.

Joseph (2010) says that teachers' sense of efficacy, that is, the extent to which they believe that their efforts affect learners learning, is a significant indicator of effective

teachers. He conducted his study on pre-service teachers' efficacy in the teaching of science in the United States of America using a self-designed self-efficacy scale whereas this study based in a South African urban university, focused on a particular pedagogical argumentation instructional model. In South Africa, IKS inclusion in the science education curriculum, is a policy imperative for science teachers to implement a science-Indigenous Knowledge (IK) curriculum in science school subjects such as Natural Sciences and Technology at the General Education and Training (GET) Phase, grades 4-9 and Life Sciences and Physical Sciences at the Further Education and Training Phase (FET) Phase grades 10-12.

Silverman & Davis (2009) are of the view that teacher efficacy has important implications for the induction of new teachers in order to build confidence and competence when challenged with introducing new teaching methods. They indicate that in order to build efficacy pre-service teachers would need observe model lessons and participate in mastery (skill) experiences. They also advise teacher educators to rank task difficulty in their method programmes. In addition they advocate that reflective reviews of lessons should be continuously undertaken especially in the face of ever changing education policies. This research report supports Silverman and Davis (2009) recommendations to promote the efficacy of the science method programme and the efficacy of the pre-service science teachers' ability to implement a dialogical argumentation instructional model to teach integrated science-indigenous knowledge lessons.

Mushayikwa & Lubben (2009) conclude that teacher efficacy consists of professional efficacy and classroom efficacy as the organising force that powers self-directed professional development. It will be argued that this study promotes efficacy in pre-service teachers as they launch into their teaching careers in science.

Narayan & Lamp (2010) sheds meaningful light on how to use Bandura's Social Cognitive Theory in analysing qualitative data collated from individual and focus group interviews held with the sample of pre-service teachers. Her qualitative, interpretive study on elementary pre-service teachers' self-efficacy in a constructivist inquiry-based physics class

used transcriptions and coding gleaned from audio, video and journal reports assisted by ATLAS.ti software programme.

2.9   Dialogical argumentation as a conceptual framework developed by SIKSP

The White paper on Education and Training (South Africa, 1995, p. 22) states that all programmes of education and training should "encourage independent and critical thought, the capacity to question, enquire, reason, weigh evidence and form judgements, achieve understanding, recognise the provisional and incomplete nature of most human knowledge…"

In the G.N. 82 of 2000 published in *Government Gazette* No. 20844 dated 4 February 2000, the Minister of Education, Professor Kader Asmal, has, in terms of Section 3(4) (f) and (l) of the National Education Policy Act, 1996 (Act No. 27 of 1996), determined Norms and Standards for Educators as National Policy, terms of section 7 of the policy of the seven roles of an educator are:

1. Learning mediator
2. Interpreter and designer of learning programs and materials -meaning that the educator will understand and interpret provided learning programs, design original learning programs, identify the requirements for a specific context of learning and select and prepare suitable textual and visual resources for learning. The educator will sequence and pace the learning in a manner sensitive to the differing needs of the subject/learning area and learners.
3. Leader, administrator and manager
4. Scholar, researcher and lifelong learner
5. Community, citizenship and pastoral role
6. Assessor
7. Learning area/subject/discipline/phase specialist

This policy provides a platform to initiate pre-service science teachers to move from the initial stages of their career into becoming key teachers for implementing policy imperatives dealing with the integration of science and IKS, as mentioned previously (ELRC, 2003).

Dialogical argumentation is used in this study to create discussion spaces on an identified socio-cultural and/or socio-scientific issue that is aligned to CAPS for natural science, life sciences and physical sciences at schools. This is an interactive process directed at providing all participants and opportunity to express their views in a non-threatening environment, the shared commitment is towards respectful presentation of opinions (Osborne, 2005). DAIM allows spaces for this dialectic exchanging of ideas and opinion to bridge modern (Western) science with IKS in a way that both maintain their integrity.

Kuhn (1992, 1993) supports the idea that the use of argumentative models in science education allows students to improve their cognitive and linguistic skills. They develop a better understanding of the role of argument and evidence in science. It also helps them improve their communication and writing skills and strengthens their critical thinking skills and their ability to collaborate with others.

The present study draws inspiration from an on-going Science and Indigenous Knowledge Systems Project (SIKSP) located in the School of Science and Mathematics Education, University of the Western Cape.

Arguments for understanding the science curriculum against the background of and recognition of IKS is the establishment of common ground that will assist learners who have a worldview not necessary in harmony with science thus estranging them from what is viewed as 'Western' or 'Eurocentric' or 'Modern' science (Webb, 2011, p.41). Hodson (2009) is of the opinion that modern science emerged from the "complex origins, diverse roots and continuing cross-cultural borrowing" and Lazarus (2011) argues for conscious mediating at the interfaces of knowledge (such as science and indigenous knowledge) in order for integration to succeed.

The SIKSP team embarked on a process of researching science-IKS materials for inclusion in science-IKS resource booklets in an endeavour to assist teachers with implementing an integrated science –IKS lesson. Three pilot booklets were presented at the *3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS.* These science-IKS curriculum workshop books covered themes such as Life and Living (Diwu, et al., 2011), Matter and Materials (Dine, et al., 2011) and Earth and Beyond (Langenhoven et al., 2011). Although CAPS (2004) includes Specific Aim 3, which announces the intention for teachers to address the integration of science and IKS, no resource provision was made for teachers to address this particular aspect (Dinie, et al, 2011). A dialogical argumentation pedagogy can justifiably be applied to interrogate science and indigenous knowledge system (IKS) concepts within the framework of Ogunniyi's Contiguity Argumentation Theory (CAT) which considers science and IKS as complimentary and equipollent, even though IKS is situated within both evidence-based and metaphysical paradigms whilst science is primarily empirical (Diwu et al, 2011).

The methodology used in these three unpublished resource modules emphasises story-telling, writing frames based on DAIM and visual stimulus. The teacher is encouraged to create a teaching and learning environment that provides an Inquiry-Based Science Education (IBSE) approach to understanding scientific concepts in the context of everyday lived and socio-cultural experiences. The intention is to create a meaningful learner centred approach by structuring thinking, writing, sharing, speaking and reflective spaces through DAIM in the development of integrated science-IKS lessons (Langenhoven, et al, 2011). Having defined the model used in this study further elucidation should be made on the notion of the Nature of Science, the Nature of Indigenous Knowledge Systems and their proposed integration in the school curriculum. DAIM was chosen by the SIKSP group as a method to scaffold instruction with the intention to create dialogical spaces for science-IK argumentation lessons based on socio-scientific issues. The model starts with an issue that has both indigenous knowledge and scientific knowledge viewpoints. The first engagement is at the individual cognitive level (intra-argumentation) through guided questions. The next level is the sharing of ideas in a group (inter-argumentation) with the express purpose of reaching a group understanding of

the issue. The group selects a representative to share the agreements and rebuttals raised within the group with the entire class (trans-argumentation).

Once all the groups have presented, the facilitator manages a whole class discussion seeking trends and understanding of the issue by drawing on indigenous knowledge as well as scientific knowledge. The final stage is an individual and/or focussed group interview with selected participants on their understanding of the issue and processes taken to reach that understanding. Throughout the period, the role of the coordinator is not to interfere but to facilitate the process of dialogical argumentation by raising thought-provoking questions (Erduran, 2006; Ogunniyi, 2004; 2007a & b; Ogunniyi & Ogawa, 2008; Ogunniyi, 2011; Langenhoven & Ogunniyi, 2011a & b; Ogunniyi, 2008) Note that cognitive harmonisation evolves continually at each step and the steps are cyclic in nature with opportunities for participants to reflect on their views and perceptions. The pedagogical schema model developed during the Science Indigenous Knowledge Systems Project (SIKSP) seminars and workshops in 2009 is represented in figure 2.2 below.
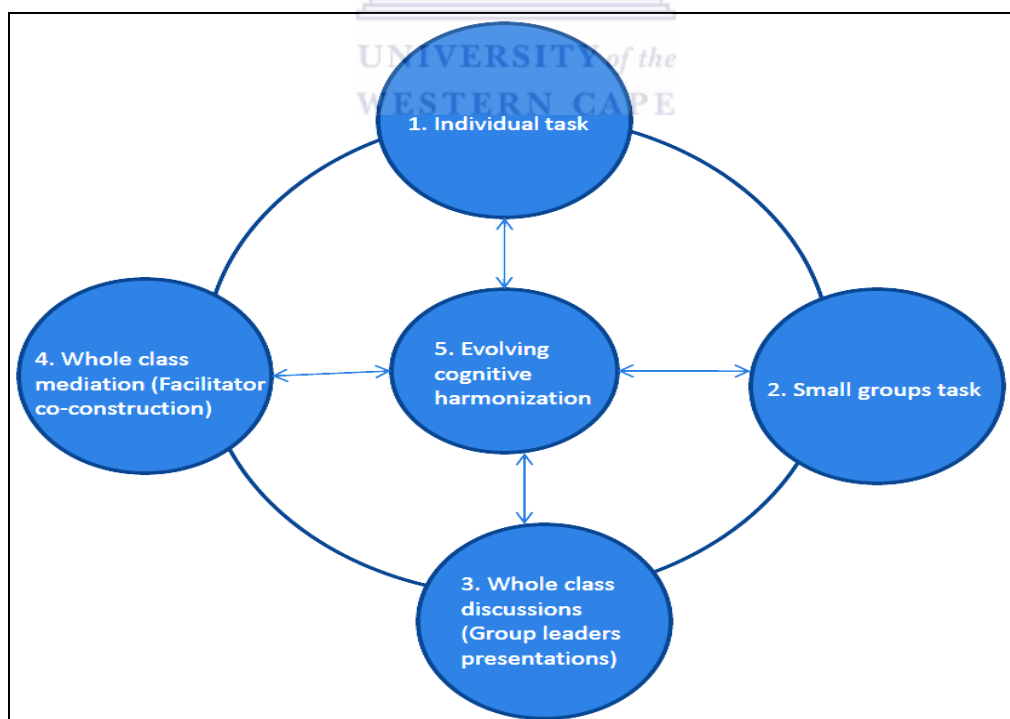
Figure 2.2 Pedagogical schema for implementing dialogical argumentation-based classroom discourses: Source: Ogunniyi, M.B. (2009)

66

According to Ziman (2000) a scientific notion of a dynamic system is a model or a simple representation of a complex entity. A useful indicator for an effective model is that it provides a vivid picture of the system it purports to represent as precisely as possible. According to Justin and Gilbert (2002), models play a central role in enabling students to learn about the nature of science and how scientific inquiry is carried out by scientists. In the same vein it is expected that a dialogical argumentation instructional model would reflect a form of argument whereby arguers are engaged in the type of argument that provides an ample opportunity to reach some consensus.

In other words, the central focus of the study is to encourage pre-service teachers to use arguments as a tool for meaningful classroom discourse i.e. arguments that result in meaningful learning through debates rather than arguing with no clear-cut goal in mind. In the case of pre-service teachers one could add that the instructional model they use should enable them to teach science based arguments whose main focus is reaching meaningful agreement on the basis of valid evidence and justifiable reasons rather than wholesale transmission of pieces of information to their learners. By implication they would be expected to teach an integrated science and indigenous knowledge systems curriculum not indoctrination but through contentions and consensus (Hodson, 1992).

In this regard, several cohorts of teachers who have benefitted from the SIKSP alluded to earlier, have already successfully applied it in primary and secondary schools in the Western Cape and beyond (Ramogoro & Ogunniyi, 2010; Siseho & Ogunniyi, 2010; Langenhoven & Ogunniyi, 2011; Nhalevilo & Ogunniyi, 2011).

Osborne & Collins (2000) are of the view that school science should prepare learners to deal more effectively with contemporary socio-scientific issues. Their contention is that since the youth of today is the future public of tomorrow, attention should be given to what constitutes contemporary science so that the alienation between science and its future public is not increased. Solomon (2001) contends that learning science is not about reading science articles, following an experiment menu or learning for regurgitation, but setting sights on preparing learners for citizenship in dealing with new benefits and ethical dilemmas.

67

To provide room for science and IK discourses in the science class, this study incorporates an argumentation framework underpinned by Toulmin's (1958) Argumentation Pattern (TAP) and the Contiguity Argumentation Theory (CAT) (Ogunniyi, 1997). Essentially, these theoretical constructs to some extent are in agreement with socio-cultural constructivism as espoused by Vygotsky (1978) and personal constructivism as espoused by Piaget (1966). Vygotsky's theory emphasises the role of the social; environment in learning and cognitive development. In Vygotskian theory, a mediator assists thinking and action between the learner and the environment, with the purpose of developing the child's cognitive capacity. He also believed that language is the most important in developing higher cognitive functioning and allows a child to interact with other people by trading ideas.

In my view when DAIM is applied in science lessons, learners get the opportunity to work together and gain knowledge from each other. The use of this model may improve learners thinking abilities, being able to work under pressure and allows the learners to become familiar with science and IKS during discussions. Interaction, discussions and debates occur between the teacher and learners when using DAIM. This allows teachers to get a better understanding of each learner's Zone of Proximal Development (ZPD) (Collins et al, 1989; Vygotsky, 1978; Erduran, 2006).

2.9.1 A modified Dialogical Argumentation Instructional Model (DAIM)

I considered the argumentation model as presented by Ogunniyi (2009) and listened to comments and suggestions made by (SIKSP) members in the workshops as they grappled with the various steps that the model suggested. My first observation was that different kinds of teaching and learning spaces emerged in addition to what the initial argumentation model offered. Secondly the model generated an important debate around the naming and sequencing of the emerging cognitive stages.

The following historical order of events leading up to the Third Workshop in the Science and Indigenous Knowledge Systems Project (SIKSP) will help in contextualising the further development of the teaching and learning argumentation model.

In 2008 the School of Science and Mathematics (SSME) at the University of the Western Cape commenced with 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.

The Masters course consisted of eight structured modules with emphasis on the Nature of Science; Nature of Indigenous Knowledge Systems and contiguous/integrated relationships between the two, in addition to research design modules. These science educators expressed difficulty in understanding and implementing the philosophy mooted by Learning Outcome 3, in the RNCS (2002) policy document to integrate science with technology, society, indigenous knowledge systems and the environment. Thus the idea to launch the SIKSP series of seminar and workshop sessions was born with the express purpose of developing curriculum resource material that aligns with the Natural Sciences, Life Sciences and Physical Sciences as espoused in the National Curriculum Statements (NCS) with specific focus on the science-IKS knowledge mix proposed in this learning outcome.

The pedagogy of using dialogical argumentation as a tool or schema to promote interactive participation by learners in science-IKS based lessons formed the basis of the research paradigm of the mini-thesis of our students and one of the task required them to design and implement a science, IKS or science-IKS lesson as a preparatory stage to their research study.

These lessons were to be piloted at their respective schools and video recorded for analytical research. The first round of visits identified lack of confidence and competence in using dialogical argumentation-based teaching strategy in their lessons.

As facilitators of the programme, we reflected on our own practice and concluded that an alternative teaching strategy was needed in order to empower the teachers. A stronger experiential-based learning with a research paradigm would be applied. Using a mix of inductive, deductive and analogical pedagogies, argumentation-based material was designed for use in the workshop environment. The process of teaching argumentation was to use two scientific examples in the first instance, namely, (a) problem solving on density and (b) an unknown salt. One IKS exemplar was used, namely, characteristics and processing of gari obtained from cassava. Two focus group interviews were conducted after each of the two hour long workshops. Flowing out of the archived video and audio recordings, patterns emerged which informed the research facilitators of possible trends, complexities and models.

(a) Structure and process of the Third SIKSP Workshop

This four-hour workshop was conducted from 9h00 to 13h00 on a Saturday morning. Fifteen participants were present consisting of three facilitators and four groups of three educators each. Each group was provided with a digital recorder to record their discourse on the topic chosen. The workshop presenter allowed each teacher time to internalize the task presented before allowing the group to engage in discussion with each other. The group leaders were encouraged to report to the class as a whole, providing claims, evidence, warrants and rebuttals as per Toulmins' schema, with a view to reaching agreement or consensus around the stated task which was as to select the best out of three processes to extract gari from cassava.

(b) Observation

The teachers were exposed to a process of dialogical argumentation in two previous science lessons one assumed that they had acquired knowledge the argumentation process.
I observed that the first contact individuals made with the gari sample, was to start a dialogue with other group members, when initially the task was to engage individually with the gari sample and the documented processes.

The group discourse was much easier, but I noticed that the discourse was cyclic in nature, meaning that intra and inter discourses were occurring simultaneously thus leading to expanded understandings. The facilitator placed time limits on the engagement and tended to intervene or mediate in an effort to fast-track the process.

The following transcript represents an exemplar discourse in Group Four:

STEP 1 (Individual-intra dialogical argumentation (DA) & Step 2 (Group-inter dialogical argumentation (DA)

Description Comment: Group 4: Argumentation Lesson on Characteristics of gari made from cassava (using the senses) and working from sensory observations. The facilitator provides additional information in a worksheet where educators are asked to determine the characteristics of gari and to find a comparative product in South Africa.

Individual argument (Intra) alternates with the groups (inter) argument.
Facilitator mediates argument by keeping the group on track.
T1: Put in mouth it's hard
T2: Let's work to flavor and taste
T1: Its hard
T3: It taste like breadcrumbs
T1: It taste like what?
T2: It is saltless
T3: How do explain a slight tinge?
T2: Is it yeast?
T3: All right smell.
T1: Yes a sour smell, that's the yeast smell
T2: Flavour, tasteless no flavor, cream
Facilitator 1: Taste by letting it mix with the saliva
T1: What is this again?
Facilitator 1: Yes its gari, made from a tuber cassava, like a potato
T2: Like borrie?
T1: A strong taste.
T3: Like a woody taste.
T2: Looks like maize meal.
T3: What must we write for appearance?
T1: Different in shape, and size.
T3: It is very light, like flakes.
T1: I breathed hard and it went in my nose.
T3: Yes like flakes, particles are different sizes.
T1: Light in weight.
T3: Where does that fit in?
T1: We can put it with size it says how big it is.
Facilitator 1: Then for the second part of processing you don't have to do only one. You see here in A, B and C processing you see washing here and washing here and washing here, so most of the processes are repeating, look at all of these and pick the most critical.
T2: So you want to give us the answer now (laugh).
Facilitator 2: Don't just stick to one
Facilitator 1: You have to think of the biochemical, food process, biochemistry…. Integrate the science into the way it is prepared
T1: It tastes like rice.
T2: So it is like starch.
T3: Gari is tasteless.

71

T1: No if you put a lot in your mouth then it is a slight tinginess on your tongue as it gradually becomes soft.
T3: Actually taste like what…. Marie biscuits
T1: Can it be like oats?
T2: More like rice.
Facilitator 1: You should now be in D2
T2: Why don't you give us a time, then we Know what to work towards.
Facilitator 1: You should take into account the background. Like I have a food technology Background but T1 don't have that background
T1: We must reach a consensus.

At the end of the group discussions, group leaders were asked to present their consensus findings to the class. This process erupted into confusion, caused mainly by the critique, questions and rebuttals raised in the main by the facilitator and counter challenges by the class group. It was then suggested that the group leaders give their report unhindered, by writing down their findings on the board, followed by a discussion mediated by the facilitator. This process worked well and was agreed to by all. In the discussion process interesting phrases like harmonization of concepts, an evolving process of cognition, co-construction and spinning cycles were coined, which deserved a place in the model that was starting to crystallize. The fifth and last stage of the model could be the Focus Group Interviews, whereby, good and bad narratives are related, understandings are conceptualized and contextualized with complexities identified. The purpose of the DA model was to reach cognitive harmonization (agreement) on a given problem, issue or socio-scientific concern.

I considered these experiences and sought to develop a dialogical argumentation model where cognitive spaces could be combined with teaching and learning spaces in a scaffold-like structure or writing framework starting from a socio-scientific-cultural issue established as a starting or nodal point.

The **modified Dialogical Argumentation Instructional Model** (Refer Figure 2) as presented and discussed in this section has evolved from the one used in Figure 1. This model is comprised of six (6) stages that evolve as knowledge is constructed into an expanding shell-like structure. The concept of the expanding shells is a form of visual modelling to show how knowledge grows and evolves in a constructivist way as the teacher and learner move from one learning space to another. This progressive growth movement is facilitated by the teaching and learning activities occurring at the various stages of DAIM. The growth of knowledge and specifically science-IK knowledge tends to be sequential as DAIM is

implemented as a teaching and learning strategy to investigate a socio-scientific-cultural issue.

This model provides a useful knowledge processing framework for supporting teaching and learning processes by speaking to the following functionaries:

1. **Lecturers** can use the framework to design a dialogical argumentation programme for teaching science/IKS topics in an interactive way.
2. **Science teachers** to lead learners to a greater understanding of socio-ecological, indigenous knowledge and health promotion concepts (Henton, 1996).
3. The framework enables **teachers and learners** to reach optimum levels of critical thinking by applying dialogical argumentation to support DAIM with evidence and to reach consensus.
4. Promote the development of **teaching methodology** that transcends the bounds of normal training and research.
5. Enables **science education researchers** in following through an implementation process with cohorts of teachers studying science education programmes at the pre-service and in-service levels at University.

In order to achieve the goal of cognitive harmonisation or understanding and appreciation of viewpoints, the model suggests paying attention to the narratives of the experiences of the participants, their understandings of science-IKS concepts and the complexities of using DAIM.

The modified model consists of six distinct stages as described below:

Stage 1: Nodal point

The process starts with the selection of a socio-cultural-scientific topic that includes an integrated science-indigenous knowledge concept.

Stage 2: Individual Thinking Space (Intra-dialogical argumentation)

The individual learner investigates/inquires/considers the issue and/or problem/controversy or concern presented in narrative form. The individual is required to think about and formulate an opinion (claim) supported by reasons (evidence, data) in response to a series of questions. Learners record their claims and reasons (grounds) in writing assisted by a writing frame report card. This step is regarded as individual dialogical argumentation or intra-dialogical argumentation since the conversation is with oneself. This **'thinking space'** is intentionally created and facilitated by the teacher.

Stage 3: Small Group Sharing Space (Inter-dialogical argumentation)

Individuals share their views with other members of their small group of no more than five by engaging group members in debate, with the intention of establishing claims, counterclaims, rebuttals with supporting grounds with the intention of reaching group consensus on an agreed point of view. This **'sharing space'** can be regarded as inter-dialogical argumentation as it occurs between participants in the group. The purpose is to reach a common group understanding of the issue under consideration and to give each member an opportunity to articulate their opinions and in this way learners acquire a participatory voice in contributing to the argument or debate.

Stage 4: Group Presentation Space (trans-dialogical argumentation)

Each group in the class selects a presenter who will share that group's point of view (claims and counterclaims, evidence and warrants) with the rest of the class. This can be presented via a text poster and an oral presentation. In order to allow for trends and thoughts to develop no discussion or debate is allowed until all presentations have been made. The teacher facilitator creates this **'presentation space'** and chairs the follow-up class discussion in stage 5 by collating trends and emerging ideas.

Stage 5: Whole Class Interpretive Space (meta-dialogical argumentation)

Mediation by the facilitator (teacher) is initiated and the entire class has an opportunity to contribute further arguments based on evidence, (grounds i.e. data supported by warrants, backings or qualifiers). Particular note is taken of opposing claims or rebuttals.

The whole class debate is facilitated by the teacher who acts as a co-constructor of the argument. This stage recognises the participants' contribution to joint co-construction of knowledge and understanding through the identification of trends, themes and a meta-cognitive view about the issue under consideration. The objective is to use this **'interpretive space'** to highlight disagreement and ultimately to reach a common understanding or consensus or viewpoint referred to as cognitive harmonisation.

Stage 6: Focus Group Reflective Space

The purpose of opening up a space for dialogue with the whole class is called **'reflective space'** with the intention to strengthen the consensus reached, and for learners to voice any nagging concerns that may exist.

Stage 6: Focus Group Reflective Space
Focus group interviews to assess levels of cognitive harmonisation of science/IKS concepts

Stage 5: Whole Class Interpretive Space - Whole class dialogue
(meta-dialogical argumentation)

Stage 4: Group Presentation Space
Group leader present the groups'consensus viewpoints
(trans-dialogical argumentation)

Stage 3: Group Sharing Space
Group members share ideas and strive for group consensus
(inter-dialogical argumentation)

Stage 2: Individual Thinking Space
Individual considers topic and supports claim/s with evidence
(intra -dialogical argumentation)

Stage 1: Nodal Point
socio-cultural-scientific concept/concern/issue

Figure 2.3 Dialogical Argumentation Instructional Model (DAIM) for teaching an integrated science and indigenous knowledge systems lesson using teaching and learning cognitive spaces (Adapted from Langenhoven & Ogunniyi, 2009; Ogunniyi, 2009)

The process contributes to facilitating cognitive harmonization of a concept or concepts under discussion. The harmonization process actually begins with Step 1: Nodal Point and fans out in ever widening expansions as dialogical argumentation generate fresh new insights into the epistemology of the issue under consideration. As the pedagogical

76

schema unfolds knowledge evolves and is co-constructed with possible additions of new perspectives and insights.

The stages of DAIM are located within an ever-expanding shell structure that symbolises the evolving nature and construction of knowledge acquired by learners as the teacher facilitates the process of dialogical argumentation. Science teachers should be fully engaged in the development of teaching and learning material that recognises the interface and interconnectedness between science and Indigenous Knowledge Systems (Michie & Linkson, 1999). Toulmin's Argumentation Pattern (TAP) was used to rate the level at which dialogical argumentation occurs whilst Contiguity Argumentation Theory (CAT) was used to reconcile conflicting schemata between common sense and anthropomorphic worldviews with the mechanistic, empirical and counter intuitive views embedded in the nature of science with respect to school science (Ogunniyi, 1997; 2000; 2004; 2008; Langenhoven & Stone, 2009).

2.9.2   Observations of DAIM in action

This report is focussed on recent studies where DAIM was used to teach science concept lessons and science-IK lessons. The review will focus on papers presented at conferences in South Africa in addition to journal papers. The value of such a review adds to an emerging body of knowledge where dialogical argumentation is used as pedagogy. These studies assume that given a dialogical or intellectual space, teachers and learners can better advance their views for or against issues that requires an informed societal response in a non-threatening environment. Furthermore Kolstø (2001a; 2001b; 2006) designed a series of argumentation type lessons based on the historical case of Ignaz Semmelweis story of a Hungarian doctor concerned with determining the cause(s) of child bed fever. These lessons were supported with writing frameworks and reading references for use in teaching and learning and promote the art of dialogical argumentation. This review also draws attention to the reflections of participants involved with the SIKSP project on the use of DAIM as pedagogy in realising an integrated science-IK curriculum in schools and the use of TAP and CAT as analytical tools.

77

Initial attempts by teachers thus exposed to the processes of dialogical argumentation instructional frameworks tended to focus on science related concepts such as chemical equations (George & Ogunniyi, 2013); mining (van der Linde, 2011); weather patterns (Riffel, 2013). Philander (2013) used DAIM to teach the topic of water and water pollution to a grade 3 class. The Deputy minister of Science and Technology, Derek Hanekom, who had expressed interest in dialogical argumentation pedagogy was invited to observe Philanders class of 9 year olds in action. He was impressed with the level of confidence and level of dialogue reached by the young learners. The teacher taught a lesson on the uses of water and required the learners to draw concept maps of these uses and present their maps to the class as an exemplar, here is a short extract of what transpired between two learners and their teacher.

L1: You can use water…Can I also say you can use water. You can rather shower instead of bathing because bathing takes more water. And you can use water by … You can go to the church and people put water on your forehead. And the third one is you can use water as cooking. The fourth one is you can fetch water. If your mother has a new child and you go to church, you can see how the pastor put water on the new child, when he is born.

T: Anybody that want to comment? Anybody?

L3: I disagree with you because … when evil spirits come into your house, you put your fingers in the water and spray some around the house….

The transcript demonstrates the influence that everyday experiences have on learner perception of the use of water, certainly not science textbook knowledge, but knowledge that is far more interesting and serious to the learner's context. Note also how claims and counter-claims are made in the form of a narrative which if analyzed according to TAP and would be placed at Level 5: Argument that involves multiple rebuttals and at least one rebuttal challenging the grounds. The discourse in this grade 3 science class demonstrate the mix of different world views held by learners based on religious beliefs 'holy water'; spiritual rituals 'evil spirits kept away'; everyday experiences 'birth of babies'; and environmental awareness 'shower instead of bathing to save water'. Learners support their claims with backings and some rebut claims made by other learners. The teacher facilitates the discourse using rhetorical and

78

directed questioning techniques. The teacher also pointed out in her masters study that dialogical argumentation needs to be taught as a process in order for it to be effective in a science class.

The study will analyze similar kinds of transcripts generated by the lesson presentations of the cohort of pre-service science teachers in response to some of the research questions listed in Chapter One.

2.9.3   A review of selected studies on the integration of science and IKS

An extension to the SIKSP project was a collaborative effort to conduct a systematic review of science–IKS literature in South Africa and Mozambique between 1970 and 2012. The results of this investigation culminated in the 2012 *South African-Mozambican Published Research on Indigenous Knowledge Systems Conference.* As Ogunniyi (2012) pointed out in the preface to the series of papers published in the conference proceedings, the studies reviewed, reported and straddled various IKS fields including: public health; education; humanities and the social sciences; agriculture; technology; physical and natural sciences. Although this study focused on argumentation the evidence provided by reviewed IKS literature, point to the richness of available literature which can be accessed and used to develop curriculum materials for an integrated science-IK curriculum.

Dinie & Ghebru (2012, p. 110) analyzed eight papers comprising ethno-mathematics and ethno-botany-agriculture and appealed for an IKS methodology that can move IKS from merely documentation to practical applications. They further observe that for this transformation to be effective other role players like the community should lend support to the initiatives in promoting IKS in education.

The reviews of a further five papers by Mushaikwa & Angaama (2012, p. 45-47) are mostly empirical papers about education with specific reference to the policy of the South African Curriculum (C2005) which calls for an integration of science and indigenous knowledge. The questions raised in these papers are "What IK?" and "How is this to be implemented"? Argumentation in the research is seen as a possibility and Otulaja, et al, (2011) argues that this argumentation pedagogy may be too cumbersome for teachers to

implement in view of the challenges presented by a new curriculum seeking to introduce indigenous knowledge which is a totally new epistemology in science classrooms in addition to the pedagogy of argumentation. Of significance is the argument for repositories of resource books that teachers can access. The authors argue further that an equipollent stance is favoured where both worldviews co-exist, the one informing the other.

Amosun & Luckay (2012) argue for teachers to bridge the gap between research papers having IK content to that of education and more specifically science education. Teachers should take the initiative and provide meaning to issues and contexts by developing their own IKS resource materials. This enables a socio-cultural context characteristic to be added to learner's knowledge constructs, thus guiding them through a created cognitive conflict in order for them to develop their own critical voice. In summary they stated:

> Framing the research into argumentation format allows learners to be aware that both science and indigenous knowledge are built on pockets of knowledge which are not absolute; and that expressing their views can contribute to further construction of knowledge. (p. 65).

Langenhoven (2012) approached the review of articles from a capacity building exercise paradigm, by assessing the efficacy of the reviewers when tasked to review science-IKS papers using CAT as the tool for structuring the critical voice. The reviewers used were Bachelor of Education (Honours) students who were provide with notes and practice sessions on the processing skills of critically reviewing published papers on science-indigenous knowledge systems with a view to highlighting the authors' critical voice. He noted that in order to facilitate the use of this review process mechanism to build academic capacity in potential reviewers, the following guidelines could be followed:

- Papers to be grouped into meaningful themes (education, public health, humanities, agriculture, science,) as stipulated in the SA-MOZ Systematic Review program of action (Nhalevilo, 2011).
- Reviewers should be provided with quality exposure, exercises and supervised experience on review processes and underlying theoretical frameworks.
- Continue the practice of collaborative writing based on the reviews, in the engine room of a seminar/workshop setting as is currently enjoyed by the SIKSP participants.

Finally the usefulness of this exercise goes beyond mere description and ties in with Owston's (2005) views that "…systematic reviewers must consider broader issues, such as the way a report's findings are communicated, interpreted and ultimately applied".

Nhalevilo (2011) sees the systematic review process between Mozambique and South Africa as beneficial for identifying and recording research conducted specifically in education to realize the incorporation IKS policy into the education system. The importance of rhetoric is significant in that there is a need for science teachers to be aware of science-IKS debates. Theoretical lenses to understand this debate and policy prerogatives can help foster teacher efficacy in implementing an integrated science-IKS lessons using DAIM as a pedagogical strategy. Piloted exemplars of integrated science-IKS lessons designed by members of the SIKSP team and pre-service science student teachers will be discussed in Chapter 4.

2.9.4   Barriers faced by science teachers in implementing IKS

Modern science is thought to be the subject matter that is mostly taught in school science. Teachers are still navigating their way around the content of C2005 and the many curriculum changes that have been made since its' inception (See discussion on curriculum Chapter 1). Teachers expend their energies trying to teach Specific Aim 1: Knowledge Acquisition and Specific Aim 2: Skills Acquisition at the expense of Specific Aim 3: Science and Society, for the following main reasons:

(1) Specific Aim 3 is not examined with as much rigour as that of the first two.

(2) Teachers do not seem to be comfortable with the content of Specific Aim 3 in which IK is a component.

(3) Textbooks have little or no IK content and there is even less guidelines in teacher guides of how to enact the teaching of an integrated science-IK lesson. Adequate research into materials design for integrating science-IK is not overtly evident. In the Norms and Standards for Educators Policy (2000) it is stated that "…educators should be competent in designing original teaching and learning resources".

(4) The intention as stated by DoE (2002) to integrate IKS into the school curriculum reads: "The Department of Education should take steps to begin the phased integration of IK into curricula and relevant accreditation frameworks", requires publishers to include appropriate

material in science textbooks, which seemed to take on a dichotomized approach rather than an integrated one.

(5) The NCS and CAPS workshops implemented between WCED and held during school holiday breaks concentrated on developing learning programmes and work schedules with no clear understanding by workshop presenters of an integrated science-IK approach and no clear methodology.

(6) Education policy mentions inclusive education as one of its goals, yet the exclusion of IKS in classroom teaching is problematic and negates against achieving these goals.

(7) Most in-service teacher training has focussed on literacy, numeracy and conducting systemic testing in order to improve low scores in these subjects at the General and Training (GET) phase.

Naidoo & Vithal (2014) wrote about enacting policy with respect to teachers implementing IKS in to school science. They identified three approaches. These include: The incorporationist approach, whereby IKS is selectively inserted into science, the separatist approach whereby IKS is presented side by side with science and the integrationist approach that makes links and connections between IKS and science. They conclude that approaches used by teachers would depend on the context of engagement but favour the integrationist approach which also resonates with Diwu & Ogunniyi (2012, p. 334) who conceded that there are points of intersection between the two thought systems. The most telling point made is their argument for greater guidance and research into content and pedagogies for implementing a science-IKS curriculum. These sentiments find traction with this study in that a pedagogical teaching strategy is investigated precisely to implement IKS into school science.

a)   A teacher's cultural influence

An analysis undertaken by Van Wyk (1997) of pre-service and in-service teacher reflections after being exposed to a university science-IK Unit Assessment Standard, found that a representative of one or other dominant cultural group takes more ownership of the indigenous knowledge component of the curriculum than a teacher who is not of an indigenous cultural/ethnic group. The non-indigenised teacher tends to pass over indigenous knowledge in a disassociated and/or cold manner. The transmission of the curriculum by the

indigenised teacher is to draw on his/her life experiences and to make more meaning of cultural contributions to the context of school science whereas the dissociated teacher can only draw from the of learner's worldview and life experiences.

> IKS embodies ultimately a pedagogy that fosters cultural, social and identity criticism to validate the centrality of learners' experiences and how educators could support them to understand that their realities are socially constructed, and inevitably will be reconstructed as time goes on as exposure to different contexts are enhanced (p. 311).

b)   Importance of teacher efficacy

In addressing these concerns and reservations and in line with other researchers, researching pre-service teacher efficacy in implementing DAIM after an intervention Unit Assessment Standard dealing with Nature Of Science (NOS); Nature of Indigenous Knowledge Systems (NIKS); Integrating Science and Indigenous Knowledge Systems (SIKS) and Dialogical Argumentation Instructional Model (DAIM), found that pre-service science teachers in training at a university are strategically positioned to promote the principles expressed in the foregoing literature review for implementing an integrated science-IKS curriculum. The intention of the study is to report on how pre-service science teachers implement DAIM as a pedagogical teaching strategy for integrating science-IKS lessons

Vandeyar (2003, p. 193) states that

> IKS gives substance and content to culture thereby inviting discussions around the issue of objective content to all cultures. Generations of knowledge have been built up by indigenous peoples and because of the influence of the modern era it seeks to prevent the destruction of the past or more specifically of the social sinews that bind people's contemporary experience to that of earlier generations". …inequality, inequity, subjugation and marginalisation issues that have plagued our nation for three generations must be addressed by all the role players in education, in order to study IKS without bias. IKS has been seen by modern science as being of no value. It has been said that IKS is antiquated nonsense science. If modern science is

considered, then the only way of entering a University, for school leavers, then the integration of the two knowledge systems will have difficulty in getting appropriate acknowledgement at school level. (p. 197).

A recent master's thesis by Loggenberg (2012) using Langenhoven et al, (2009) DAIM model as a teaching strategy concluded that the sample of science teachers could successfully implement the strategy with confidence and motivation and that learners, especially those from a non-western background, who engaged with the argumentation approach on electrostatics also gained confidence and motivation in understanding scientific concepts.

Teacher training programmes at University are obliged to prepare teachers in following a teaching strategy that could establish a platform for creating teaching and learning environments that addresses all three Specific Aims equitably and with rigour, more so Specific Aim 3 because it expands on the question of the relevance of science (Sjoberg, 2002a; Langenhoven, 2006) as to why locating science in a socio-cultural context is relevant.

In trying to understand the cognitive states revealed by the participants' arguments and reflections on the issues related to the use of DAIM in integrating a science-IKS curriculum, Contiguity Argumentation Theory (CAT) is used to navigate any conceptual cognitive fluctuations.

One of the unit modules in the lecturing programme is that of the Nature of Visual Modelling (NOVM) intended to provide pre-service science teachers with additional stimulating visual support for integrating a science-IK curriculum.

2.10   The Nature of Visual Modelling (NOVM)

Traditional modes of teaching are offered through a 'talk and chalk" approach. The teacher focused on passing embedded knowledge to the learners by talking them through the content and the learners wrote notes and memorised the transfer of information for reproducing under testing or examination conditions at a later set time. Learners were expected to sit still in class, take notes and never question the teacher. This approach caused

the learners to be bombarded and overloaded with scientific facts, (Sampson & Grooms, 2009; Simon & Johnson, 2008). In order for the teacher to make an assessment of whether the learner absorbed the newly acquired knowledge or not they were subjected to tests and if they could re-produce the information, it was accepted that they understood the content covered (Simon & Johnson, 2008). Whether the re-production was truly an indication of meaningful understanding or merely a matter of memory was of least importance as the teacher's ultimate aim is to cover the lesson content. The "talk and chalk" teaching methodology has been around for decades and to this very day it is still used because some teachers still believe that, it is an effective method of teaching that also models the way they were taught. The "talk and chalk" methodology demands learners to be absolutely focused at a high level of concentration, as the learners are not able to stay focused for long periods of time, they are bound to lose interest, which in turn sparks negative attitudes. When learners are in a negative frame of mind, it places the teacher under immense stress. This challenge is often accompanied with disruptive behaviour, abusive mannerisms and worst of all learners losing complete interest in the subject.

An alternative teaching methodology which should be advantageous to both the learner and the teacher is called for. Hall &Sampson (2009), advocate the incorporation of teaching methods that involves dialogical argumentation. While Bricker & Bell (2008) support the incorporation of visual modelling. Some researchers believe that the implementation of the two concepts creates the opportunity for a cognitive shift. The benefit of resorting to dialogical argumentation and visual modelling is that classrooms become learner centred and this in turn creates a climate for active learner involvement. The teacher, benefits in that the need for talking throughout the entire lesson is minimised and the teacher can fulfil a true role as facilitator (Leitao, 2000).

I wish to focus on the importance of visual modelling as a strategy for effective science teaching. According to the National Academy of Sciences (2006), the use of modelling in science teaching makes the learning of abstract concepts comprehensible. Modelling promotes dialogue and team co-operation between participants. The purpose of models and modelling in science is to bridge the gap between the world of experience and the theory of scientific knowledge according to Francoeur (as cited in Gilbert, 2004). Spatial

(visual) modelling in science entails the use of three dimensional models to represent and or help explain abstract scientific concepts. The use of spatial *(visual)* modelling enables learners to understand the nature, scope and limitations of science, through the visualisation of abstract concepts (Gilbert, 1995).

Francoeur (as cited in (Gilbert, 2004, p. 116) elucidates that the functions of modelling and models in science and in education is to bridging the gaps between scientific epistemology and the experienced world. For example, within an African context there are various metaphysical explanations to account for lightning strikes that in no way approximate to scientific explanations there are different explanations to the causes of lightning strikes within an African context which is real and valid to the holders. Modelling as proposed by proponents of social constructivism in teaching and learning such as Piaget (1966), Bruner (1996) and Vygotsky (1978) have the potential to assist pre-service of socio-scientific issues.

The reality of what happens in a science classroom is usually one where the teachers interpret the curriculum in terms of what is to be assessed and plan to teach towards that assessment by using textbook content. Thus teaching and learning is directed mainly towards assessment and examinations rather than deep critical conceptual engagement. This exam orientated curriculum often leads to poor learner performance with the blame being laid at the door of the teacher. Science teacher training programmes require exposure of teachers to alternative teaching strategies and perceptions other than the positivist scientific approach in order to gauge teacher efficacy (Bandura, 2000) and readiness to border cross (Aikenhead, 1996) between everyday experiences of learners and scientific worldviews. Successful learning environments are those that build upon solid understanding of the skills and knowledge individual learners bring to the classroom thus facilitating and building on new information encountered (Bransford et al, 1999).

Mushaikwa., Langenhoven & Stone (2014) reports on participants who were asked to reflect on their experiences in spatial modelling as a tool for concretising the teaching and learning of revolution and rotation of the earth, moon, sun system. The following transcript is provided:

Melody: The main benefit is that it assists learners to move from known to unknown. Often concepts are abstract and learners struggle to understand them. If one conceptualises, concepts they become doable for learners. It is especially useful in science due to the abstract nature of many scientific concepts.

Ben: *I think spatial modelling provides simulation models of real world. Models focus on the understanding of space, size and position of objects in the real world. The teacher creates the environment for learning when modelling by making use of the learners' prior knowledge, skills and learner uniqueness. This also gives learners the opportunity to express their uniqueness. It creates opportunities for critical reasoning when learners are engaging with knowledge and peers reviewing science knowledge. This enables them to construct their own knowledge which is scientifically acceptable.*

Stephen: *Spatial modelling requires the learners to take abstract concepts in science and make it easier by means of constructing smaller, life like models... Since everyone has either cultural, religious or scientific worldviews on scientific concepts, agreeing on what information to use would usually be difficult to resolve, but when using spatial modelling it results in all the learners in class to experience the same information together.*

From the above excerpts it is evident that the primary goal of a science teacher in a classroom is to use teaching strategies that enable learners to understand the concepts that she/he teaches. When one is able to prepare resources that enhances the teachers delivery of content and by using suitable teaching strategies to maximise conceptualisation of concepts by the learners whereby the content is contextualised. Stephen sees the transcendence and equipollent value of culture, religion and science worldviews being brought into harmony through modelling activities whilst Ben is of the view that modelling allows for sharing knowledge in a creative way. Melody on the other hand becomes aware of how theory and praxis merge. Their mere engagement in model construction and modelling unravels a whole lot of process skills, such as dialogue and evaluation of the model. This can lead to remodelling to improve the model, thereby enhancing technology and design skills. Theories, hypotheses and experimentation can evolve from the modelling process. Models are used to summarise and simplify processes that are complex.

Ramadas (2009) reviewed visual and spatial models in science which prompted me to consider the role of visual modelling as a unit. Ramadas (2009) argues that visual and spatial thinking is an integral part of doing and learning science in the sense that models are idealisations of science and are simplifications of complex, real-world phenomena, often expressed in concrete, visual or symbolic modes. Initially visual thinking was placed in opposition to verbal modes of thinking but visual thinking (imagery and diagrams) are inseparable from language-based forms of reasoning. In other words model-based reasoning is a combination of verbal, visual, symbolic and mathematical models. Through this transformational reasoning in science and more specifically through engaging with the pre-service teacher training programme and in dialogue with the sample group an argumentation model (to be discussed later) was developed and this led to opening up teaching and learning spaces for synergising and simplifying the links between the apparent disparate modules of the programme.

These modules are: the nature of science (NOS); the nature of indigenous knowledge systems (NOIKS); the nature of visual modelling (NOVM); a dialogical argumentation instructional model (DAIM) and its' accompanying theoretical frameworks for argumentation analysis, namely, TAP and CAT, in conjunction with Bandura's Socio-cognitive theory. The model emerging and developed from this study has a 3D structure shaped into a triangular pyramid which consist of one triangular base, three faces, three interfaces and one internal voluminous space when constructed, which represent the seventh cognitive space following on the six cognitive spaces as mentioned in the Dialogical Argumentation Instructional Model (DAIM). This seventh cognitive teaching and learning space is called the aesthetic space of conceptual harmonisation (Grey, 1999). This space brings together concept and context and represents the pinnacle achievement of a successful implementation of DAIM and in Vygotskian (1962) terms the Zone of Proximal Development (ZPD). I named this model the Pyramidal Argumentation Model (PAM) which will not be discussed in this study but in follow-up papers.

2.11   Chapter Summary

In this chapter the context for the study was provided as well as a review of literature and similar studies which considered argumentation as a teaching strategy for use in science classrooms. Focus on the rationale for an integrated science-IKS curriculum in school science education policies in South Africa was explicated in the extant literature. Theoretical and conceptual constructs were explained with the emphasis on the development of a Dialogical Argumentation Instructional Model (DAIM) as an alternative teaching strategy for implementing a science-IKS curriculum. The reader is introduced to the research design in Chapter Three, as well as the research instruments selected to collect data and interrogate the efficacy with which pre-service teachers manage the reality of implementing DAIM as a teaching strategy in the science classroom.

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

3.1   Introduction

This chapter will provide a detailed account of the procedure used to gather data on how DAIM was used to enhance pre-service teachers' efficacy in implementing a science-IK curriculum. The collection and compilation of data is used to explicate response to the research questions stated in Chapter 1.

3.2   Research Design

The study is based on a case study design that entails the use of both quantitative and qualitative mixed methods approach (Robson, 2002). Yin (as cited by Robson, 1994, p.178) defines a case study as a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence." Some of the criticism levelled at a case study includes the fact that it deals with a small sample and hence its' findings are not generalizable beyond that sample. It is associated with the one-group designs and is easily susceptible to subjectivity. However it is for this reason that I am using a one-group pre-post-test design that the case study is appropriate. Since empirical data was gathered using a range of questionnaires as well as qualitative data using reflexive diaries and interviews the case study design allows for flexibility across raw score data in the case of using Likert scales as well as socio-cultural contexts of reality as in indigenous knowledge cosmologies. Engaging multiple methods of data collection will lead to more valid, reliable and diverse constructions of reality (Golafshani, p. 604). The general case study plan deals with the step by step procedure of selecting the sample, developing the instruments, identifying the procedure for data collection and analysis. Robson (2002) further defines a case study as a research strategy focusing on the study of single cases which can be an individual person, an institution, a situation and so on. A case study uses multiple methods of data collection and most often it is qualitative data but quantitative data collection can also be used.

In structuring the rich data set, I identified three phases of pre-service science teachers' engagement with a science method course presented in the first semester of the one-year Post Graduate Certificate of Education (PGCE) course. The course focuses on NOS and NOIKS. The second phase is that of implementation of an integrated science-IK curriculum using dialogical argumentation framed within a model as an instructional teaching strategy. After the teaching practice block of seven weeks and upon the pre-service science teachers return to campus, the third phase was enacted which focussed on reflective narratives about their experiences with DAIM to teach a science-IK lesson in the science classroom.

3.3   Sample

Creswell (1998, p. 118) suggests that purposive sampling can provide a rich bank of data collected through empirical and qualitative means inclusive of focus group interviews.

A purposive target sample of thirty (30) pre-service science teachers enrolled in a science teaching methods course at post graduate level at a university was used in this Study. The purposive sample is homogeneous in terms of a number of internal and external factors such as academic background (all have at least a bachelor's degree in science), graduate attributes, career choice and exposure to a Dialogical Argumentation Instructional Model (DAIM) as a science teaching method (De Vos, 2005; Maree, 2008). This purposive sample is the Post Graduate Certificate of Education (PGCE) students enrolled for a one year teacher training programme at an urban university in the Western Cape Province University, South Africa.

3.4   Research instruments

To generate data in this study a number of questionnaires were adopted. The questionnaires used in the study include the following (1) Nature of Science Questionnaire (NOSQ); (2) Characteristics of Indigenous Knowledge Systems Questionnaire (CIKSQ); (3) Nature of Science and IKS Questionnaire (NOSIKSQ); (4) Test of Science Related Attitudes (TOSRA); (5) Reflective Diary Questionnaire (RDQ).

3.4.1 Nature of Science Questionnaire (NOSQ)

(Appendix B)

This instrument underwent rigorous validation and elicited responses to directed questions on the nature of science and the source of that view. The questionnaire is useful as it provides a baseline of pre-service students understanding of NOS. It is useful to compare whether a conceptual shift has been made after a training programme on NOS.

3.4.2 Characteristics of Indigenous Knowledge Systems Questionnaire (CIKSQ)

(Appendix C)

This questionnaire provides a variety of natural science-IK scenarios' that significantly delineate between the understandings of phenomena of two worldviews. The way the participants respond to each scenario would determine the worldview shaping their understanding of such phenomena.

3.4.3 Nature of Science and Indigenous Knowledge Systems (NOSIKSQ)

(Appendix D)

This questionnaire is concerned with determining the nature of the subject's familiarity with the science-IK curriculum to which they were exposed. Also their responses to the questionnaire were to reveal to what extent they had come to understand Specific Aim 3 of the new curriculum dealing with science, technology and socio-cultural issues pertaining to IKS.

3.4.4 Test of Science-Related Attitudes (TOSRA)

(Appendix E)

This instrument was adapted by Fraser (1981) from Kerlinger & Kay's Education Scale. TOSRA attempts to measure attitudes of teachers to education practices. Since TOSRA is concerned with measuring teachers' attitudes to educational practices it was also considered suitable for appraising the pre-service teachers' attitudes towards DAIM, an instructional approach different from what they were used to.

92

3.4.5   Reflective Diary Questionnaire (RDQ)
      (Appendix F)

The purpose of RDQ is to provide the pre-service teachers' the opportunity to recount their experiences as participants in the methods course based on DAIM. In addition it was to elicit honest responses from them on their return from teaching practice and to recount their experiences relating to the efficacy of integrating a science-IK lesson using DAIM as pedagogy without engaging in prior conversation with their peers. More details about all the questionnaires are presented in Appendix A. It was hoped that the use of the various questionnaires would help to triangulate and increase validity of the data collected (Guba & Lincoln, 1987)

3.4.6   Bandura's Teacher Self Efficacy Scale (BTSE)
      (Appendix G)

The final statements of BTSE were modified to specifically measure the attitudes of pre-service science student teachers to the science teaching methods aligned to the Curriculum and Assessment Policy Statements (DOE, 2011) for science subjects at schools.

The purpose of procuring data using these instruments is for triangulation purposes as well as sensitising participants to the context of the research, the language of this specific research and the concept of a reflexive research practice.

The purpose of using triangulation as a process is directed at the need to increase for increasing the validity of a given study. Denzin (1998) identified four types of triangulation: (1) data triangulation-the use of various 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 will be made of all of the above methods of triangulation except (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 in solving the problems associated with rival 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 & Miller, (2000, p. 126) defines 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".

The work by Lincoln & Guba (1985) is of interest to the processes of data gathering and analysis. They advise that the following measures will increase the degree of credibility: prolonged engagement in the setting, persistent observation, triangulation of data, 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 monological data generation (Robson, 2002).

In order to increase the dependability and the stability of data over time, careful recordings of the details of each stage of the process should be kept. These details could be used in what Lincoln & 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 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 will be drawn upon to present vignettes of best practices in the science classroom.

The summary results are reflected in appendices and drawn upon when and where needed in order to support arguments around the research questions.

3.5 Focus Group Interviews

Focus group interviews present the opportunity to access data that cannot be achieved from observation and fill the gaps and omissions left out in questionnaires (Bogden et al, 2003). This type of interview provided an in-depth look at the beliefs, perceptions and experiences of the pre-service student teachers on their experiences in using DAIM as an instructional teaching strategy to implement a science-IK curriculum. Similar focus group interviews were held with participants in the SIKSP research group. The valuable insight gained from the SIKSP focus group interviews ultimately informed my thinking around the development of the six stage DAIM pedagogical schema. SIKSP teachers who participated in piloting DAIM reported positively on its contribution to creating a positive learning environment where learners could actively participate in discussing relevant socio-scientific issues. I modelled the focus group interview process on the SIKSP experience.

The data collection process culminated with focus group interviews being conducted. Permission for the interview was obtained from the thirty (30) participants at which stage they were also informed of their ethical rights. These ethical rights included a guarantee of anonymity, the right to withdraw at any stage and to use the information until the study had been completed. All thirty (30) participants were divided into four random groups for the purpose of the focus group interview. To avoid discourse contamination of the interview process, the following procedure was followed: participants gathered in the lecture room where a colleague engaged them in computer-based activities. The selected group was called out and interviewed in the interview room. On completion they were excused and allowed to

95

leave the area thus avoiding contact with the next group. The focus group interviews of the pre-service science teachers were recorded, transcribed and used in the interpretive discussions.

3.6   Piloting of instruments

The instruments used in the study were adapted from various studies done under the auspices of the Science and Indigenous Knowledge Systems Project (SIKSP). Fuller details of how these instruments were developed have already been published (Riffel et al, 2013; Diwu & Ogunniyi, 2012; Ogunniyi, 2004; 2006; 2007a).

3.7   Reliability and Validity

The reliability of an empirically designed instrument can be defined by the degree to which the collected data can be interpreted consistently across different situations. It may be subjected to different methods such as test-retest and inter-scorer reliability. Before instruments were administered the inter-scorer method was used, whereby raters scored items on a scale of 1 to 5. This study used inter-scorers reliability which measured the degree of agreement between two or more scorers, judges or raters. Any item scoring an average of 3 or less was discarded (Bernard, 2011).

Secondly validity refers to the degree to which a measuring instrument has actually measured what it is designed to measure (Field, 2009; Ramaligela, 2013). In this study questionnaires were used to understand pre-service teachers' awareness of the nature of science, the nature of indigenous knowledge and the nature of science-IK teaching paradigms. To ensure the reliability and validity of the instruments a pilot study was carried out prior to the commencement of the methods course in order to assess the validity and appropriate use of the instruments. The reliability and validity of these questionnaires were submitted to a panel of science teachers and science education lecturers for rigorous testing in 2005. The panel interrogated and ranked the items on a scale of 1-5, (1 indicating a poor item and 5 indicating an excellent item). Next, two pairs of rankings were subjected to a modified Spearman-Rank Difference formula. The final adapted drafts of the questionnaires used to

collect data ranged between 0.95 to 0.98 thus indicating a strong face, content and construct validity (Ogunniyi & Hewson, 2008).

Robson (2003) describes a case study as a detailed account of a small number of individuals with some features in common and focuses on antecedents, contextual factors, perceptions and attitudes preceding a known outcome. It is used to explore possible causes, determinants, factors, processes, experiences and so that contribute to the outcome. In this study I am of the opinion that the intended outcome for pre-service science teachers exposed to a science-IK based intervention module for teaching an integrated science-IK lesson using DAIM, may be realised.

3.8   Research Intervention

At the start of the instructional programme in the first semester of studies, pre-service science teacher students were provided with a code of ethics, rights and orientation into the rationale of the research programme based on education policy documents as discussed in chapter 2, and its inclusion in the science method modules. A series of pre-test questionnaires were applied as indicated above to determine prior views, perceptions and attitudes related to the study.

Following on this stage which ran for two three hour sessions, participants were provided with a collation of reading material by M. B. Ogunniyi and developed through the Science and Indigenous Knowledge Systems Project (SIKSP) sponsored by the National Research Foundation (NRF), entitled "An argumentation-based package on the nature of science and indigenous knowledge systems" consisting of two volumes: Book One: The Nature of Science and Book 2: The Nature of Indigenous Knowledge. In addition a series of lectures and activities based on Dialogical Argumentation Instructional Model (DAIM), e-learning and interactive chat rooms, and demonstration lessons were conducted to focus on the Nature of Science (NOS), the Nature of Indigenous Knowledge Systems (NIKS) and the integrated science-IKS curriculum's articulation with the NCS and CAPS science education policy documents (Natural Sciences, Life Sciences and Physical Sciences).

The implementation of the argumentation-based course was based on the following procedure for each three hour session. In the first term the three hour sessions were devoted to assessing students' familiarity with conceptions of NOS and IKS through questionnaires as well as interrogative discussions using writing frameworks and models of dialogical argumentation as applied in the SIKSP seminars and workshops. These sessions provided students with practical exposure on the process followed when conducting an argumentation-based lesson. Through this experiential approach argumentation was seen not as a means to undermine or denigrate belief systems or score points, but more as an intellectual activity of how to support claims with relevant and meaningful evidence. The thirty minute wrap-up of any three hour session was then used to clarify issues and reach as far as possible some form of cognitive harmonisation with respect to alternative worldviews. Through these avenues students were orientated to extant literature, essay writing, individual and group presentations of the integration aspects of science and indigenous knowledge imperatives and could grapple with the interpretation of the new curriculum.

The profile of this sample of students were varied, and indicated that they came from diverse science epistemological backgrounds with expertise in one or other field. These participants were Bachelor of Science graduates with majors in two science related discipline areas, for example, graduates in micro-biology or bioinformatics or chemistry and may not have a complete repertoire of school related science subjects. The science method programme was generic in nature and equipped participants with a pedagogy that resonated with any science topic. Cognisance was taken of the SIKSP seminars and workshops experiences and these revealed the challenges encountered by teacher educators when facilitating the teaching of DAIM to a freshmen group not exposed to teaching and learning methodologies in their undergraduate degree and/or national diploma content courses.

Clearly the rules of dialogical argumentation needed to be taught in the context of NOS and IKS. Amidst much scepticism and anxiety students were required to make a paradigm shift from a conventional lecture centred teaching approach to one that required critical thinking along deductive and inductive ways. Diwu, (2010) noted that African adults would argue in favour of their cultural background knowledge and say 'isintu sithi', meaning 'our tradition says this or that'. He further points out that they would say 'eyam imbono',

which means, 'in my own personal opinion – not school, not my culture, but I see it this way' which manifested itself in the discussions of this group. Students grappled with finding cognitive coherence between common sense everyday intuitive worldviews, school science worldviews and indigenous knowledge systems worldviews.

3.8.1   Modelling the structure of a classroom lesson

Pre-service science student teachers were introduced to argumentation and DAIM through demonstration lessons. I followed an inductive approach, whereby a socio-scientific topic was mooted for discussion. Time on task instructions were provided and evidential material was provided to support either view. At the end of the argumentation process, the model was provided and a discussion on each stage was done as explained in Chapter 2. The teacher is required to consolidate ideas, clarify issues and ensure that the duality nature of a science/IKS lesson is achieved (DAIM structure is discussed in chapter 2). Once this process was established I introduced integrated science-IKS concepts through model lesson demonstrations by SIKSP members who took on the role of guest lecturers. Four SIKSP members were guest presenters, demonstrating how DAIM is implemented. The group discussions on the lessons were video-taped and audio-taped inclusive of participants' comments on the argumentation process. Theoretical and conceptual frameworks discussed in chapter 2 were used to analyse these four training sessions listed as: (1) Sound: Health hazards of the Vuvuzela (a sound horn); (2) Spatial Modelling: Earth-Sun-Moon; (3) Weather predictions: Sayings and Instruments and (4) Learning science through story-telling.

After these demonstrations participants were required to prepare lessons showcasing a topic in science that included IK and to present their lesson by using DAIM as a teaching strategy, to the class. In this way individuals were able to prepare, practice and model an integrated science-IK lesson using DAIM as a teaching strategy. The teacher facilitator takes on the role of instructor, curriculum designer, time manager and co-constructor of knowledge, thus guiding learners to cognitive harmonisation which is important for understanding the science-IK concepts envisaged with an integrated science-IK lesson.

Following on these demonstration lessons, students were then instructed to work in groups of three or four in preparing a science/IK-argumentation based lesson for presentation at in-house demonstration trials. This presentation provided valuable peer critique. Recordings were made of these argumentation lessons. In the third term all student teachers were located at schools for teaching practice. A random sample of these pre-service teachers were visited with a view to evaluating their efficacy in implementing DAIM for teaching science-IK topics. The classroom observations were audio-taped and video-taped. The transcriptions were also subjected to careful analysis using TAP, CAT and Socio Cognitive theory as analytical tools. A classroom visit protocol started with the researcher conducting (1) an individual audio-taped interview before the lesson; (2) observation of the lesson using video and audio tape; followed by (3) a de-briefing interview with the student teacher after the observed lesson. All lesson documents were collected as well as the worksheets used by the groups of learners for further analysis.

The full cohort of thirty (30) student teachers completed a reflexive diary in the first contact session after their return from teaching practice in the fourth term. This diary captured their reflexive memory around their teaching practice experiences with DAIM as they attempted to implement the science-IK curriculum (see Appendix 6).

The study was regarded as complete when the student teachers completed the set 'Take-Home' examination which included a question on the design of an integrated science-indigenous knowledge lesson incorporating DAIM as pedagogy. A power-point presentation formed a compulsory part of this exercise.

3.8.2 Development of a Dialogical Argumentation Instructional Model

This study was conducted as part of a larger project, 'The Science Indigenous Knowledge Systems Project (SIKSP)' located at the School of Science and Mathematics Education (SSME) in the Faculty of Education at the University of the Western Cape, and funded by the National Research Foundation (NRF). Members of this project group are actively involved in experiential learning involving the development and hands-on trials with dialogical-argumentation based lessons using Toulmin's Argumentation Pattern and

Ogunniyi's Contiguity Argumentation Theory as theoretical constructs and lenses for analysis.

The DAIM used in this study was developed in the Science and Indigenous Knowledge Systems Project, hosted by the School of Science and Mathematics Education at a Western Cape Province university. This workshop provided the cauldron for teachers and students to engage with the imperatives of a proposed indigenisation of school science as stipulated in Curriculum 2005 (C2005) formulated in the policy documents NCS (2001); CAPS (2011) by the South African government. My first engagement with argumentation occurred when Toulmin's Argumentation Pattern (TAP) was applied during a lesson developed around indigenous food products such as umqombothi which is a traditional beer prepared by ethnic groups and included in celebrations and rituals in South Africa (Kwofie, 2009; Diwu, 2011). The focus of the workshop on making African beer was on processing methodologies and narratives of traditional practices. For example, women preparing umqombothi must cover their hair and dress appropriately as a sign of respect for the ancestors and the gods, indirectly linked, in all probability to the issue of hygiene. Flowing out of these pilot discourses and application of an argumentation mediated understanding of food quality assurance processes mapped onto indigenous knowledge activity a pedagogical schema emerged. In analysing the processes of discussion members agreed that consensus on claims and grounds could be reached pertaining to science-IKS dialogue through an inductive, deductive and analogical reasoning. This agreement was referred to as cognitive harmonisation.

3.9 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 for easier interpretation (Friese, 2012) whilst the quantitative data set was analysed using the SPSS software programme where appropriate (Pallant, 2001; Field, 2003). In brief the data transcripts (audio and video) will be subjected to a descriptive level and a conceptual level of analysis. This allows for easier tracking of trends and categories for further analysis

using TAP and CAT as analytical lenses (Pallant, 2001; Field, 2003; Friese, 2012). The findings are then discussed in the context of the extant literature in relation to teacher efficacy in implementing DAIM as a method to integrate science-IK lessons.

3.10   Ethical considerations

This deals with the issue of ensuring that the interests of the subjects of the study as well as those of the stakeholders are recognized and protected as stipulated by the Senate Research Committee (SRC) of this large South African urban university in the Western Cape Province, South Africa. Before the commencement of this study permission was obtained from all the stakeholders and included student teachers, learners, their parents/guardians, school administrators, curriculum advisers and the Western Cape Education Department (WCED). The anonymity of the pre-service teachers is assured by giving them the option to withdraw from further participation at any stage. All names used in this research are pseudonyms to protect the privacy of participants.

The participants completed letters whereby their permission is requested to use the data collected in the research for the purpose of report writing. Confidentiality and anonymity is guaranteed and they had the option of withdrawing at any given. All questionnaires and interviews are treated in confidence with the guarantee that the results would not be shared with any other participant or used indiscriminately. The following generic checklist is used to track all permission requirements:

1. Principals permission letter
2. An oral explanation of the purpose of the study followed by a letter
3. Mentor teachers permission to use the class
4. All interviews are strictly confidential and a confidentiality letter was written to the schools concerned
5. Learner questionnaires would be anonymous
6. Names of school are kept anonymous and no information about the schools or learners or student teacher will be divulged to any person.
7. At the end of the study the school principal and the selected student teacher participants would receive a summary report of the findings of the study conducted.

All the participants signed confidentiality letters prior to individual and focus group interviews. Also permission to record the interviews is requested before their participation.

3.11   Chapter Summary

In this chapter an overview of the research design was provided. The case study as a conceptual framework was explicated and the mixed-method approach where appropriate to collect data was explained. Both quantitative data and qualitative presented for analysis provided diverse views on the study. Participants were orientated into the argumentation paradigm. The study sample is described together with the framework for data collection as well as an orientation as to how the data would be collected from the sample. Ethical considerations were discussed in terms of confidentiality and anonymity. The collation of the reflective diaries of the samples and the responses provided by participants during focus group interviews provides a rich bank of data for analysis and discussion going forward into chapter 4.

CHAPTER 4
RESULTS AND FINDINGS

4.1   Introduction

As indicated in chapter 1, the study was concerned with determining the effects of a dialogical argumentation instructional model (DAIM) in enhancing the ability of a group of 30 pre-service teachers to implement a science-indigenous knowledge curriculum as stipulated in Specific Aim 3 of the Curriculum and Assessment Policy Statement (CAPS) promulgated by the Department of Basic Education (DBE) in South Africa. This chapter describes and analyses the data obtained through the administration of the various instruments, namely: questionnaires, focus group interviews and the reflective diaries of the selected cohort of pre-service science teachers.

In pursuance of the aims of the study answers were sought to the following research questions:

1. What are the pre-service science teachers' pre-post conceptions of NOS and NOIKS?
2. What are the pre-service science teachers' pre-post conceptions of an integrated science-IK curriculum?
3. What are pre-service science teachers' pre-post conceptions of their self-efficacy in using DAIM to implement a science-IK curriculum?
4. What are pre-service science teachers' practical experiences during the teaching practice when attempting to use DAIM to implement an integrated science-IK lesson?

The first aspect of the data analysis focuses on the pre-service science teachers' pre- and post-test conceptions of the nature of science (NOS) and the nature of indigenous knowledge (NOIKS). The notion "pre-post-test conceptions" refers to the conceptions held by the pre-service teachers before and after being exposed to DAIM. The underlying

assumption of the study is that the pre-service teachers' ability to integrate science and indigenous knowledge (IK) in a classroom context depends on whether or not they hold valid understandings of both knowledge corpuses. According to Aikenhead (2006) and Ogunniyi (1982; 1988; 2006; 2007a & b) if teachers hold inadequate conceptions of NOS what they teach would be a corruption of that thought system. The same is of true of NOIKS. To determine the pre-service teachers' conceptions of both knowledge corpuses therefore warrants an exploration of their understanding before and after the intervention or treatment i.e. DAIM. In other words their pre-test conceptions of NOS and NOIKS relate to what they held before they were exposed to DAIM while their post-test conceptions relate to views after they had been exposed to DAIM.

The second aspect of the analysis focuses on two things namely: (1) the practical application of implementing a science-indigenous knowledge curriculum; and (2) the pre-service teachers' evaluation of their sense of self-efficacy using a dialogical argumentation instructional model (DAIM) while implementing an inclusive science-IK curriculum in their classrooms. However, in view of the vast amount of data gathered in this regard only the ratings of striking narratives of the pre-service science teachers are selected for discussion from their journals/diaries and transcripts of the focus group interviews. A further focus is on their narratives pertaining to their attestation on their ability to use DAIM as a teaching strategy in the implementation of a science-IK lesson.

A cursory examination of the pre-service teachers' responses to the four research questions would reveal whether or not DAIM has been effective in enhancing their pre-post conceptions of NOS and NOIKS and their ability to implement a science-IK curriculum. It can be assumed that if DAIM as the treatment is not effective so would be the pre-service teachers' understanding of NOS and NOIKS or their ability to implement the new curriculum. As indicated in chapters 1 and 2, DAIM is underpinned by two argumentation theories namely, Toulmin's (1958/2003) Argumentation Pattern (TAP) and Ogunniyi's (1997) Contiguity Argumentation Theory (CAT). Both TAP and CAT have also been adopted as the units of analysis for exploring the data. Both constructs are easy to use in exploring perceptual changes that tend to occur when people are involved in an

argumentation discourse (Erduran, Simon & Ogunniyi, 2007a & b; Ogunniyi & Hewson, 2008; Osborne, 2010; Simon and Johnson, 2008).

4.2   Using TAP and CAT as analytical lenses

As shown in chapter 2 the TAP format adopted for the study consists of six levels i.e. levels 0 to 6 (see Table 2.4). As discussed in chapter 2 TAP is suitable for analysing logical arguments as are commonly encountered in a science classroom discourse. However, when the subject being discussed goes beyond rational arguments and involves emotive and value-laden arguments TAP is no longer suitable as a unit of analysis. It is in this regard that the contiguity argumentation cognitive categories become handy for interrogation the discourse (Ogunniyi, 2007a & b).

It is apposite that despite the differences between TAP and CAT the two constructs should not be seen as exclusive analytical lenses. They may in fact be used in a combined and modified fashion depending on the nature of the data in vogue. Arguments may involve both epistemic and metaphysical worldviews. An epistemic worldview is construed here in terms of veridical, precise or truthful knowledge of testable evidence or facts. A metaphysical worldview on the other hand refers to knowledge based on non-logical, non-testable and non-logical and even intuitive knowledge. It is well known that depending on contextual changes an argumentative discourse can embrace logical and non-logical reasoning. For that reason, a worldview may involve logical, non-logical arguments or a combination of both. It is in light of this that in a certain setting TAP is applicable while in another CAT is more applicable and of course an emerging argument for combining the two theories in the analysis may add more validity to the socio-scientific decisions or conceptions that are articulated. The section that follows is an attempt to address the research questions sequentially.

4.3 Research Question 1

What are the pre-service science teachers' pre-post conceptions of NOS and NOIKS?

For ease of reference the data analysis would first explore the pre-service science teachers' pre-post conceptions of NOS in terms of TAP

4.3.1 Using TAP to analyse pre-service teachers' pre-post conceptions of NOS

In view of the vast amount of data involved in this study only 11 out of 18 items of NOS have been selected for analysis in this report. For the same reason their responses to the other items are presented in Appendix D. Table 4.1 and Fig. 4.1 below reflect the pre-service science teachers' conceptions of NOS. The model column is based on over 95% agreement among a panel of NOS experts in earlier studies (Ogunniyi, 2006; Nhalevilo & Ogunniyi, 2014).

Table 4.1 Pre-service science teachers' pre-post conceptions of NOS

No	Statement N = 30	Pre-test			Post-test			
		A	D	Blank	A	D	Blank	Model
q1	Science tells us the truth about the natural world.	58%	32%	10%	66%	33%	-	D
q2	Scientific knowledge is trustworthy because it is supported by testable evidence/data.	83%	17%	-	78%	12%	-	D
q3	A learner may fail to understand a scientific topic simply because the language used in class does not match/his/her way of thinking.	92%	8%	-	66%	33%	-	A
q4	The purpose of school practical work is to confirm scientific theory.	89%	11%	-	91%	9%	-	D
q5	In their work, scientists are influenced by their	18%	67%b	14%	90%	10%	-	A

	socio-cultural and psychological frameworks.							
q6	To understand what science is, there is no need to consider, for example, philosophical, religious, psychological, sociological or linguistic questions.	25%	75%	-	8%	92%	-	A
q7	Before a scientific discovery is accepted, many scientists have to test and confirm the discovery, and reach agreement about it.	83%	17%	-	92%	8%	-	A
q8	The truth of science is the same for everybody. It does not depend on anyone's personal beliefs or situation.	30%	70%	-	23%	77%	-	A
q9	Scientific theories are like maps of reality. They help us see order and structure in a very complicated and confusing world.	82%	8%	-	92%	8%	-	A
q10	Scientific investigation follows a step by step procedure.	91%	9%	-	100%	0	-	A
q11	Scientific knowledge grows by argument and counter argument.	91%	9%	-	91%	9%	-	A

Key: q = question; A = Agree; D = Disagree
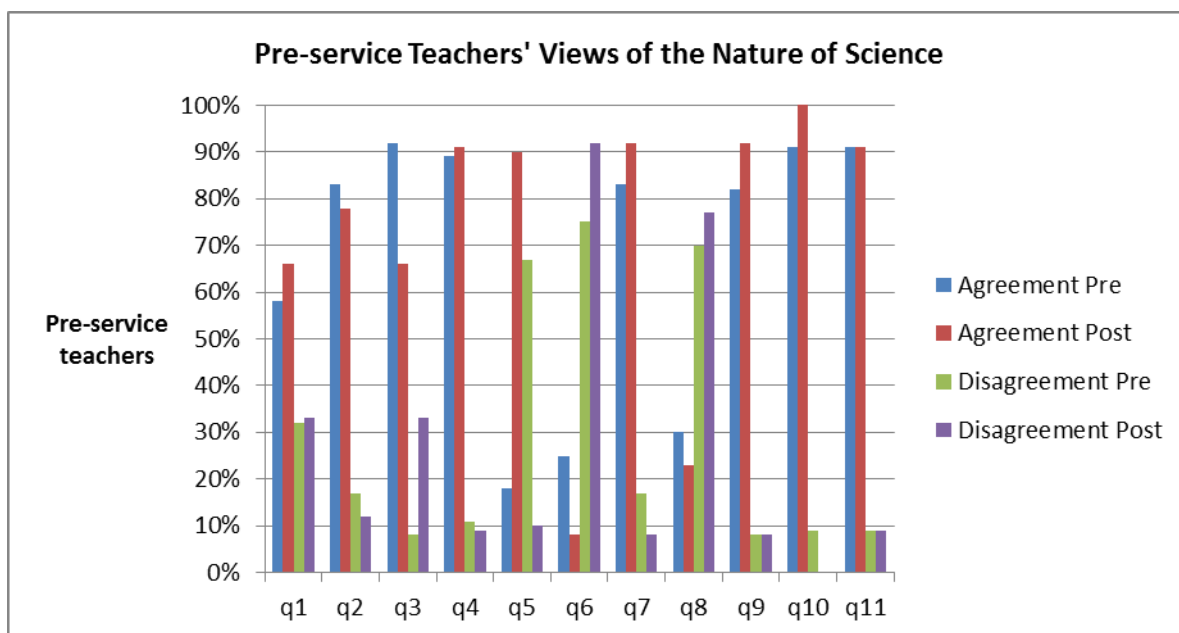
Figure 4.1 Pre-service Teachers' pre-post-conceptions of NOS

An examination of Table 4.1, Fig. 4.1 and Fig. 4.2, suggests that the pre-service teachers' pre-post responses remained more or less the same as far as q1, q2, q4, q9 and q11 are concerned. However, a notable change seems to occur in q5 at the post-test where 90% of the pre-service teachers agreed that "In their work, scientists are influenced by their socio-cultural and psychological frameworks." At the pre-test only 14 % agreed with that statement. Although the model response choices for q1 and q2 based on expert opinion should be "disagreement," 58% and 92% of the pre-service teachers respectively expressed agreement with those items. While 92% of the pre-service teachers at the pre-test agreed with expert opinion about the import of language on conceptual understanding in science (q3), this percentage dropped to 66% at the post-test. In q4 89% and 91% at the pre- and post-test respectively thought contrary to expert opinion that "the purpose of school practical work is to confirm scientific theory." The pre-service teachers' view probably reflects what goes on in most South African classrooms but this view does not accord with the acceptable aim of science education (Ogunniyi, 2006; Nhalevilo & Ogunniyi, 2014;).

Contrary to the views commonly expressed in the extant literature on NOS only a few of the pre-service teachers seem aware that scientists may be influenced by their socio-

109

cultural and psychological frameworks. Indeed, a plethora of studies on NOS has shown that often scientists are influenced by the ethos of and the paradigms of their community of practice (Kuhn, 1970; Lederman, 1992; Lederman, Wade & Bell, 1998; Mc Comas, 2000; Ziman, 2000; Abd-El-Khalick, 2004; Ogunniyi, 2004, 2006). Only a small percentage 25% and 8% at the pre- and post-test) of the pre-service teachers seem to be aware that scientists do not need to worry about philosophical, religious, psychological, sociological or linguistic issues. This of course is not to say that scientists in their personal or private lives are not concerned about such issues. Figure 4.3.2 below is a representation of pre-post-shifts of the pre-service teachers' responses relative to the valid model of NOS.
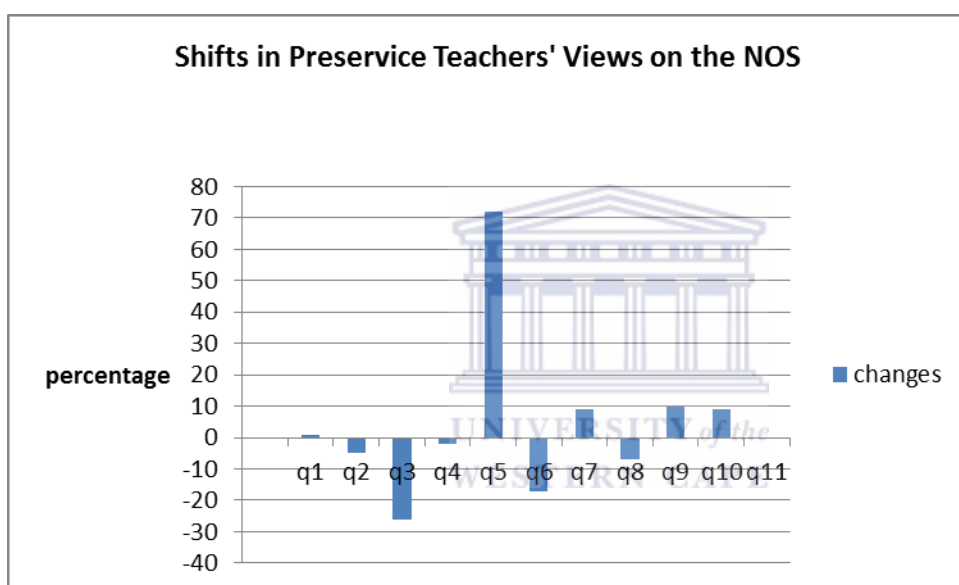
Figure 4.2 Shifts in Pre-service Teachers' correct Views on the NOS

Before engaging with exemplar questions on pre-post science teacher conceptions the following table of sources are presented as an overview of where they drew their inspiration for their response indicated in brackets after their response. Code: S – science; B – books; I – internet; M – media; R – religion; C – culture; F – family; T – tradition.

Table 4.2 Pre-service science teachers' sources of their beliefs and/or views for NOS

	science	books	internet	media	religion	culture	family	tradition
Mean	21%	17%	12%	9%	9%	6%	5%	1%
Rating	1	2	3	4	4	5	6	7

110

The major sources for the pre-service teachers' conceptions of NOS in a descending order are: science courses (21%), books (17%) and the internet (12%). The internet as a source for the pre-service teachers' conceptions of NOS should not be seen as a surprise in view of the prevalence of information technology and its wide applications in many fields today. The media (visual and printed) seem to have lost its previous third position in an earlier study (Ogunniyi, 2011) by dropping into fourth place. The other sources for the participants' conceptions of NOS include in a descending order religion (9%), culture (6%), family (5%) and tradition (1%). The excerpts below are representative of the individual participants' views about NOS:

q1: '*Science tells us the truth about the natural world*'

T1: **Pre-test:** It explains things around us (water regulates the temperature of day and night) (S). **Post-test**: Information gathered from reading books (B, M). TAP Level 1, since a claim is made with an example.

T4: **Pre-test**: Scientific knowledge is tested and proven as correct (S). **Post-test:** Science is about facts and evidence (B). TAP Level 0, as a claim is stated with no grounds.

T5: **Pre-test**: Science is constructed by humans prejudice (B, R). **Post-test:** Science is not always right (R). The statement is rebutted with a counterclaim. TAP Level 1, grounds are mentioned in the form of a perception 'human prejudice'.

T8: **Pre-test**: I believe that religion tells the truth of the natural world (R). **Post-test**: The truth is relevant to the generation and time and available knowledge and technology (S. R, B). TAP Level 2, rebuttal with grounds based on timelines.

T16: **Pre-test**: Science zooms into nature and explains natural phenomena (Sc., B). **Post-test**: It does explain a lot of what we never understood about the earth (Sc.). TAP Level 1, claim with explanatory example.

T22: **Pre-test**: Science is everyday life (B, R, F, I). **Post-test**: In science there are some of the things that we use and they are natural e.g. Gold and air. TAP Level 1, claim with example.

The sample of responses above seems to be basic statements with minimal supporting evidence and range from the re-wording of the given statements in some cases to providing at

111

least one example to support their view as seen by participants T1, T16, T22, who agree with the sentiments expressed in q1. T5 and T8 show evidence of a counterclaim and/or a rebuttal. Their supporting view is based on religious beliefs (T8) and moral perception (T5). An average of two thirds (66%) of pre-service science teachers agree with q1 in both pre-post conceptions, which seem to suggest the dominant influence of modern (Western) science in which they were schooled.

I next selected Statement q11 as a third exemplar for comment because the concept of argumentation, which is the particular focus of this study, is introduced as a teaching and learning strategy to grow scientific knowledge.

q11: *'Scientific knowledge grows by arguments and counter arguments'*

> T12: **Pre-test**: Scientists need to *discuss and talk* and *disagree to agree* (B, I). **Post-test**: *Debating and arguing* help us in getting *different perspectives* and therefore *broadening our vision* (B). TAP Level 2, provides evidence and warrants.
>
> T16: **Pre-test**: Yes. (blank). **Post-test**: People *sharpen their knowledge* and understanding through *debate* (S, T, F). TAP Level 1, from a position of terse agreement T18 proceeds to offer reasons for agreeing with this statement.
>
> T18: **Pre-test**: Yes because you *generate ideas* (blank). **Post-test**: Not only by arguments but also by *observations* (I). TAP Level 2, because the participant provides a warrant for agreeing and therefore makes a counterclaim, though no hard evidence is led.
>
> T22: **Pre-test**: There is a variety of *cultures and religions* so that is why (M, I, T). **Post-test**: Again *science evolves* and this is one *proven way*. TAP Level 1, claims with examples.

Legend

These responses seem to show a pre-disposition towards understanding the value of argumentation as a process necessary for scientific knowledge to grow. Words and phrases such as *'discus and talk', 'disagree to agree', debating and arguing'* points towards the openness to dialogue. Through using TAP analysis I could identify the grounds for this acknowledgement and value that participants placed on a teaching strategy that may contribute to supplementing their teaching practice in order to enhance scientific knowledge, such as *'getting different perspectives'* in order to *'broaden our vision', 'sharpen their*

knowledge', 'generate ideas' and *'science evolves'*. The most telling response is by T22 who sees the *'variety of cultures and religions'* probably perceived as present in a multicultural classroom, as justification for engaging in argumentation for growing scientific knowledge. This view is supported by the high level of participants agreeing in both the pre-and post-test (91%) that scientific knowledge grows through argumentation. These responses also indicate the openness for creating a teaching environment where dialogue can occur and for moving science teaching from a positivist process driven activity to a social interaction that requires a discourse and reflexivity of socio-scientific situations (Ghebru & Ogunniyi, 2013).

CASE STUDY 1: A students' science lesson using TAP as an analytical tool

The following case study of a students' science lesson will illustrate how a science concept is treated through applying TAP to understand the level of *group argumentation* in a science lesson.

Nicky decided to trial an argumentation based lesson with a grade 12 class. Her research question was **'Is there place for creationism in science?** She felt that the topic was controversial as the theory of evolution formed part of the syllabus, but learners generally came from religious backgrounds and she wanted to ascertain their baseline prior knowledge and feelings towards the topic. Nicky, a 24 year old post graduate student comes from a conservative Christian background and although being a life science major, had anxious moments about how to teach such a controversial topic.

I suggested that she teach the lesson as a demonstration lesson to her peers in a practice run. She decided to use the dialogical argumentation instructional model. After showing a power point excerpt on evolutionary concepts, she divided the class into five groups of six members. Each group was given a time schedule and a writing grid on which to record their claims, reasons (grounds) and rebuttals on the question. I collected their response writing grids and tabulated each groups arguments according to assess the TAP level at which the group discussions occurred (see Table 2.4: TAP levels of argument, Ogunniyi, 2009).

Table 4.3 TAP levels of classroom dialogue

CLAIMS/ COUNTERCLAIMS	GROUNDS	WARRANTS	REBUTTALS	TAP LEVEL
Group 1 The group believes strongly that creationism and science are linked.	The Christian Bible and the Koran are filled with references to medicinal plants, animals and plants. What scientists are discovering now are already spoken about in the in the Koran.	none	none	Level 1: Claims with evidence and warrants, no rebuttals
Group 2 This group argues for no place and believe that the two theories are incompatible.	The two theories exist in different spheres. A scientist and creationist think differently.	The age of the Earth do not correspond to the age given by creationist.	No evidence in creationism to rely on it.	Level 2: Claims, grounds warrants
Group 3 This group believes the two theories are incompatible.	Science and the bible are totally different. I believe that both parties do not fully understand each other.	Scientists are still searching for proof and creationism is the conclusion thereof. The first organisms were actually in water and science couldn't prove what created them.	I disagree because evolution states that monkeys were created before humans.	Level 2: Claims, grounds, warrants and rebuttal
Group 4 We agree that if we could not prove it through science then we have creationism to supplement explanations. Belief becomes innate and become internalised where science is acquired and accepted to provide theories that are changed and amended.	Creationism is prepared	Religion poses a belief system that is personal to man. Religious aspects forms part of your belief. As a scientist you cannot explain everything by theories and observations	We only trying to understand science which offers limited explanation	Level 2: Claims, grounds, warrants and rebuttal

Group 5

Some believe that there is place for creationism in science. However, there are some that do not believe in it at all. Evolution adds value and substance to humanity and creation.	Theory of continental drifts confirms what the bible says	Evolution man gets the credit whilst in creation God gets the credit	Evolution devalues human life.	Level 2: Claims, grounds, warrants and rebuttal

Legend

Two out of the five groups claim that the two theories (creationism and evolution) are incompatible, though for different reasons. Group 2 compares incompatibility of thought systems whilst Group 3 points out that the scientists and creationists don't understand each other. Group 2 carry their argument through by using a warrant on the 'disagreement on the age of the Earth' with an attack on the lack of evidence from the creationist viewpoint. On the other hand Group 3 is split, one thought indicate that science 'cant' find proof for what created water organisms' but this is rebutted with an argument that seems off the mark bit which actually has some credence when the student states that 'monkey came before man' probably making out a case for evolution. According to TAP levels, Group 3 seems to have debated more rigorously. Bell and Linn (2000) is of the opinion that when students argue amongst their peers about meaning and implications of data they prompt one another to re-examine their beliefs and assumptions.

The argument in group 1 use the science spoken about in the Bible and Koran as the link between creationism and evolution, whilst not expanding much on the evidence in the holy books they have provided as grounds for their decision. Similarly group 5 argues at TAP level 2 where claim and counterclaim is advanced with science (continental drift) again being found in the Bible. An Alternative rebuttal against evolution is proffered. Kuhn (2005) point out that argumentation allows students to fill the gaps in their understanding, examine claims and evidence and consider alternative perspectives.

Group 4 provides a bridged argument where an attempt is made to amalgamate and rationalise the two cosmologies, thus claims counterclaims and consensus is reached 'as a

scientist you cannot explain everything by theories and observations. Whilst TAP addresses the processes of deliberation it is unable to deal with the cognitive state of mind that shifts in and out of contrasting worldviews and cosmologies, therefore CAT provides an analytical framework to explore statements as made by group 4 'belief is innate and internalised and science is acquired and accepted to provide theories that are change and amended'.

4.3.2   Using CAT as an analytical lens

Since the focus in this study is primarily on the integrative nature of scientific knowledge (SK) and indigenous knowledge (IK) in the school curriculum, I chose to interrogate the pre-post-test responses to question eight that juxtaposed a science perception with that of the belief systems of the individual.

q8*: "The truth of science is the same for everybody. It depends on anyone's personal beliefs or situations". (See Appendix J for the full schedule of responses)*

I will use the following broad categories in the pre-post-test scenario to consider the frequency of the participants' responses to selected excerpts in particular.

Key: Percentage %

N= 30

> *Legend 1: Agree in both pre-post-test*   *20%*
> *Legend 2: Agree in pre-test, disagree in post-test*   *20%*
> *Legend 3: Disagree in both pre-post-test*   *60%*

For ease of reference the following code will be used when discussing trends, perceptual shifts and patterns concerning the new curriculum. The shaded letters indicate the patterns of perceptual shifts or views undertaken by the participants in terms of CAT categories: *DSw* denotes a dominant scientific worldview; *SIKw, a suppressed indigenous knowledge*

worldview; <mark>*DIKw*</mark>*, a dominant indigenous knowledge worldview;* <mark>*SSw*</mark> *suppressed science worldview;* <mark>*ASw*</mark> *an assimilated science worldview;* <mark>*Ew*</mark>*, an emergent worldview; and* <mark>*EQw*</mark> *an equipollent worldview* (Ogunniyi, et al., 2012).

Legend 1: Agree in both pre-post-test   20%

Six (T2, T8, T9, T13, T25) student teachers who agreed with the statement in both pre and post-test view science as dominating in the pre-test: T2: '*Science is facts'*; in the post T2: '*Science is concrete'* (claim) supported by grounds but he acknowledges that *'personal beliefs influence'* the claim (*real, theories are debatable*) and provides warrants '*eg. Big bang theory'*

Similarly T9 equate science with truth and states that *'I will teach science truth no matter what'* but also states categorically in the pre and post-test to *'consider others who might feel differently'* giving the example of *'evolution vs religion'* there appears to be some sort of border crossing from trust in science to acknowledgement of religion (Aikenhead,1996). According to CAT T9 teacher displays a <mark>*DSw/SIKw*</mark> stance.

Legend 2: Agree in pre-test; **disagree** in post-test   20%

There are six teachers (T1, T15, 19, T20, T21, T22) who stated strong support for science irrespective of belief *'no grey areas in science'*; *'science is approved by scientists'*; *'scientists discuss and agree to the same thing'* <mark>*(DSw)*</mark> amongst others. In the post-test, belief and culture is alluded to as *'pure scientific fact is universal'* in other words science fits the beliefs and situations of where people find themselves; *'science personal belief contributes to what say and that can influence my personal believes'* <mark>*EQw.*</mark>   These pre-service science teachers shifted from a dominant science worldview to an equipollent worldview after the NOSIKS series of lectures.

Legend 3: Disagree in both pre-post-test   60%

The majority (60%) of pre-service science teachers disagreed with the q8 on the basis of strong religious convictions as revealed by the following responses.

117

*T10: **Pre-test**: Most of the time religious people disagree with the things that scientists come up with or believing to be true. **Post-test**: There are learners who believe that it is only God who is the creator of everything, so definitely they will be confused, so they must find a way to make everyone understand.*

*T11: **Pre-test:** Those who are pro-religion tend to disagree with scientists about how the universe started for example, Big Bang theory. **Post-test:** I would present science as truthful but always maintain that it is open to change as new evidence of different theories may come to light leading them to be discarded or entrenched.*

*T14: **Pre-test**: Science is one view of how the world has become as it is and religious people has a different view of how the world has come as it is compared with scientists. **Post-test**: If you have different beliefs a science will teach it differently because science always clashes with religion and my religion beliefs is stronger than my beliefs in science.*

*T26: **Pre-test**: Everyone may be different in their way of conducting research. **Post-test**: many people have scientific as well as religious beliefs.*

*T27: **Pre-test**: Religion tradition has influence. **Post-test**: We are not one dimensional but multi-dimensional, therefore we all perceive things differently.*

The main thread running through these opinions is the juxtaposing of science vs. religion. T26 sees this dichotomy of clashing ideas *'God as creator vs Big Bang theory'* and *'Most times religious people disagree with the things scientists come up with'* (T10 – pre and post- test) and *'science always clashes with religion'* (T14-post-test) also t14 takes a DIKw/SSw stance when he says *'my religion beliefs is stronger than my beliefs in science'*. Evidently teachers are influenced by their religious convictions and the implications for carrying these biases over to controversial school science topics like evolution, origin of the universe and cloning, requires a teaching strategy that will allow learners to engage in a respectful and meaningful way so that learners viewpoints are not denigrated. These sentiments are expressed by T10 who says in his post-test *'learners who believe that it is only God who is the creator of everything, so definitely they will be confused, so they must find a way to make everyone understand'*. The study is hopeful that the development of DAIM as described in this study as well as the emerging argumentation model PAM would be able to address this teachers' concern.

Three of the teachers (T11, T26, T27) concur that science is open to change, to new theories and new insights. T11 takes an emerging stance *Ew* stance *'new evidence of different theories may come to light leading them to be discarded or entrenched'* whilst T26 takes an equipollent stance *EQw* *'people have scientific as well as religious beliefs'* and T27 has an assimilated view *Asw* *'we all perceive things differently'*. These cognitive shifts evidently are also prevalent in the learners since teachers and learners come from the same religious communities, the same cultural communities, the same traditional communities and are therefore no different in forming similar views and opinions.

To corroborate my opinion allow me to draw on another thread of thought permeating through the cluster of responses categorised as *culture and tradition*. There are four teachers (T16, T17, T18, T29) that allude to the influence of indigenous knowledge in their understanding of science as truth.

> T16: **Pre-test:** *Circumstances and conditions under which people live determine what they believe. Some believe in witchcraft others not.* **Post-test:** *Your personal belief is how you see the truth and vice-versa.*
>
> T17: **Pre-test**: *People are different in their ways of thinking and believing.* **Post-test**: *Some of the people believe in their own IK.*
>
> T18: **Pre-test**: *Is not the same for everyone, it depends on personal beliefs.* **Post-test**: *People are not living in a vacuum but in the context of their culture, tradition and belief systems.*
>
> T29: **Pre-test**: *Truth is subjective and depends on context and belief.* **Post-test**: *Science is a human endeavour it is influenced by human belief.*

These views attest to an equipollent stance *(EQw)* where cognitive shifts move between dominant science/suppressed IK *(DSw/SKW)* and dominant IK/suppressed science *(DIKw/SSw)*, depending on the context and circumstances, *'Some believe in witchcraft others not'* (T16 – pre-test); *'Some of the people believe in their own IK'* (T17- post-test); *'People are not living …in the context of their culture, tradition and belief systems'* (T18 – post-test); *'Truth is subjective and depends on context and belief'* (T29- post-test). These excerpts further illustrate the close interaction between the nature of science and the nature of indigenous knowledge systems in the lived experiences of people and in particular these pre-service science teachers. This research study attempts to understand these contexts and lived

119

experiences of beginning science teaches in order to facilitate a meaningful and relevant science teacher training programme at this and other tertiary institutions. The findings in this section may contribute to strengthening the rationale for a more rigorous integrated science-IKS curriculum in the method of science (Natural Sciences, Life Sciences and Physical Sciences) module

When the post-test of NOSQ was compiled an additional open ended question was included by the SIKSP research team with the sole purpose of identifying the impact if any of the intervention programme.

Based on your experiences in the workshops what was your view about NOS (a) before (b) after and (c) What is your new understanding of the nature of science?

Through these exemplar pre-service science teachers responses to the question above I will be using CAT as an analytical lens to identify any cognitive shifts in the views. Pseudonyms are used.
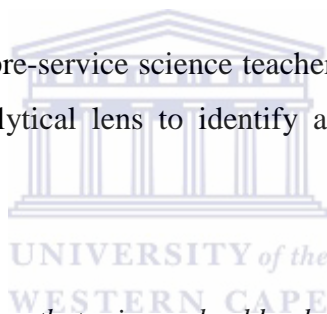
Lewi   ***Pre:*** *I had the perception that science should only be taught from textbooks (DSw). IKS was insignificant (SIKw). I was strictly textbook bound.*

        Post: *I know that science is our experience of natural phenomena whether using deductive reasoning or IKS (Asw).*

        Understanding*: It has made the concept (of integrating science and IK) much clearer and understandable in terms of the new curriculum.*

Van   ***Pre****: That it's a one sided account (DSw), not taken into account (SIKw) religion, cultural beliefs etc.*

        Post: *I understand how the natural world with its people work. Natural science developed learners skills they used in **everyday life (Ew)**. Develop the ability to think (DAIM). Understand science as a human activity. It answers questions about the physical world. Understand responsibility to society, social justice and societal order (TAP 3).*

        Understanding*: It has **broadened my understanding** and motivated me to love science*

and carry over my interest to learners.

Albie   **Pre:** *My belief was that science was just for the elite* (DSw).

Post: *Now I know science is our* **way of living**. *Gave me a* **better understanding** *and appreciation for IKS.*

Understanding: *My understanding grew so much that* **I will use IKS** (Asw) *in my lessons.*

Jared   **Pre:** *Science existed before scientists were there. The whole world is about science, whether it be modern or indigenous* (Dualistic).

Post: *One cannot plan lessons without thinking on how to implement NOS.*

Understanding: *I respect the dialogical argumentation. I am more aware of the facts of NOS arguments* (DSw).

Lagi   **Pre:** *Where did I come from? Who created the earth. How does the earth turn. The faces of the moon* (Supernatural- existential).

Post: *Practically investigating, experiments do research on scientific topics. The constructing of science knowledge. Science investigation* (DSw). *Society and science.*

Understanding: *Find information step by step; investigate knowledge in certain topics, how things work. Language expands. Communicate fluently. I can do practical work on my own* (DSw).

Law   **Pre:** *That science is difficult and complex to understand* (DSw).

Post: *Science is not that difficult if you are really interested. It is exciting to learn about your world* (DSw).

Understanding: *Science should be practiced as a hands-on subject (practical). You have to prove to the learners that the theories are true* (DSw).

Faith   **Pre:** *SK differ as it is based on facts, truth, tests, experiments, whereas IK is based on culture/religious beliefs, family traditional practices, believing that thunder for instance is caused by the 'gods' speaking to the community/ancestral beliefs* (EQw).

Post: *SK is more based on books, and tested knowledge where IK come naturally – more on survival skills to be able to live sustainably. It is knowledge used by our parents, grandparents and great grandparents, not really book knowledge – They did*

not learn about it, it came naturally.

Understanding *Science is more advanced more modern, more modern technology whereas IK is more about how to overcome a problem using what was available at the time (EQw).*

Nicky   ***Pre****: SK is logic, calculated, interpretation of how the world work. Science is practical, observable and testable. Science is valid as it explains and interprets the world technically. It is clinical and clean cut. IK on the other hand is primitive science that was always been with us, that was taken for granted or minimized, but only now taken seriously. However **they work together** (Asw), it forms part and parcel of each other. The physical, cultural social and spiritual world work together and should **not be seen in isolation** (Asw).*

Post*: Nature undergoes evolution. IK forms the foundation of science. Natural and unnatural causes explains events. Supernatural forces are also at play. IK is derived from olden days, carried over from generation to generation. It's allowing of learners bringing their heritage into the class before introducing scientific views (Asw).*

Understanding*: Science must never 'Judge' IK. Science and IK are harmoniously married, intertwined and interlinked. Olden people of yesterday were the biggest scientists. Science and IK is holistic and integrated. We should reject the claims that science works in isolation and that science work only in the physical world while IK is only concerned with social, cultural and spiritual worlds (Asw).*

Legend

Lewi, Van, Albie and Law held dominant science views on the trustworthiness, complexity and textbook authentication of science (Mason et al., 2012), being the truth and as Albie says 'only for the elite'. In the pre-test IK is seen by them as of little or 'primitive' value (Zinyeka, 2013). Of these four participants, Law maintains the dominant science worldview in both pre and post responses, based on proving theories *(DSw)* overtly (Mason et al., 2012). This is understandable especially if schooled in and indoctrinated by modern (Western) science that science is infallible. Albie, Van and Lewi concur with the aspect of understanding being reached and appreciation for IK to be incorporated into a scientific paradigm.

The following teachers Faith and Jared expressed explicit Ubuntu values in both pre and post- test responses with equipollent views: Faith defining what science knowledge represents and what IK represents, reminding one of collateral thinking (Jegede and Aikenhead, 1999). She rationalises that science knowledge (SK) and indigenous knowledge (IK) are present but seemingly represents collateral worldviews. Jared makes a terse statement that shows dualistic inclinations but not a defined perceptual shift and seemingly slipping back into a *DSw* mode of thinking about NOS. Similarly Lagi asks these existential questions about origins of life and the universe and tending towards dualistic notions in his pre-test response but then slips back to seeking explanations from a science viewpoint *(DSw)*.

Nicky's response stands in sharp contrast to the others which seem to indicate that her epistemic background assisted her in articulating an assimilated viewpoint. Her profile indicated that she was a natural medicine graduate and thus had a solid grasp of the integrative aspects of SK and IK. She uses phrases like *'always been with us'* (IK); *'they work together'; 'IK forms the basis of science'* and *'Science and IK are harmoniously married, intertwined and interlinked (Asw)*. She demonstrates a strong integrative view of SK and IK which may have been enhanced by the DAIM engagement during lectures.

4.3.3 Pre-service science teachers' pre-post conceptions of IKS

Professional development of teachers is one of South Africa's national goals in continuing the reform of the education system which starting with Curriculum 2005 up to the latest review of curriculum statements, viz., Curriculum and Assessment Policy Statements (CAPS, 2011). Throughout this development of education policy a multi-cultural orientation to science has been encouraged by incorporating societal and cultural aspects into science education. This implies that indigenous knowledge (IK) should be addressed by teachers in the classroom and that 'the science curriculum should be relevant' (Sjoberg, 2000a, 2002c).

A series of situations with an indigenous knowledge experience coming from the lived experiences of communities were presented for student comments. I selected Story 2

from 'My idea about Nature (MIAN)' questionnaire as an exemplar from amongst five similar scenarios. The full instrument can be viewed in Appendix A.

CASE STUDY 2

People who fall into a coma or die for a while often come up with interesting stories about their experience in the 'after life'. Suggest your own explanation.

I am going to use the following broad worldview categories to examine the following initial responses of some of the teachers in addition to CAT categories mentioned earlier (Ogunniyi, 1987, 2007 a & b, 2011).

- ➢ *Scientific:* The scientific explanation of the scenario or phenomenon was generally acceptable and the respondent's personal belief matched that of the scientific explanation.

- ➢ *Dualistic:* The respondent was able to describe and/or explain the situation in scientific terms but expressed personal beliefs in terms of religion or the supernatural.

- ➢ *Supernatural:* In this category the respondent dismissed the scientific explanation and explained the phenomenon in terms of religion or the supernatural.

- ➢ *No code:* When questions were not answered at all or were unintelligible they were placed in this category.

CAT Code:	DSw – dominant science worldview; DIKw – dominant indigenous knowledge worldview; SSw – supressed science worldview; SIKw – supressed indigenous knowledge worldview; Ew – emerging worldview; EQw – equipollent worldview; ASw – Assimilated worldview. Note: A dominant science worldview implies a suppressed IK worldview and a Dominant IK worldview implies a suppressed science worldview.

Extract of a sample of pre-service science teachers responses

Debs: I think there is some event stored up in our brain of what that particular individual thinks of as heaven. In situations where a person dies for a while I think they experience what they created in their mind of the afterlife. (**Supernatural**) **DIKw**

Lewi: When a person dies they are dead they can't come back to life the body will just go back to the dust and the breath will go back to GOD. If they wake up from something that looked like death it's either a coma or a fake death. (**Supernatural**) **DIKw**

Albie: When a person dies his/her soul lives. I believe the brain will stop once the heart stops, because the main function of the heart is to pump blood and the brain need the blood to function. When a person is in coma, I believe his/her spirit temporarily leaves the body. If a person comes out of coma, than it means his/her spirit found a way back to the body. (**Dualistic**) **EQw**

Law: The brain does not stop immediately the heart stops, so 'after life experiences are like a dream stored up in the brain before it stops. There are many dreams that come as a result of the energies of the day that have been kept in the brain during the day, that are being expressed during the night. The same phenomena happen when someone is in fall into a coma. However when he or she dies, the body stops to communicate with the spirit and mind. If there is a ghost of that individual, it means the demons have taken his or her image to move around. (**Dualistic**) **EQw**

Dave: People in coma could be dreaming, I don't know what happens in the case of people who die and come back to life. (**Supernatural**) **DIKw**

Mati: Your soul have a strong energy so it cannot be lost and therefore goes to another world of energy. (**Dualistic) EQw**

Matso: One becomes a living soul only when the human body and the "breath of life" (as described in the Holy Bible) are one. The one cannot be (live) without the other. When one dies, the "breath of life" returns to God and the human body perish. Thus, the living soul is no more (no body and no "breath of life").This is possible, even probable. The Holy Bible use "breath of life" and spirit interchangeably. Thus, I agree. The spirit leaves the body and returns to God. (**Supernatural**) **DIKw**

Susi: When a person dies the mind can conjure up certain thoughts. (**Supernatural**) **Ew**

Manu: From my spiritual upbringing, I am taught that the spirit/soul lives on irrespective of the natural body dying. When you are in a coma, you may not be awake but your brain may still be active, so it is as though you are in a deep sleep. And when you

125

sleep, there is still brain activity. For this reason, we could say that these "stories" are merely dreams. (**Dualistic**) **DIKw/SSw**

Nose: I believe that these stories are true and that people do experience these things when they are in a coma, I believe that we are a spirit that lives in a body and have a soul. (**Supernatural**) **DIKw**

Legend

The overall result for this scenario indicated that out of 30 respondents a scientific stance was not taken. Where a scientific explanation was given, it was tempered with a spiritual or cultural reason, thus indicating a dualistic worldview. Respondents responded in a way that personal beliefs, religion and spirituality peppered scientific view. The answers reflect dominance one worldview over the other to a lesser or greater extent. The work of Gunstone and White (2000) concurs that in spite of plausible scientific descriptions and explanations, peoples' personal views are resilient and will persist.

Lewi, Matso and Nose offer no other explanation but that based on bible and church teachings, thus taking a supernatural dominant indigenous knowledge *(DIKw)* stance albeit from a religious perspective. Albie, Law and Mati takes an equipollent *(EQw)* stance *'energy is transferred'* and *'brain activity continues in a coma'*. The thread references to dreams (Manu, Dave, Law), spirits/souls (Nose, Manu, Matso, Law, Albie, Lewi) and ghosts/demons (Law,) feature prominently. This cognitive conflict between soul, spirit, dreams, energy as mentioned by the respondents in the sample is illustrative of intra-dialogical argumentation, whereby the individual strives in the privacy of his/her own mind to reach a consensus, a cognitive harmonisation or understanding of the controversy or issue or problem.

CASE STUDY 3

One could safely assume that these lived experiences of pre-service science teachers have an influence on the way they teach certain topics and therefore a teaching and learning strategy that may assist with them navigating the lived experiences of their learners (coming from similar backgrounds with similar cosmologies) are of paramount importance (Loggenberg, 2012; Barnhardt et al., 2005, Ogunniyi, 1987, 2011). To illustrate this point I

would like to refer to the responses proffered by pre-service science teachers to Q6(c) of the CIKSQ (Appendix C).

*Q 6c A learner asked her classmate, "How did the world come about?" Her classmate replied, "Science state that it probably occurred by chance or due to the force of a big bang or something like that." The first learner then asked further, "Where did the force that produced the bang come from?" Her classmate retorted, "**I don't know ask the science teacher**." How would you deal with such questions if they were asked in class?*

Table 4.4 below provides a summary of the sources on which pre-service science teachers based their responses to question 6c.

Table 4.4 Pre-service science teachers' sources of their beliefs and/or views

	science	books	institution	media	religion	culture	family	tradition
Mean	13%	19%	13%	23%	14%	10%	8%	0%
Rating	**3**	**2**	**3**	**1**	**4**	**5**	**6**	**7**

The major source of pre-service science teachers sources on NOIKS is media (23%), books (19%), Religion (14%) followed by science and institution (13% each). Once again the surprising or not so surprising first place is clinched by media concurring with the result in table 4.2 on sources for NOS. Social media inter-alia internet is observed to be commonly used on the smart phone. In fact in classes where smart phones are allowed, it is common practice to see students using smart phones to google in order to gain access to information quicker and faster than looking for books or journal articles for that matter. While technology in education is being utilised more and more often in the classroom, another clear front runner is religion and cultural practices. By combining the IK sources (religion, culture and family) which translates to 32% then at most one-third of this cohort of teachers have a disposition towards an IKS influence. If we collapse science and institution, assuming that this is the major scientific sources, then 26% compared to personal (IKS) source of 32% shows somewhat an equivalence difference of 6%. I next proceeded to interrogate their responses to the above question. I intend using TAP and CAT in this analysis, as TAP will give an indication of the level of their argument while CAT will indicate their cognitive state of mind at the moment that they had an inter-argumentative moment as an individual and in line with the first stage of DAIM, where students in the privacy of their own minds grapple in

conversation with themselves on what view or opinion to record. I first proceeded to group responses under the CAT codes (see Table 4.5) then considered possible TAP levels of argument. Furthermore the responses also provide pointers as to how pre-service science teachers predict their style of infusing or not infusing IKS into science teaching, with reference to the *integrationist*, the *incorporationist*, the *separatist approach as* explicated by Naidoo and Vithal (2014) and my own addition the *segregationist* teaching approach.

Table 4.5 Pre-service science teachers responses to Q6 (c) rated according to CAT

	EQw	DSw/SIKw	Ew	DIKw/SSw	ASw
Mean	39%	28%	21%	6%	6%
Rating	1	2	3	4	4

CAT Code: **DSw/SIKw = Dominant science/suppressed IK worldview; DIKw/SSw worldview = Dominant IK/suppressed science; EQw = Equivalent worldview; ASw = Assimilated worldview; Ew = Emerging worldview**

(1) EQw = Equivalent worldview is rated as first (39%) and in support thereof some participants comments are listed below: Note: Codes in brackets behind the extract refer to CAT codes (Table 4.5) followed by sources codes (Table 4.4).

> T4: *I would be **open minded** to the beliefs of the individuals being taught provide all information on **religious and scientific aspects** on the topic and let the learners know that from these explanations and reports one can **decide which are to be true** to you and also to note that it is now the truths of truth and that is being discussed till today. (EQw) (B,I,F,R)*

> T20: *I would give that as homework to any of them, that they should **use any source** they have in mind, library, internet, etc., and **bring that discussion** for the following day, because discussion without clue, only ends with noise making and chaos in my classroom. In the meantime I will **need to prepare myself** for that topic as I am the one with the **final say**. (EQw); (S,B,I,M)*

Legend

These teachers project a balanced view and openness to discussion and dialogue in the class. Both emphasise the collection of information as data and evidence to bolster the discussion. The teachers forward their arguments at TAP level 2/3 as they give grounds that

128

are backed up by warrants. T20 accepts the responsibility of facilitator and the need to plan. The decision in the case of T4 is left to the learner. Although their teaching method may differ, they seem to be headed towards an incorporationist approach whereby information and evidence will be considered and compared to see how science and IK may fit together.

(2) DSw/SIKw = Dominant science/suppressed IK worldview (28%) is the next highly rated view.

Debs: *I can answer them in a scientific understanding and religious understanding, but I **will not go deep in a religious way** because they have to **understand science more than a religious**. (DSw/SIKw); (S,B,M,R)*

T9: *In the science classroom, any questions related to scientific subject matter should be answered or dealt with by sound, scientifically proven answers. The basis of science is posing questions, hypothesizing and proving the answers whether the actual outcome is the same or different to what the "researcher" initially thought. The setting in the classroom should be such that the student is able to gain the most from his **science education and develop critical thinking without it inferring with personal or religious beliefs**. (DSw; (S,B,I,M).*

T18: *It is my duty as teacher to get the child's perspective and understanding of the issue at hand, so both as a teacher and a mentor I have the responsibility to guide and help them **understand things form the scientific perspective**. At school my **faith and my beliefs** don't really count what matter is **my duty** to be a teacher to the learner **empower them with scientific knowledge** and also to show them that **science most of the time contradicts their cultural and social beliefs**. (DSw); (S,B,M)*

Legend

All these teachers are of the opinion that science teaching is their duty as shown by the highlighted phrases. Their belief that religious beliefs and culture has no place in the science class is stoic. They come from a positivist science perspective probably based on how they were 'taught' science, thus modelling the same kind of misconception about IKS worldviews. They would denigrate any religious belief and IK as subservient or even non-existent to that

129

of science. Note T18 who declares *'I must show them that science most of the time contradicts their cultural and social beliefs'*. Their level of argument with claims and counter claims in TAP terms fits in Level 2/3 but their teaching approach appears totally segregationist, as they do not make allowance for any IK in their teaching regimen.

(3) Ew = Emerging worldview registers 21% and these teachers seemingly is adopting a wait and see what happens attitude.

> T15: *Whether you know the answer or whether you do not, always try to answer the question in such a way that it would formulate into a **healthy classroom discussion**. In this way you would obtain **various views** from different people but it may also broaden your **knowledge** of the content. (Ew); (B,M)*
>
> T19: *I was going to first set-up a sort of a debate or **discussion** with the learners so that they can have clear understanding, **see ideas, opinions and then share all those ideas** and come up with solid **answers and conclusion** because at least I would be having much **more knowledge** about the subject . (Ew); (B,M,I).*

Legend

These teachers show a predisposition to applying a DAIM teaching strategy by engaging with learners in debate, listening to views, acknowledging the art of discussion and valuing resolutions to the issues/problems inquiry as determined by lesson topics. In addition they are open to learning in a collaborative way and not assume an authoritative stance. Their TAP argumentation level is set at Level 2. I placed them in the Ew group as they seem to be searching for an identity and are not sure of their worldview status. Their predilection seems to veer towards an incorporationist teaching approach.

(4) ASw = Assimilated worldview (6%)

> T14: *The way in which I answer the question would be based on the **pupil's cultural or religious stand point**. I would make sure he/she tries to **grasp my understanding as well as theirs** which could also teach them tolerance. **I will try** to be as objective as I could be trying to **focus on the factual science** and help them **slot it into their beliefs if necessary**. (ASw); (R,C,F)*

Legend

This teacher seems to be projecting a viewpoint that science can be absorbed into the cultural or religious understanding of the learner. The objectivity-subjectivity is a point of debate as the teacher navigates this integrationist approach. According to TAP Level, the argument fits a Level 1 with claim and minimal grounds. The teacher shows intention 'will try', 'could be trying', 'help them', 'teach them tolerance' pointing towards creating a platform for dialogical argumentation. The teacher is not dogmatic in his views but accommodating, hence an integrationist.

(5) DIKw/SSw worldview = Dominant IK/suppressed science (6%)

> T21:   *I **do not believe in the big bang theory**. As a teacher I think I would give the leaners a chance to discuss the topic while listening to what the leaners understand. Then I would bring in **my religious beliefs** and explain why I do not belief in this theory. (DIKw)(R,C,F,M)*

The stance of this teacher is rooted in religion and she displays a separatist approach where there is a science belief and a religious belief and never the twain shall meet. The teacher may find integrating science and IK a challenge if in anyway contradictions arise. She does however show tolerance for listening and explaining of concepts and beliefs which augurs well for dialogical argumentation in lessons with contentious issues.

Overview of Legends

The responses by pre-service teachers to case studies 2 and 3 as analysed above provide insight into the thinking of teachers and reiterates the importance in this study of ensuring that pre-service science teachers be made aware of their own belief systems as they search for an identity in relation to indigenous knowledge. The questionnaires allow the students to understand their own multi-cultural common sense and those of others. It is clear from extant studies that this study engages with a crucial element of pre-service science teacher readiness and competence in conceptualising and implementing the sentiments expressed in Specific Aim 3 of CAPS, in their first outing to schools and secondly can the

study contribute to the design of science education programmes for teachers who are required to navigate their own understanding of NOS and NOIKS before launching into teaching methodologies for the integration of a science-IK curriculum (Amosun et al., 2013; Aikenhead and Ogawe, 2003; Afonso and Ogunniyi, 2011; Chilisa, 2012; De Beer and Whitelock, 2009)

4.4 Research Question 2

What are the pre-service science teachers' pre-post conceptions of an integrated science-IK curriculum?

In South Africa, the natural sciences subject discipline covers four themes, namely, life and living; matter and material, energy and , earth and beyond and is taught from grade 4 to grade 9 levels which constitutes the General Education and Training (GET) band. Life sciences and physical sciences subject disciplines are taught from grade 10 to grade 12 in the Further Education and Training (FET) band. In this study any reference to science, is inclusive of natural sciences, life sciences and physical sciences. A further interrogation of selected statements taken from the TOSRA questionnaire (See Appendix E) is discussed and may reveal significant trends. The two sets of selected statements are categorised under Learner centred constructivist activities (L) and IKS and socio-cultural integration (I) and tabulated in table 4.4.1 and 4.4.2 below.

Table 4.6 Learner centred constructivist activities (L)

Number	Statement	Test	A	N	D
	N = 30 Key: [%]		%	%	%
	A: Agree; N: Not Sure; D: Disagree				
10	The science educator should encourage learners to **question concepts and theories through argumentation** to thoroughly investigate the available evidence and alternative theories before accepting any ideas.	Pre	82	0	18
		Post	97	0	3

12	The **emotional and social development of learners** is as important in the evaluation of their progress as their academic achievement in science classes.	Pre Post	64 100	18 0	18 0
16	Learners **learn more** about science concepts by doing **practical hands-on-investigations** that develop science process skills and help them to construct their own science knowledge than by **learning abstract concepts from a textbook.**	Pre Post	73 100	9 0	18 0
18	I enjoy a challenge and like trying out **new science teaching methods** which I have not used before such as **argumentation** using Toulmins' Argumentation Pattern (TAP).	Pre Post	63 76	27 24	10 0
25	Science is **fun and relevant** to the understanding of the physical, social and technological world we live in.	Pre Post	84 90	0 10	18 0
26	Science is **boring** and is not relevant to modern 21st Century life.	Pre Post	0 0	0 0	100 100
28	Learners should be given the opportunity to **challenge existing science concepts and theories** with the understanding that a given theory or scientific model stands or falls on the basis of current empirical evidence.	Pre Post	91 100	9	0

Legend

Considering Statements 10 (82%); 16 (73%); 18 (63%) and 28 (91%) which emphasize argumentation pedagogy linked to practical consideration of science concepts in addition to considering the socio-cultural context from which learners come is strongly supported as shown by the high percentage of students agreeing with the statement in the pre-test. In the post-test after the intervention lectures and activities, these percentages increased as illustrated by statements 10 (97%); 16 (100%); 18 (76%) and 28 (100%) indicating a

dramatic shift from the not so sure and disagree responses in the pre-test with more students shifting to the agree valuation showing a positive move in the post-test to the themes of the statements. These teachers now seem more positively pre-disposed to an **argumentation pedagogy** after the intervention lecture series.

Pre-service science teachers showed a strong leaning towards Statement 25 that state *"science is relevant and not boring"* <mark>*(DSw),*</mark> with 81% agreeing similarly all 100% disagree fully with Statement 26 *"Science is boring and is not relevant"* <mark>*(DSw).*</mark> The results of the two statements corroborate. Although all 30 student teachers recognize that science is relevant to the 21st century (Statement 26), 18% disagree (Statement 25) that science is fun and relevant. This anomaly is interrogated further when considering the reflections obtained from the focus group interviews and reflective journals. In general this category leans positively towards a learner-centred teaching approach in suggesting support for using an argumentation pedagogical framework.

In table 4.4.2 statements having a socio-scientific-cultural link are directed at bringing about awareness by pre-service science teachers of the nature of indigenous knowledge worldviews which teachers and learners may hold in a multi-cultural classroom thus informing teaching practices that acknowledge and value alternative worldviews to that of modern (Western) science.

Table 4.7 IKS and socio-cultural integration (I)

Number	Statement	Test	A	N	D
	N = 30 Key: [%]		%	%	%
	A: Agree; N: Not Sure; D: Disagree				
1	The content of the sciences learning areas should be determined by the **interests and social needs** of the learners and should **acknowledge indigenous knowledge practices** of different communities in South Africa.	Pre Post	69 100	31 0	0 0
2	Knowledge of **facts about science phenomena** is **more important** for learners to know than to do science investigations that focus on developing	Pre Post	27 41	0 18	73 42

134

	science process skills such as observation, measurement and experimental design.				
8	I enjoy teaching science lessons and believe that it is important to try to develop learning experiences that **involve hands on practical investigations** that include **reference to indigenous knowledge** of local communities	Pre	100	0	0
		Post	100	0	0
29	The wisdom of ancient cultures and beginnings of scientific enquiry is imbedded in the **stories of myths, legends and indigenous folklore** of most cultures and **storytelling** can provide insight and stepping stones that aid the understanding of selected science concepts	Pre	73	18	9
		Post	86	14	0
30	**Myths, legends and indigenous folklore** have no place in a 21st century science classroom.	Pre	18	28	54
		Post	16	70	24

Legend

This category reflects on pre-service science teachers' views on indigenous knowledge in a socio-cultural context with 69% agreeing with the idea whilst 31% not sure (Statement 1). Similarly there is a strong belief amongst 73% teachers that much can be learned from IK (Statement 29) with 18% not sure and 9% disagreeing. In addition, myths, legends and indigenous folklore (Statement 30) is seen by 54% of teachers as having to be acknowledged in the science class, with 28% not sure and 18% in agreement with the negative statement that *"myths, legends and indigenous folklore have no place in the science classroom"*. The responses to Statement 8, reflects 100% pre-service science teachers supported the sentiment of recognising the inclusion of IK into the school curriculum indicating a strong pre-disposition towards an integrated science/IK curriculum.

Overview

These findings seem to provide some important baseline indicators relating to those factors that require strengthening and those factors that need inclusion in an intervention

lecturing programme for pre-service science student teachers. The White paper on Education and Training (South Africa, 1995, p. 22) states that all programmes of education and training should

> '…encourage independent and critical thought, the capacity to question, enquire, reason, weigh evidence and form judgements, achieve understanding, recognise the provisional and incomplete nature of most human knowledge…'

Maila and Loubser (2003) concurs that the production of Indigenous Knowledge is contextually grounded through social constructivist approaches and argues that both traditional knowledge processes and scientific knowledge systems are crucial for addressing environmental issues and challenges faced in South Africa and the world.

4.5   Research Question 3

What are the pre-service science teachers' pre-post conceptions of their self-efficacy in using DAIM to implement a science-IK curriculum?

The thirty science students enrolled for the PGCE course were a mixed group from diverse subject specialisation areas in science (Natural Science; Life Science; Physical Science) diverse socio-economic and language backgrounds and with the majority (24) having no teaching experience, four having tutoring experience and two having eight and four years of teaching experience (see Appendix H). The test was administered after a series of lectures on the nature of science, nature of indigenous knowledge systems, integrating science with indigenous knowledge and dialogical argumentation instruction in the first semester (January to May), but before their teaching practice visit to schools in the third school term (July, August). The same questionnaire was administered immediately on their return from teaching practice but with an additional question added in order to elicit their reflections on their science teaching experiences. The question reads as follows: *Describe your experiences in attempting to apply the Dialogical Argumentation Instructional Model for teaching a science-indigenous knowledge lesson/concept.*

The Bandura Teacher Self-Efficacy (BTS) scale was modified to measure variables of significance to this study and was intended to measure teacher attitudes in an empirical way. Since this was a new scale based on Bandura's self-efficacy scale, a Chronbach's reliability test was conducted, which produced alpha Cronbach value of 89.1< 1 and therefore a fairly reliable score. The overall BTS scale result is presented in figure 4.1 in addition the means of the variables are tabulated in table 4.3.
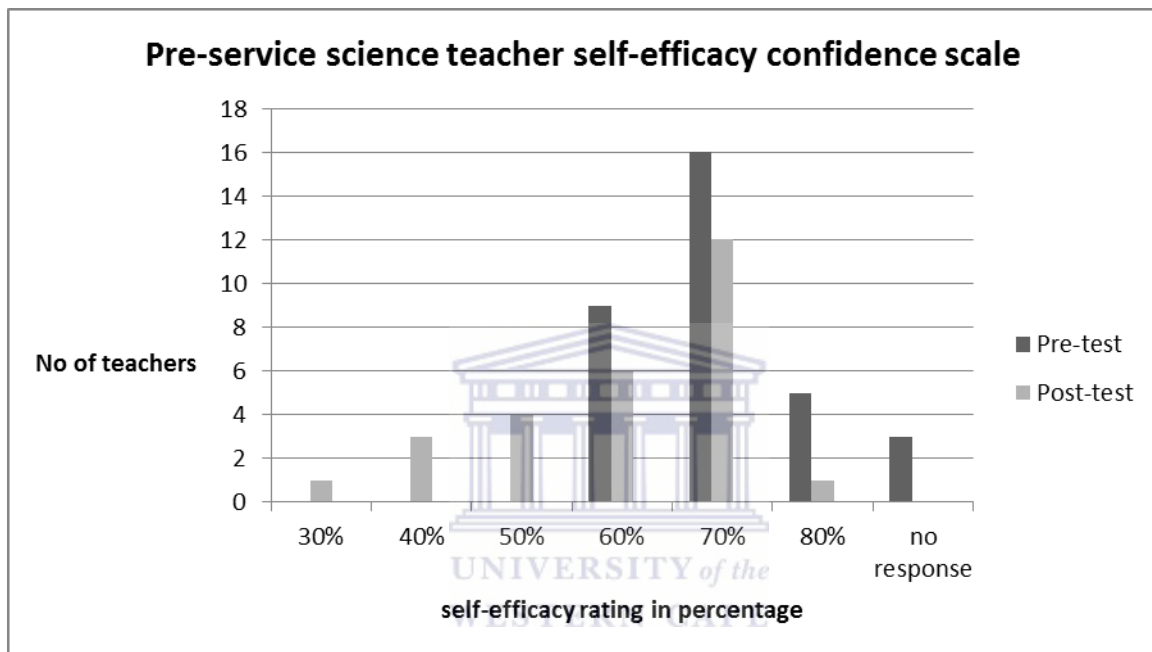
Figure 4.3 A Bandura Teacher Self-Efficacy Scale: Pre-service science teacher self-efficacy confidence scale in using DAIM to teach lessons based on an integrated science – IK curriculum

From the graph we see at the pre-test level pre-service science teacher confidence was estimated by them at > 60%. These pre-service teachers appear to have overestimated their teaching ability. This over-estimation could be ascribed to the confidence and understanding that was acquired as a direct result of the interactive lecturing programme. Smith and Strahan (2004) refers to the practical experience that teachers acquire in the apprenticeship model where micro-teaching activities are tried with peers in a simulated classroom setting as a factor that may have contributed to this over estimation in comparison to the post-test result which shows a marked reversal but probably a more real or authentic rating to that of the pre

137

teaching practice initial rating. The graph indicates a more even and probably more realistic efficacy rating distribution.

These scores have been extracted from the focus group interview transcripts where participants were asked to give a verbal rating of their efficacy in using DAIM to implement a science-IK lesson as well as their post-test scores on Banduras' Self-Efficacy rating scale. One should remember that the teachers had to perform two actions (a) to prepare an integrated science-IK lesson and (b) to implement this lesson using DAIM. Tentative results based on their self-efficacy rating suggest that 23 participants scored themselves 50% and above with a substantive number twelve scoring at 70%. This score appears to provide a strong indication of confidence with one teacher rating herself at 80%.

Table 4.8 Means for Teacher Self-Efficacy variables

No	Variable	Pre-service science teachers	
	Teacher Self-Efficacy	Mean Pre-test (n = 30)	Post-test (n = 30)
1	Ability to plan an integrated science-indigenous knowledge lesson	68,2	60
2	Ability to select a socio-cultural-scientific issue	72,5	60,1
3	Your understanding of DAIM as a pedagogical model	80,6	71,2
4	Ability to create teaching and learning spaces using DAIM	76,3	59,4
5	Provide quality resources	67	70,1
6	Successful integration of a science-	65	51,1

indigenous knowledge
concept

Analysis revealed that the overall means on the variables for teacher self-efficacy, except one, dropped significantly in the post-test. This result concurs with that of Pendergast & Garvis (2011) who ascribes these significantly lower scores as a 'reality shock' gained from their experience during teaching practice. The two important trajectories in this study was the preparation of an integrated science-IKS lesson and secondly using Dialogical Argumentation Instructional Model as a teaching strategy to implement this lesson. Pre-service science teachers expressed reasonable ease with planning an integrated science-IKS lesson (Pre-test 68,2%: Post-test 60%), their comfort with selecting a socio-cultural-scientific issue dropped from a pre-test result of 72,5% to a post-test result of 60,1%. This may be ascribed to participants having free choice to select topical issues for presentation at micro-teaching sessions held on campus during lecture time, whereas they needed to comply with topics as determined by CAPS pace-setters (pace-setters are a week –by-week content-based teaching guide) provided by the education department to schools. The sixth variable: *'Successful integration of a science-indigenous knowledge concept'* shows a decline from 65 % in the pre-test projection to an actual 51,1% in the post-test experience. The reasons advanced for this decline are identified in the reflective report that follows.

Secondly whilst teachers find traction with understanding DAIM: *'Your understanding of DAIM as a pedagogical model'* (80,6 % in pre-test declines to 71,2% in post-test) their ability to apply the model to teach an integrated science-IK lesson is much reduced: *'Ability to create teaching and learning spaces using DAIM'* (76,3% in pre-test declines to 59,4% in post-test). The interviews and reflective reports seem to suggest inherent challenges faced by the teacher, significantly the school environment and learner behaviour are feature most prominently as challenges amongst others. No doubt Bandura's (1997) Reciprocal Determinism Model is to be seriously considered when interrogating argumentation-based teaching and learning programmes at teacher training facilities in tertiary institutions. These pre-service science teacher programmes strive to improve teacher self-efficacy beliefs especially when alternative content, contexts and pedagogies compared to that of traditional

teaching strategies such as 'talk-and-chalk' (taken over by 'talk-and- power point'); note taking; textbook focus; pen-and-pencil tests and examinations, are introduced.

Of interest is the cluster of four teachers who scored themselves below 50% and who also provided good reason for the difficulties that impacted their ability to use DAIM as a teaching strategy during teaching practice. The experiences of some pre-service science teachers presented below were gleaned from reflective diaries and focus group interviews discussed in greater depth in the findings to the third research question. The responses are used here to highlight some of the challenges they faced and to provide balance to somewhat overrated self-efficacy scores. The following physical science teachers (T24, T15, T16) scored themselves in the post-rating at a modest 40%, 30% and 40% compared with initial pre-ratings in the 60% to 75% range respectively.

> T24: I did mainly maths for 4 weeks and observed physical science lessons mainly. It was difficult to engage with DAIM, as the pace setters were mainly theoretical based and calculations of topics like molar quantities and concentrations which was far removed from IK. Traditional teaching approaches were used. I was unsuccessful in trialling DAIM. (Rated at 70%- pre; 40%-post)
>
> T15: Class was resistant to DAIM interaction. Very disruptive – learners are used to writing notes from textbook. Technology is new to them, did not quite enjoy life sciences. DAIM is a good model but I found difficulty in applying it in this type of class. (Rated at 75% - pre; 40% - post)
>
> T16: I did not do it, did not have internet. (Rated at 65% - pre; 30%-post)

These three Physical Science teachers (T24, T15, T16) appeared frustrated by the pace-setters of the curriculum, calculation-based topics, traditional teaching methods (notes, calculations) and lack of adequate resources. As beginner teachers, they needed to follow the ethos of the school and the teaching programme as stipulated by the school. They could not trial the methods nor include a suitable science-IK lesson in their teaching schedule throughout the duration of their visit. Is this an indictment on school management, intransigent CAPS, reluctant physical science mentors or the ethos of reductionist views of science teaching? The issues are complex and multifaceted and therefore challenging,

especially for physical science teachers. This observation is clearly an unsatisfactory situation and requires early identification in the lecturing programme so that remediation can occur.

It may be prudent to provide a profile on these teachers in order to understand their seemingly non-compliance with the tasks.

Profiles of teachers

T24 is a 25yr old female physical science and mathematics graduate, unmarried mother, who displayed a very strong leaning to pure science and preferred using traditional 'talk-and-chalk' approaches for as she says *'it is less threatening'* and *'learners are quiet and kept busy'*. She showed willingness to engage but encountered obstacles caused by the assigned teaching schedule *(taught mainly mathematics)* and the CAPS pace setters.

T15 is a 27yr old male graduate in physics and biochemistry, who prefer working in a laboratory, could not find a job and turned to teaching. He encountered disciplinary issues in the class with *'rowdy learners'* which seem to indicate poor management skills as well as poor mentorship the incumbent in-service science teacher. The school is situated in a poor sub-economic area and draws learners with various social problems.

T16 a 24yr old isiXhosa male appeared very reticent from the start, not participating verbally in any of the DAIM activities requiring him to express a views and opinions. He would respond in monosyllables or tend to fade into the background. It seemed that language may have been a barrier, but his peers indicated that throughout his studies he tended to be very quiet and displayed a rather mediocre attitude to teaching citing *'lack of internet'* why he could not comply with the task set. These beginning teachers who are starting out in their science teaching careers present a strong case for subject mentorship and as subjects for follow-up classroom-based action-research.

The following two teachers (T23; T25) had made a conscious decision to plan and engage with an integrated science-IK lesson based on DAIM as a teaching strategy. Both indicated that prior to the PGCE programme they had heard of IK/IKS from other sources.

141

T23 recalls a lesson whereby indigenous medicines were compared to modern medicines, and mentions specifically the African potato and its cures. She also relates discussions in class on evolution and the big bang theory. This knowledge encouraged her to pursue lessons in these areas and she states '*It is up to the teacher to create a platform for integration'*. She holds a dualistic or equipollent view of science and IK *(EQw)* as she navigates the border between science and IK for herself (Aikenhead, 1996).

> T23: *I taught the origin of the solar system and formation of universe. The focus was on the Big Bang theory and I used DAIM to hear their views. Their arguments were based mainly on religious aspects, not right or wrong because this is home knowledge. Had to sit back and listen to them. With grade 10 I introduced IKS ideas by using garlic and ginger, and this story was used to initiate discussion around traditional medicine and western knowledge. It is up to the teacher to create a platform for integration.*
> *Learners like to challenge and see if you the teacher know your work. If you know the work and confident then you continue and then they know or do not know.*
> *(Rated at 65% - pre; 80% - post)*

On the other hand T25 is not explicit about the lesson content but extolls the value she finds in using DAIM. In sharp contrast to the negativity of note taking raised by T15, she turned the note taking incident into a positive reason for using DAIM. This claim is at a level 3, (TAP) whereby a claim is made with grounds (Ogunniyi, 2009, p. 5). Using DAIM gives learners the opportunity to voice their opinion. Her confidence was boosted when a '*...a teacher with 30 years teaching experience used DAIM in a lesson and reported that she was pleasantly pleased at the positive outcome of the teaching strategy in keeping an otherwise rowdy class quiet and engaged'*. Of interest is the rather confused notion that the in-service subject teacher had of the purpose of using DAIM. She perceived DAIM as a possible disciplinary strategy rather than a dialogical argumentation strategy for understanding science concepts in context.

T25: *What pushed me to implement DAIM was when I noticed that Grade 10 just spent time to write notes, spent 45 minutes just writing and I was waiting for teacher to speak to them, which did not happen. I asked what do they expect from me, and they said they don't want to write much they want to do want do practical, want to be involved. They said they were serious. I found when you involve them they pay more attention. Their notes came from the discussion of the topic. DAIM forced them to listen and they found when they were involved in the lesson they took notes. They liked the lesson and the fact that they could voice their opinion provided you set the scene. They talk a lot but they talk about nonsense and when you give them a talking point they responded very well. The teachers saw my DAIM lesson and marvelled at the fact that the learners were so engaged, they saw how this normally rowdy class were involved. One teacher with 30 years of experience tried this method and was pleasantly pleased with the outcome.*

Able to recognise flaws and correct myself, even the teacher made mistakes. I need to identify where one needs improvement. Recognise the gaps in content, therefore continuous learning will give confidence.

(Rated at 70% - pre; 70% - post)
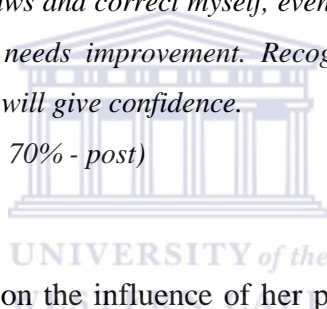
Furthermore T25 reflects on the influence of her parents and her home environment up-bringing as having fanned her interest in buying into the argument for an integrated science-IK curriculum, when she says '…*my parents would always use examples of their past to simplify things for me. I always found their way of explaining things to be more effective and interesting'*. This view reflects an *(Asw)* stance whereby the student attaches value to past wisdom.

4.6   Research Question 4

What are pre-service science teachers' practical experiences during the teaching practice when attempting to use DAIM to implement an integrated science-IK lesson?

The cohort of 30 pre-service science teachers enrolled for the science method course with a specific focus amongst others on dialogical argumentation as a teaching strategy for implementing an integrated science-IK lesson were requested to reflect on their experiences in a questionnaire titled:

"A Reflective Diary on using a Dialogical Argumentation Instructional Model (DAIM) to teach an integrated science-indigenous knowledge lesson".

The question reads as follows:

> *Some of you took modules relating to integrating science and indigenous knowledge (IK) in the classroom e.g. the Socio-psycho-cultural module and the Philosophy of Science module which focused on the Nature of Science. Most if not all of you have read the argumentation-based packages, Book 1 and 2 dealing with the Nature of Science (NOS) and Indigenous Knowledge (IK). It is now apposite to find out how some or all of these experiences have informed the way you navigate, frame or make sense of controversial socio-cultural issues such as the teaching or the implementation of a science-IK curriculum in the classroom. In view of this, please answer the following questions as freely and as candidly as you can.*

CASE STUDY 4

This case study explores themes and trends that emerged from the responses made by the pre-service science teachers to Question 2 (a), specifically stated as:

> *In what ways have your experiences in the method course or related activities (modules, micro-teaching, demonstration lessons) informed the way you i.e. bring coherence to, or make sense of the pieces of information or experiences you have acquired in terms of the way you construed the controversial issue of integrating science and indigenous knowledge (IK) at the time you **started** participating in the activities and **now**?*

The data obtained from the responses to question 2a of the reflective diary were carefully scrutinised to identify how the teachers' experiences informed the way they made sense of the policy directive to integrate science and indigenous knowledge systems in the school science curriculum. The participants responses (views and experiences) were transcribed and clustered into three groups according to the way they construed the *"controversial issue"* before, during and after the seminar-workshop series. A selection of exemplar responses follows. In addition teachers' responses are linked to the CAT categories in order to identify any cognitive changes made by participants in reference to the inclusion of IKS in the school science curriculum.

This analysis generated the following question:

What were teachers' initial views about the integration of science and indigenous knowledge in the science classroom?

The narrative of teacher's experiences prior to their involvement with the science indigenous knowledge project workshops were clustered into **three groups:**

Group 1: Indigenous Knowledge Systems (IKS) as an unfamiliar term

Group 2: Perceptions that Indigenous Knowledge Systems (IKS), is about superstition, myth and witchcraft

Group 3: Reservations about the feasibility of implementing an integrated science-IKS curriculum

.

Group 1: Indigenous Knowledge Systems (IKS) as an unfamiliar term.

Prior to post-graduate studies and/or involvement with SIKSP teachers indicated that they were unfamiliar with the term IKS and therefore did not consider it important.

> T14: *The first time I participated in the concept of IK and IKS were new to me. I did not even hear about it obviously could not think about what this integration of science with IK in the school system meant.*

> T7: *At the beginning it (IKS) was not visible in the curriculum: there was only occasional reference to it when dealing with Learning Outcome 3 (Science and Society). I did not spend much time on IKS topics simply because I did not see it as is important.*

Group 2: Perceptions that Indigenous Knowledge Systems (IKS) is about superstition, myths and witchcraft

A recurring perception among teachers indicates that they were of the opinion that IKS was about superstition, myth and witchcraft, and that indigenous knowledge was considered as backward among those who are educated. (Science – dominant, IKS – suppressed S)

> T6: *There has been talk that IKS is associated myths and witchcraft and that there was no way that IKS and science could coexist.*

145

> *T9:*   *I thought that Western Science is dominant over IKS. Western (science) is the only science that can heal people. In my view IKS was all about witchcraft. I was not so fascinated by IKS at all in science education.*

Group 3: Reservations about the feasibility of implementing an integrated science-IKS curriculum

Teachers were initially uncertain about how to implement the process of integrating IKS and science in the school science curriculum, and were of the opinion that there would be opposition to the implementation of the policy mandate.

> *T3:*   *At the beginning when I started, I felt that IKS and science were two different knowledge systems and that it was impossible to combine the two.*
> *In my view integration of the two would bring confusion to learners because I was of the view that IK explanations are not the same as those of school science.*
>
> *T16:*   *I did not know the term nor why such importance was attached to world views in a science environment and how to integrate the two. The curriculum expected teachers to include IK in their lessons but never offered any training or whatsoever.*
>
> *T15:*   *In my own teaching practice, my attempts at integrating IK content according to the dictates of curriculum was more of the nature of adding anecdotal information about cultural practices that could be linked to modern science practice.*

Prior to their post-graduate studies and involvement with SIKSP modules, pre-service science teachers were unfamiliar with the definitions and what Indigenous Knowledge Systems entailed. Many thought that indigenous knowledge was about superstition and witchcraft, consequently they expressed doubts about the integration of Western Science and IKS in the school science curriculum. This uncertainty caused anxiety and hesitation in dealing with the education policy imperative to integrate science and IKS in the school curriculum and more specifically the science curriculum.

Pre-service science teachers were required to trial DAIM as a teaching strategy in implementing a science-IK lesson during teaching practice. They were also required to keep a diary of reflections whenever they used this approach. On their return, these reflective diaries were collected when they attended focus group interviews. All focus group interviews were

conducted on the same day in a sequential order. In other words, students were placed in a holding room where a random selection of six to eight participants per group was made. On completion of the participants were dismissed and the next group was interviewed. In this way no post contact was made by the exiting group with the incoming group thus avoiding contamination of the questioning regimen.

The following exemplars are illustrative of the results and findings presented in two sections namely:

> **Section A: Quantitative summary** of pre-service science teachers' focus group interviews which is further divided into two categories, namely:
> **Category 1: Evidence of a planned science-IKS lesson for teaching practice** and
> **Category 2: Evidence for using DAIM in a science and/or a science-IKS lesson.**

> **Section B:** Comprises of vignettes of the transcripts of dialogue that transpired in two focus groups**.**
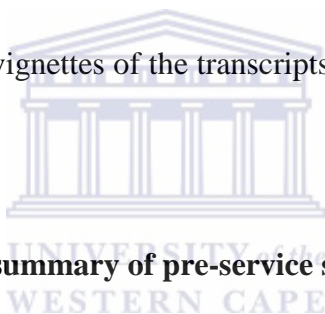
4.6.1 Section A: Quantitative summary of pre-service science teachers' focus group interviews.

Table 4.9: Evidence of pre-service science teachers who planned a science-IKS lesson for teaching practice

Category (N = 30)	YES	CAT category	NO	CAT category
science-IKS lesson	T6; T12; T13; T15; T16; T18; T19;	EQw (70%)	T3; T5; T14; T16; T18; T20; T24; T25;	DSw (73%)
	T1; T2; T7; T8	Ew (30%)	T11; T21; T22;	DSw/SIKw (27%)
20 interviewed 10 absent	**Percentage of Total**	**50%**	**Percentage of Total %**	**50%**

Legend

The result show that of the teachers interviewed 50% planned a science-IKS lesson, whilst 50% only managed to plan a science-based lesson. This in part is due to various factors as

mentioned in the reflective reports, namely, CAPS pace setters that project week by week lessons to be covered; preparation for impending examinations and Annual National Assessments; intransigence on the part of subject teachers who are behind with the syllabus content; for physical science teachers the content to be covered as per the pace setters were on theoretical constructs of molar related and atomic theory concepts; lack of science-IKS material was cited as was scarce resource material on the internet. Time constraints and learner unfamiliarity with the DAIM teaching strategy and the concept of an integrated science-IKS lesson was seen by subject teachers schooled in the positivist teaching approaches, as unfamiliar territory and they were reluctant to engage with such pedagogies.

Table 4.10 Pre-service science teachers who used DAIM in a science and/or a science-IKS lesson

Category	YES	NO
(N = 30)	Science/IK lesson	Science lesson
Used DAIM	T1; T3; T5; T7; T8;	T2; T6; T11; T15; T16; T18;
Did not use DAIM	T12; T13; T14; T19; T25	T20; T21; T22; T24
20 interviewed **10 absent**	**Total = 10** **(50%)**	**Total = 10** **(50%)**

Legend

Those pre-service teachers 50% pre-service science teachers in the focus group interviews who indicated that they used DAIM as a teaching strategy came mainly from the Natural Sciences and Life Sciences subject disciplines. Although governed by CAPS pace setters, it appears that these subject content lends itself more to argumentation approaches. Those teachers not so favourably disposed, cited reasons such as large, classes; rowdy learner behaviour; learners being disruptive due to substance abuse; lack of classroom management; emphasis on traditional teaching methods; preparation for examinations; lack of teacher support amongst others.

The results, disregarding the absentees on the day of the focus group interviews, are actually split halfway for both categories, that is not to say that those who planned a science-IK lesson also did not use DAIM or that those who used DAIM did not plan an science-IK lesson. We could consider whether those who planned a science-IK lesson also used DAIM to implement it. The corresponding result from the table showed that only 23% (4) teachers attempted to use DAIM to implement an integrated science-IK lesson.

4.6.2   Section B: Vignette of the transcripts of focus groups

The following vignettes of pre-service science teachers post reflection reports on their experience in using DAIM as a teaching strategy for the first time to teach an integrated science-IKS lesson during teaching practice are analysed to determine their level of success or otherwise. In vignette one the focus is on the experience of one pre-service science teacher and in vignette two the experiences of six participants are reflected upon.

Vignette One

This vignette is a case study of one pre-service science teacher as she grapples with using DAIM to teach an integrated science – IK lesson/s.

> T10:   *This is definitely something that can assist in teaching and getting learners actively involved in lessons. The challenges we face with this is that in many schools, educators are not trained for this. They are used to the talk and chalk and that's what they feel comfortable with. I believe that as new educators qualify and implement this in their classrooms, this will become the norm and chalk and talk will become less. All of this is ultimately up to the educator to implement. The learners look up to the educator for guidance and if this is the way the educator teaches, it will also be taken up by the learners in this way.*

This teacher acknowledges the value of a learner centred teaching approach and observes that the teacher is an agent for change. This change may be effective through modelling teaching strategies. This teacher-learner interaction is viewed by the teacher as a key driver for introducing an alternative teaching and learning strategy. This view is

149

supported by Bandura (1986) who suggests that modelled behaviours are learned and therefore learners imitate others.

> *I really enjoyed interacting with them on this level where they also seemed very pleased with themselves for being able to make a contribution to the lesson. It was just unfortunate that I was not able to do this with every lesson due to the amount of work we needed to cover and the time constraints we faced.*
> *I believe if this method of teaching is implemented in the right way, it can be to the advantage of the learner and the educator. It will be less time the educator needs to spend in front of the class. The learners also feel a sense of accomplishment if they were able to make a contribution to the lesson.*

The teacher reflects on the sense of ease experienced by both teacher and learner when using a teaching strategy that gives learners a voice thus contributing to the lessons progress. Bandura (1997) believes that this sense of achievement contributes to a sense of self efficacy for beginning teachers and once developed is resistant to change. The teacher further reflects on the lesson that was taught to a grade 9 class.

> *There were three methods that I mainly used in my lessons of which I observed from various teachers during my teaching observations. These methods were the narrative method, demonstrative method and the Socratic method. Most lessons included all three methods as I would introduce a topic by using the narrative method, present a diagram with labels which relates to the explanation and always ask learners questions where I recap on the current lesson or recap on the previous lesson. The Socratic Method was commonly used during the lessons. This method kept the learners engaged in the learning process, as I would constantly pounce on inactive learners. The other strategy that was used to involve the learners in the learning process was introducing them to Indigenous Knowledge Systems which forms the base of the CAPS curriculum.*

Here the teacher taps into belief and culture thus allowing learners to articulate their ideas and then attempts to demonstrate the phenomenon in a practical way, by considering the science in the IKS view thus providing the scientific explanation for these natural

150

phenomena. This knowledge remains prevalent in a multicultural class. These views illustrate how cognitive shifts can be modelled with an emerging equipollent view according to CAT (Langenhoven and Oguinniyi, 2011., Ogunniyi, 2002., Diwu et al., 2011).

I used indigenous knowledge systems in the grade 9 lessons for learners to share their cultural beliefs about the basis of thunder and the rainbow. The Xhosa culture believes that thunder is meant to strike someone who has been cursed by a Sangoma. However the scientific fact is that thunder is created by the build-up of negative charges in the clouds that are attracted to the positive charges on the surface of the Earth. The Zulu culture believes that the rainbow is a ghost that absorbs water. To prove the scientific fact of how a rainbow is created I used a glass prism (representing raindrops of water) and shinned a flashlight (representing sunlight) at an angle. The light reflected through the prism with colours of the rainbow thus indicating that sunlight is reflected through raindrops of water as a rainbow.

Furthermore the teacher seems to understand collateral learning (Jegede, 1995) and the juxtaposing of multiple teaching methods in the science-IKS lesson through using the narrative, demonstration and Socratic teaching methods.

However, the teacher did not demonstrate unequivocally to what extent DAIM was applied. In a further follow-up interview, she responded as follows:

I myself found it challenging to explain and formulate discussion around certain concepts due to my lack of knowledge and background on the matter at hand. This made it a bit complicated to have a meaningful and content based interactive lesson in some cases. Learners were used to a certain teaching and learning setup and environment in class as well as the school as a whole. Many of the learners showed signs of anxiousness and uneasiness when asked to self- investigate a certain topic in a way how they understood it in simple and everyday life in terms of sciences. They felt out of place and exposed at times because they are used to being standard in their way of thinking and reasoning if any. Learners were used to just answering a question without it being applied and analysed in everyday scientific environments they have found themselves in. Learners were hesitant to explore and contribute to this style of teaching. Their levels of reasoning were in some cases very limited and

not insightful. Some learners did not put much thought into their answers while others answered with confidence.

The teacher proceeded to highlight her own challenges and her observations of the learners' behaviour. According to Bandura (1997) external factors influence the ease and comfort with which teachers transmit information. The learners' perceptions, behaviour and experiences with teaching methods did not find coherence with the argumentation approach as demonstrated by their resistance to this new teaching strategy. They were 'anxious', 'just answered questions', 'levels of reasoning were limited and not insightful'. The reaction of the learners to the lesson did not meet the teachers' expectations.

In my opinion, the application of DAIM is a good pedagogy. Under perfect conditions, this pedagogy would allow learners to tap into their critical thinking and analysing and reasoning skills which they all have of. This method would steer and direct an educational argument and learners would learn from themselves and from one another. This is a good method to use to build up learners self-confidence and knowledge base. All in all it is a viable tool for creating discussion around indigenous knowledge. To me this is an easier and free flowing way of learning and remembering.

This was a major challenge for me as I had to figure out what appropriate steps and ways to implement IKS and Dialogical instruction for each concept taught. As I've taught every day, I couldn't find time to do ample research on ways to set up and execute dialogical lessons as I would have liked to do. I did in the end find it to be time constrained and just focused on investigative studies on a few concepts.

The teacher's observations and the grounds provided in support of her claims, for using DAIM in spite of learners' resistance, shows a positive constructivist shift from being challenged towards resolving the issues. She notes that a full day of teaching does not leave much time for research, probably with a view to accessing suitable integrated science-IKS material. These time constraints and supply of resource material are referred to by most beginning teachers in their reflective responses (Ogunniyi, 2004; Onwu et al., 2005; Newton et al., 1999).

Vignette 2

The following six (6) extracts of pre-service science teachers' responses during a focus group interview held after teaching practice are analysed below. Note the value in brackets is their self-efficacy rating

Legend: T21: Lesson: Static electricity

This teacher shows a shift from a science dominated world view (DSw) to a more assimilated IKS worldview ASw, *'I did not know scientific knowledge came from Greece, Egypt...'* She expresses amazement at the beliefs of some learners, *'God is angry and sends lightning'* ascribing this to a lack of scientific understanding on their part. She is grappling with these cognitive shifts and appeals for *'specific lesson plans'*. Her observation of DAIM is as an add-on method rather than as the lesson plan methodology for the topic. She attributes the methodology of dialogue as a possible contributory factor to what she explains as a *'disorderly environment'* and is *'disruptive to the learning processes'*. She understands the historical significance of past contributions, which indicates a cognitive shift towards assimilating IKS ideas.

> *T21: Grade 9 Energy and change: Formation of static electricity. Sought knowledge from learners, God is angry, African and Indian mixed religions in class, said Lightning comes from God, thunder and lightning. Learners lacked basic knowledge.*
> *Viable: It is good but it is not part of assessment and therefore not assessed, so teachers do not teach towards it because tests and papers are not geared to IK. The space must be filled between teaching and IK. I see it as a way of preserving knowledge IK knowledge, prior knowledge. I did not know that all scientific knowledge came from ancient times, Mesopotamia, Greece Egypt was originated there, I didn't know. Knowledge did not originate in 1800's but opening understanding opening up history. Much of todays' science knowledge is based on early historical events before Christ as people were already doing surgery and practicing medicine. Broader knowledge of the original IK perspective does not limit you to tablets and the doctor if taken ill. IK must be done right and perceived as being valid.*

Legend: T13: Lesson: Electrostatics

The teacher comes from a rural area where natural phenomena are given metaphysical characteristics and beliefs dominate. The reference to lightning being sent as a form of punishment is very strong (Moyo and Ogunniyi, 2013) to sort out the perceived wrongdoer. The references to prevention methods for lightning like *'tyres on the roof'; cover mirrors for witches'* indicate a strong belief in the metaphysical. His stance is one of equipollence *(EQw)*. No doubt the culture and communities from which learners come influence their trajectory of thinking. He refers to *'valuable IK still waiting to be discovered'*. DAIM is seen by him as an avenue for constructing knowledge *'space for development, growth and thinking'*. In his journal he says *'I would let learners interpret while others are talking so that language is not a barrier to learning of science concepts'*. He appeals for more resources to help with *'specific lesson topics'*

T13:   *About fire and frictional forces. Spoke about how lightning is formed If your mother get angry they can hit you with lightning when they go to witchdoctor. Use of car tyres to keep lightning away, in terms of witches, cover mirrors, in terms of what attracts lightning.*

Viable: As time goes by society has changed and science concepts develop from IK. Giving some IK would make learners appreciate what they have and look towards discoveries that have value meaning Can think more of an opportunity of what happened in the past and what more can be done with undiscovered IK, they no longer have grandmothers who put us next to the fire can tell stories around the fireplace. We give learners a little bit of taste from where they come. There are also views of how valuable things in Africa have been stolen. Learners speak about not yet discovered IK. IK do the job in the place of people who are no longer there. DAIM provides space for development, growth and thinking. Also if we talk about motivating our learners show them that what we see today begins here and we own it. Build confidence in how they can be assessed

*Programme Evaluation: I thought it was going to be in much more detail about how to **approach specific lesson topics**. Even the textbook knowledge is very much summarised. (Rating = 70)*

Legend: T15: Lesson: Natural medication for urinary tract infections.

This teacher appeared conservative in her rating as her narrative clearly showed a conviction to use visual modelling as resource. Note her initial perception that the school is viewed by the community as a school of school of gangsters. Not only do teachers have to navigate new science content, new teaching strategies but also deal with societal factors from the environment that may impact on teacher efficacy (Bandura, 1997). DAIM and IK allowed her to use the narratives of learners as resource, once again highlighting the value of anecdotal evidence. She reflects in her journal that DAIM allows for social interactions. Her lesson made use of medicinal plants and the debates currently raging around legalising 'marijuana' for medicinal use. She demonstrates a Dualistic world view (EQw) by holding equipollent views on science and IKS.

> T15:   *Perception of school is lots of gangsters and unmanageable. My perception changed as I found learners to be disciplined, teachers were nice. The class of 56 learners made me very nervous. I overcame this feeling and made use of visuals and concrete objects in most of my lessons. I brought in brought objects like balls, balloons and wheelbarrows when teaching levers and forces. Learners learned a lot, they could say what they learned. I gave a spot test and they scored 90% passes. I gained in confidence and competence. I tutored grade 9. The supervisor appreciated the use of practical sessions.*
>
> *Viable: DAIM require learners to be respectful of others views and appreciative of what they know. When doing the lesson on cancer, they brought in the dagga, and what their grandparents had to say about it. IK is a good thing as it involves the community at large and its' wisdom*
>
> *Programme: Learners were amazed when I used visual models saying how much they appreciated these object lessons as it helped them to remember the lesson better. The Programme: Useful as it prepares you for TP, projection of voice.*
>
> *(Rating = 50)*

155

Legend: T11:

This teacher equates DAIM with group work. In her journal she provides reasons (1) that argumentation is a process that must be learned and the learners have not been exposed to this method; (2) she felt uneasy with the noise levels being created and generating further confusion by introducing IK. It seems that new approaches to teaching are dependent on a complexity of issues. She has not made clear which lessons were taught or how DAIM was applied, if at all. She appeared rather uncomfortable during the interview, which may be ascribed to her not fulfilling the mandate of her task. From the side of the programme, future success depends on closer monitoring of the teachers, and not leaving it to choice.

> T11: *I mainly used DAIM when I summarised. Completed the theory then proceeded with group work. I taught theory for 4 days then DAIM on a Friday, short day for group work.*
>
> ***Viable**: Learners had no IK knowledge but only scientific knowledge. Most of the time I did not want to confuse them and bring in IK to science knowledge that they already know.*
>
> ***Programme Evaluation:** More practice of science lessons. Improve teaching methods and how to manage classes. Seeing different perspectives and more individual micro-teaching. See how different science teachers teach science.*
>
> *(Rating = 60)*

Legend: T12: Lesson: Origin of Life

The teacher has a solid grasp on creating learning spaces for dialogue by first orientating 'primed' the learners into the process of dialogue then dividing the 'groups to research the views of various religious and cultural groupings; she recognises the value of stories that various religious groups may share and uses DAIM to open up dialogue spaces; the nodal point was 'story telling' and 'anecdotal stories'. She plays the role of facilitator and facilitates the connections between science and IKS. Her concern is to make the PGCE science METHOD course more experiential. The teacher holds a dualistic view and fits into the equipollent category according to CAT.

T12: *DAIM in lightning IKS with life on earth. Students not exposed. I did two DAIM dialogue type debates then sSet the mood through story-telling and anecdotal stories. Imagine sharing stories around a fire. How did life start on Earth? Learners were divided into 5 groups and could select which religion or belief system they wanted to research and unpack the stories for presentation to the class. Rastafarians, Hindus, Christianity, Evolution African beliefs, Khoisan were some of the areas researched. The presentations and DAIM group was lively debatable, lots of cross talk and resulted in much questioning. Talk about energy ties in with Big Bang theory.*

I found it quite hard to facilitate and learners would ask why do you just say OK and why are you not talking and why don't you say something. I told the learner that I am the facilitator and it is you who must take responsibility for own learning. I had to keep them on point so that no irrelevant ideas were allowed.

I went through scientific concepts. Darwinism, Evolution, Lemarck, Big Bang. Timeline and fossil as evidence on how anecdotal stories developed, and scientists were interested in getting evidence. Learners loved it especially those with strong views. Some learners refused to be involved as they are regarded by the teacher as "aeroplane learners" and would just not engage, just sitting like passengers in an aeroplane. Drugs are a big issue as some learners are sometimes stoned out of their mind. Enthusiastic learners can find their voice to offload their ideas and kept the judgemental down. When there are factual inaccuracies I would jump in, other times I let them talk and pick up on relevant comments. I wish I could get every single child involved.

Viable: A nice starting point to the lesson. DAIM depends on the class and the type of learner behaviour. DAIM is a good way of wrapping up a lesson. If there is no prior knowledge then the teacher must provide stimulus material.

Programme Evaluation: Preferred more pedagogies, not just DAIM, Students to the CAPS document. Also management and movement processes is required and how to move around in the class, more micro-teaching. (Rating = 70)

Legend T18: Lesson: Skeleton and bone disease

The teacher vacillates between being **integrationist** *(ASw)* *'linking willow bark and ginger to the treatment of arthritis,* speaks about *'extracts and Chinese medicine'* to being **science dominant** with the comment in the journal notes on teaching   electrostatics and

157

viewing the teaching about lightning <mark>*(DSw)*</mark> as being bad or in poor taste because it *'introduces the metaphysical world'*. A structured DAIM teaching strategy is equated to *'just talking and discussing'*. The supervisor was not impressed with the student using DAIM, who had the perception that *'DAIM was not good as I was facilitating more than teaching and therefore he could not evaluate me'*

.

T18:   *Skeleton and bone diseases. Not interested in IK rather in the future and what is to come. Brought in ginger and willow bark for inflammation and pain, for example, arthritis. We link it to the form of extracts. Chinese medicines and link it to what people use today, easy solutions, from a chemist. We talk and discuss rather than just teach. So keeping on target is quite difficult other than talking about the topic. The rowdy learners prefer to speak about other things other than the work.*

Viable: In some aspects some learners are interested but some are more interested in the future and how things can improve. No one wants to look at the past but on what is to come rather than what was. Supervisor said using DAIM was not good as I was facilitating more than teaching and therefore he could not evaluate me. Being new I did not challenge his view.

Programme: Focus on different methodologies, besides DAIM. It was helpful to me to know how to teach, eg lightning is a bad IK lesson as it was going into the metaphysical realm.

(Self-rating: 60)

Overview of legends

These reflections focussed on three aspects: (a) implementing a science-IK lesson using DAIM (b) view of the viability of using DAIM (c) the method of science teaching programme.

In the first instance pre-service science teachers engaged with their first lengthy block teaching practice in the third term, a period of seven weeks. They were placed at senior secondary schools and could legitimately be assigned to any grade from grade eight (8) to grade twelve (12). Science method teachers could be expected to teach Natural Sciences and/or Life Sciences and/or Physical Sciences. Although schools were required to follow the CAPS curriculum teaching schedules were also governed by pace setters, a document advising which topics were to be covered on a weekly even daily basis. Evidence in the

158

classroom suggests that these pace setters were not strictly adhered to resulting in work falling behind, or sequences being change, in short students had to fall in with the ethos prevailing at a school. I am at pains to explain this because the mix at schools did not allow for all research participants to plan and design one homogeneous lesson as a research lesson. For this reason the participants engaged with different types of lessons, depending on the lesson schedule of the school. The vignettes reflect this anomaly.

These vignettes provide a sense of emerging trends that encapsulate the conceptions pre-service teachers have of the success or otherwise of a dialogical argumentation teaching strategy as modelled by DAIM. In order for DAIM to be successful teachers are required to have a sound content background science as epistemic knowledge as well as the nature of science as revealed in the extant literature on NOS (Newton et al., 1999; Lederman et al, 2002; Dekkers and Nbisi, 2003;) in addition to understanding arguments for including IKS and engaging with teaching methodologies. In addition the concept of visual modelling improves conceptualisation as seen from the references in the extracts to objects, visuals and practical work. T12, T13 and T21 utilised narratives and anecdotes whilst T15 and T18 used objects to illustrate specific lesson concepts (Owston, 2005; Mushaikwa et al, 2014; Gilbert, 1995).

The teachers' views of the viability of using DAIM varied from enthusiasm to confusion. The following positive aspects emerged thus far, but it is by no means comprehensive.

➢ DAIM is seen as workable provided school ethos, school environment and learner behaviour is responsive (T12).
➢ DAIM is seen in a summative function to either start a lesson or summarise a lesson, some only see possibilities in using it once a week (T11).
➢ DAIM is seen as fostering growth, thinking, debating skills, building confidence (T16) and as a socialising agent (T15)

The findings suggest the need for considering the positive experiences of using DAIM and balancing them against the challenges hampering the deployment of DAIM specifically for teaching and learning of science-IK topics, with the desire to developing more robust teacher training programmes.

4.7   Chapter Summary

In this chapter the results and findings were presented as responses to the research questions. The cohort of participants is a group of pre-service science teachers in a compulsory one year Post Graduate Certificate of Education course that offers method in sciences (Natural Sciences, Life Sciences and Physical Sciences) as one of the a pre-requisites to teaching at the Further Education and Training (FET) phase in the National Department of Education (NDOE), South Africa. During their attendance at these method courses, data was collected as described in Chapter 3, specifically around their views, perceptions and experiences in deploying a Dialogical Argumentation Instructional Model (DAIM) to integrate science knowledge (SK) and indigenous knowledge (IK) as prescribed in Specific Aim 3 of CAPS. Consideration has been given to the three research questions as stated in Chapter 1 with a selection of results presented for analysis and discussion according to theoretical and conceptual frameworks as discussed in Chapter 2.

In lieu of these findings Chapter 5 will summarise the major findings, extrapolate on implications and propose recommendations.

CHAPTER 5
CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1   Introduction

This chapter provides an overview of the major findings derived from the data presented in Chapter Four. The data analysis focused on the effects of a dialogical argumentation instructional model (DAIM) in enhancing: (1) the pre-service science teachers' understanding of the nature of science (NOS) and the nature of indigenous knowledge (NOIKS); (2) their ability to use DAIM to implement an integrated science-IK curriculum; and (3) their ability to evaluate the efficacy with which they were able to implement the curriculum in a classroom context. The data analysis showed that the intervention strategy-i.e. DAIM impacted positively the pre-service teachers' understanding of NOS and NOIKS. Likewise, DAIM seemed to enhance their confidence and ability to conduct science-IK lessons. However, the study also revealed certain challenges which warrant further investigations in the area.

.

5.2   Summary of major findings

This chapter highlights some implications of the findings for various role players as well as provides recommendations and suggestions further research initiatives. However, it is apposite to reiterate that the main thrust of the study was to determine the effectiveness or otherwise of a dialogical argumentation instructional model (DAIM) in equipping pre-service teachers with knowledge and skills to implement an integrated a science-IK curriculum. In lieu of the data interrogated in Chapter 4, the following conclusions have been reached:

5.2.1   Pre-service science teachers' pre-post conceptions of NOS and NOIKS

The data indicated that the pre-service science teachers became sensitised to the cosmologies of their own belief systems, be it religious, cultural, traditional or personal self-discovery as they searched for an identity in relation to science and indigenous knowledge systems. The questionnaires allow the pre-service teachers to understand their own multi-cultural common sense and those of others. The answers that were recorded showed

noticeable positive shifts towards contextualising their previously positivist view about science. Their responses to statements involving argumentation indicated that they had a keenness to acquire the skill of using argumentation in science lessons. The analytical lenses of TAP and CAT were found handy in understanding the cognitive shifts made in the pre-post conceptions of the pre-service teachers regarding the nature of science (NOS) and the nature of indigenous knowledge systems (NOIKS). The data showed a readiness by pre-service teachers to launch into an argumentation teaching methodologies for the implementation of a science-IK curriculum.

5.2.2 Pre-service science teachers' views of an integrated science-IK curriculum before and after being exposed to DAIM

These findings provided some important baseline indicators relating to those factors that require strengthening and those factors that need inclusion in an intervention lecturing programme for pre-service science teachers. The overall outcome is positive in that it brings to the surface the importance a constructivist learner-centred approach to teaching as well as assimilating the importance of locating science within a socio-cultural paradigm. The pre-service teachers were able to see the relevance of science to their everyday living as well as become aware of the cultural and educational value of amalgamating the two knowledge corpuses together rather than regard them as polar opposites (Ogunniyi, 2007a & b; 2011). A major consideration from this data was the identification of factors such as examinations, pace setters, ill-discipline, absent teachers and intransigence on the part of school management that impacted on the delivery of a science-IK lesson using DAIM. These factors are of importance as a source of information for the design of a DAIM driven science-IK curriculum.

5.2.3 Pre-service science teachers' pre-post conceptions of an integrated science-IK curriculum

Initially the pre-service science teachers were more favourably disposed to modern (Western) science than they were to indigenous knowledge. However, when they were confronted with controversial issues such as creationism vs. evolution; origin of the universe

and life after death and so on then their apparently suppressed religious beliefs came to the surface. Another major shift among the pre-service teachers was the strong recognition they gave to IK at the post-test compared to their generally negative view about that knowledge corpus at the pre-test. This positive shift was further affirmed by the fact that all (100%) the pre-service teachers unanimously recommended that IK be included in the teacher education programmes in higher institutions. This revised worldview as in earlier studies (e.g. Diwu & Ogunniyi, 2012; Langenhoven & Ogunniyi, 2011) is most probably as a result of their exposure to DAIM.

5.2.4 Pre-service science teachers' practical experiences during the teaching practice when attempting to use DAIM to implement integrated science-IK lessons

These reflections focussed on three aspects: (a) the implementation of a science-IK lesson using DAIM; (b) the viability or otherwise of using DAIM to integrate science and IK in a science lesson; and (c) the inclusion of DAIM as a method of science teaching in the teacher preparation programmes. The following positive aspects emerged from the data where the pre-service teachers considered dialogical argumentation as a workable method for fostering growth, thinking, debating skills, confidence building and as a socialising agent.

The dialogical argumentation instructional model adopted for the study seemed to increase the pre-service teacher's awareness of the cultural and educational value of IK (Ogunniyi, 2011). Albeit, the pre-service teachers appeared to have overrated their sense of self-efficacy (ease and comfort) in using DAIM to teach an integrated science-IK lesson when exposed to the reality of the science class environment.

163

5.3   Implications of major findings

Based on the findings of the study the following implications have been identified as relevant proposals for further action.

5.3.1   Implications for Policy

Curriculum planners, subject advisors as well as in-service teachers would benefit from this alternative teaching and learning strategy if the National Department of Education can support workshops and resource materials development initiatives.

For as long as IK is seen as an add-on and not to be assessed knowledge so would the goal of integrating science with IK in the classroom setting remain but a 'pipe dream'.

Policy requires administrative and resource support in the form of materials, curriculum advisor-teacher workshops, e-learning-type platforms and financial support for any real progress to be realised.

The pre-service teachers involved in the study took part in a pilot study involving the SIKSP team (including some of the pre-service teachers involved in this study) from the University of the Western Cape, 40 Life Science teachers and curriculum advisers. The purpose of the pilot study was to expose the teachers and curriculum advisers to DAIM as a veritable tool to implement a science-IK curriculum. Some of the pre-teachers involved in this study were able to serve as effective facilitators at the workshop because they had been exposed to DAIM. This workshop sponsored by the Natural Science and Life Sciences Department, WCED, took place over a one week period during the July school vacation. Of the initial eight groups, four groups persevered to attend the presentation of DAIM lesson workbooks at a workshop in October 2014. The curriculum material workbooks that were developed are now at a publishing stage. These are the kinds of initiatives that would contextualize and give credibility to an indigenised science curriculum, in line with IKS policy (Department of Science and Technology, 2004) and the CAPS (Department of Basic Education, 2011). This study and the pilot study just described have implications for policy

in that they serve as useful exemplars for similar attempts that seek to link theory with practice. Just as the pre-service teachers were empowered to implement the a science-IK curriculum as a result of their exposure to DAIM so were the Life Science teachers and curriculum advisers involved in the two consecutive workshops in July and October. The implications of these findings for curriculum policy formulation and implementation are worthy of closer consideration by curriculum planners, teacher educators, curriculum advisers, teachers and other stakeholders.

In view of the above, policy makers could give attention to the following:

- Supporting and contributing to the 'widening and deepening of national and provincial strategies for an inclusive science curriculum
- Contributing to an enhanced appreciation of South Africa's rich cultural and scientific heritage and identity of previously disadvantaged communities
- Developing a rich knowledge base of IKS which will be freely available to local communities and which learners can claim ownership of.
- Compiling reports that have direct import for IKS policy formulation and implementation.
- Contributing positively to the development of community consciousness and sense of identity in a world dominated by a euro-centric culture

5.3.2 Implications for teacher training programmes

The findings of this study corroborate earlier findings namely, that DAIM: (1) is an effective instructional approach to generate classroom discourse; (2) is a handy instructional tool for implementing an inclusive science-IK curriculum; (3) could help to clear learners' pre-service teachers' and even practising teachers' doubts, fears as well as remove their erroneous ideas about the science-IK curriculum; (4) is effective for facilitating teachers' professional development and instructional practices beliefs; (5) could revolutionize the way that teachers teach science in the classroom context e.g. teaching in a medium of

argumentation and dialogues rather than the traditional talk-and-chalk approach so much abroad in South African classrooms today; (6) could help increase the pre-service teachers and practising teachers' awareness about the educational and cultural values of an integrated science-IK curriculum and (7) enhance teachers' self-image and socio-cultural identity (e.g. Erduran et al, 2004; Leitao, 2000; Nhalevilo & Ogunniyi, 2014a & b; Ogunniyi, 2004, 2007a & b; Ogunniyi & Hewson, 2008; Osborne, 2010; Simon & Johnson, 2008). These findings certainly have implications for the teacher training programmes. In fact it would be unreasonable to expect aspiring or new entrants into the teaching profession to implement instructional strategies with which they were unfamiliar as was the case with the new South African science curriculum. The positive outcomes of this study further reveal the potential of DAIM for implementing an inclusive science-IK curriculum.

In light of the above it seems important that pre-service science teachers be exposed in their training institutions to new instructional approaches that they would need when they commence their instructional practices. The fact that all the pre-service teachers as in earlier studies (e.g. Ogunniyi & Hewson, 2008) recommended the inclusion of such strategies into their training programmes is indicative of the positive benefits they must have derived from their exposure to DAIM (including visual modelling). During the study I found that the inclusion of visual model with DAIM-based classroom activities greatly facilitated the ability of the pre-service teachers to integrate IK with science.

The disjuncture between the efforts in science method courses at tertiary institutions and classroom practice is a well known phenomena. Often pre-service teachers find it difficult to see the connection between the generally theoretical method courses and actual classroom situations. My experience in the study has however, shown that this anomaly could be ameliorated if pre-service teachers are given opportunities to:

- Develop dedicated resource material, lesson plans, structured argumentation writing frameworks and time-on-task activities aligned to CAPS pace setters.
- Plan, design and practice individual and co-operative presentations during their course of study.

- Work under the supervision of supervisors as well as mentor teachers prior to beginning science teachers reporting at schools for teaching practice, on the methodological approaches that they would be implementing.

- Become sufficiently schooled in the use of argumentation instructional skills prior to the teaching practice.

- Visit with school management to assess the latter's willingness to accommodate the needs of pre-service science teachers to implement argumentation methodology.

- Work in a functional rather than a dysfunctional school so as to enable them to practise their teaching skills.

5.3.4   Implications for pre-service science teachers and learners

Further to the implications highlighted in the previous section, it seems apposite to state that training pre-service teachers to integrate IK with school science should be a curriculum requirement and a priority pre-service teacher education programmes. As stated in chapter 1, one of the reasons that the Department of Education (DOE) (2002) and later the Department of Basic Education (DBE) formulated the policy to indigenize the science curriculum was to make school science relevant to the life worlds of South African learners. DOE (2002) asserted that IK is part and parcel of the life worlds of all South Africans and needs to be revisited to awaken every citizen about their national heritage or what it terms "wisdom of the past" (DOE, 2002). In the same vein DBE (2011) under the General Aims of the South African Curriculum emphasized the need for learners to value "indigenous knowledge systems: acknowledging the rich history and heritage of the country as important contributors to nurturing the values contained in the Constitution…" (p.5).

With the emergence of multicultural classrooms throughout the country it has become imperative to train prospective science teachers in a way that would make teach effectively in such classrooms. Unless pre-service teachers are initiated in their training to know how to implement an inclusive science curriculum in their classrooms they would continue to join the ranks of most teachers who alienate learners from school science (e.g.

Diwu & Ogunniyi, 2012; Langenhoven & Ogunniyi, 2011; Ogunniyi, 2004, 2007a & b, 2011a &b). The Argumentation is assisted by a structured Dialogical Argumentation Instructional Model (DAIM) which requires interactive workshops for teachers to make any progress in its implementation. I wish to reiterate Loggenberg (2012) recommendation that for an effective argumentation science classroom, teachers should strengthen learners' ability to develop argument by:

- Ensuring that the selection criteria is followed to ensure that pre-service science teachers are soundly grounded in their specialist content knowledge area.
- Providing beginning teachers with the skills and tools to design DAIM inspired lessons with writing scaffolds, aligned to CAPS policy and trialled with peers.
- Providing more teaching opportunities and spaces for beginning teachers to practice their skills.
- Allowing learners sufficient time to gather and study the content on which the argument is based.
- Creating an environment in which learners are exposed to two or more conflicting ideas/theories
- Encouraging learners to give voice to their thoughts to improve their argumentation ability, as voicing thoughts contributes to critical thinking and reasoning (King,1990; Kuhn, 2005).

5.4   Recommendations

The main recommendations flowing out of this study are:

1. A science-IK educational programme underpinned by dialogical argumentation that can be continuously monitored and assessed on its relevance, value and quality.

2. Providing mentoring support and opportunities (spaces) for pre-service science teachers to practice their dialogical argumentation skills in implementing a truly integrated science-IKs curriculum.

3. Establish a consultancy for the expansion and writing of science-IK materials.

4. Continuous action research into classroom practice of pre-service and in-service science teachers who were exposed to the dialogical argumentation intervention programme.

5. Collaborative research initiatives with science-IKS departments across campuses in other provinces with a view to sharing best practices.

5.5 Direction for further studies

I believe that the stage has been set to probe this area more deeply, since most reported research in the area of argumentation as a teaching strategy to implement integrated science-IK lessons has been with in-service teachers on a homogenous topic. I believe that beginning science teachers have a vital role to play in "moving classroom practices beyond the positivist view of scientific knowledge construction" (Ghebru & Ogunniyi, 2013). Further, research studies into aspects of materials and curriculum design are greatly needed especially in terms of the sociocultural dimension teaching and learning.

The sociocultural challenges faced by an average science teacher in the classroom and the school environment today especially in many dysfunctional schools are enormous. It cannot just be business as usual. There is a need to prepare teachers who can think out of the box so to speak when confronted with a motley assembly of learners in his/her classroom with little or no intellectual interest in the lesson. Also introducing a new curriculum necessarily warrants a radically difference approach than traditional expository teaching (e.g. Erduran et al, 2004; Ogunniyi, 2004, 2006, 2007a & b; Osborne, 2010; Simon & Johnson, 2008) intransigence of officialdom at national, regional and local levels; impact of an exam driven curriculum on science-IK contexts; overcoming barriers to implementation of a science-IKS curriculum and so on. Research into the enactment of IKS policy as it relates to the education sector, both in the formal and informal sectors and across government departments.

5.6   Conclusion

Throughout this report, I have argued for a Dialogical Argumentation Instructional Model (DAIM) as a teaching strategy that can be used to equip pre-service science teachers with the necessary knowledge and skills to implement science lessons that reflect science-IK integration. Through this instructional approach teaching and learning spaces are created that promote learner engagement in discourses. Thus moving them from a rote form of learning where factual information is reduced to answers of right or wrong to a socio-constructivist approach whereby science is seen as a societal enterprise rather than a fixed dogma whose aims and contents are unquestionable. In otherwise teaching and learning science in the context of DAIM provides the intellectual space to argue, dialogue and finally to reach consensus on diverse controversial socio-scientific issues (Kolsto, 2006). An argument for the utilisation of an argumentation approach to teaching and learning science is mooted by Ogunniyi, Kwofie & Siseho (2012) who calls for a science curriculum that fulfils the social goals of argumentation by:

> … buttressing teachers' and students understanding of the scientific processes involved in IK and related practices…and it is hoped that participants might be more efficacious in the way they deploy DAIM in professional practice. (p. 22)

Although these results of this study cannot be generalised it has highlighted a number issues worth considering in the training of pre-service teachers as well as beginning teachers. The findings have also highlighted important issues relating to teacher educators especially those professionals responsible for teacher training. It is apparent that theoretical and practical teacher training programmes need to equip pre-service teachers with a sense of mastery so that their self-efficacy can be strengthened. Pre-service science teachers have to navigate and perform a complex balancing act on a daily basis. Evidence from this study shows that the schools where the pre-school science teachers involved in this study are based are based had very little awareness of how to implement Specific Aim 3 of CAPS nor were inclined to accommodate students with an argumentation pedagogy.

170

The business of science teaching requires pre-school science teachers to recognise and acknowledge not only scientific concepts but also IK in an integrated way. They now not only have to know the 'What to teach? –content knowledge'; the "How to teach?-skills' but also the 'Why? – relevance' and in addition have to deal with socio-economic problems that learners bring to the classroom and is expressed in disciplinary issues. The findings of this study along with earlier ones in the area have shown the importance of indigenizing the science curriculum (Aikenhead, 2001, 2002; Afonso and Ogunniyi, 2011; Bricker and Bell, 2008; Onwu and Mosimege, 2004). In addition the findings have shown that pre-service teachers and teachers exposed DAIM are more effective in creating enabling science-teacher-material interactions and to increase learners' awareness about their indigenous heritage than those who have not been so exposed. In that case DAIM appears to hold promise for future studies in the area and therefore warrants more investigation with larger samples than has been the case in the present study.

Despite the positive outcomes of the study some of the pre-service teachers still battle in using DAIM in their lessons. Nevertheless, until DAIM becomes the driver of the integrated science-IK lesson, its success may be elusive. Until a large enough cohort of in-service science teachers and more specifically school management become aware of the progressive role that argumentation can play, real integration will continue to a pipe dream. Where there are best practices, it should be nurtured. My belief is that an indigenized science should feature more prominently at tertiary institutions rather than wait until the teachers are on the field.

The contribution of this cohort of pre-service PGCE science teachers who participated in this study to a coherent teaching and learning constructivist argumentation model is also worth noting. Of importance is the self-efficacy shown by these participants in their willingness to amalgamate the different cosmologies of science and traditional cultural worldviews (IKS) through using DAIM (Diwu, 2011; Diwu and Ogunniyi, 2012; Langenhoven, 2009).

It is hoped that what the pre-service science teachers involved in this study have imbibed would follow them to their instructional practices. It is also hoped that their experiences in the DAIM-based workshops would be cascaded to other teachers and impact positively on their learners wherever they teach. Although my experience since I joined the Science and Indigenous Knowledge Project (SIKSP) has been exciting and fruitful my involvement in this study has proved very informative and useful and I believe that despite the challenges that I have encountered, the experience has been worthwhile. I further hope it would enhance my instructional practice and future studies in the area.

REFERENCES

Abd-El-Khalick, F., and Lederman, N.G. (2000). Improving science teachers' conceptions of nature of science: a critical review of literature. *International Journal of Science Education, 22(7),* 665-701.

Afonso, E. & Ogunniyi, M.B. (2011). Teachers' deconstruction of the image of science through contiguity argumentation theory-Paving the way for IKS in school curriculum. Proceedings of SAARMSTE, 332-343.

Agrawal, A. (2002). Indigenous Knowledge and the politics of classification. UNESCO. Blackwell Publishers.

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

Aikenhead, G.S. (2003). Review of research on human perspectives in science curricula. *Paper presented at ESERA (European Science research Association) Conference,* Noordwijkerhout, The Netherlands.

Aikenhead, G.S. & Jegede, O.J. (1999). Transcending cultural borders: Implications for science teaching. *Research in Science & Technology Education, 179,* 45-66.

Aikenhead, G.S. & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Culture Study of Science Education, (2),* 539-620.

Aldous, C.M. & Rogan, J. M. (2009). The implementation of the natural Science Outcome Three: Embedding the learning of science in societal and environmental issues. *African Journal of Research in MST Education, 13(1),* 62-78.

Amosun, O.I. & Luckay, M.B. (2012). A critical analysis of studies focusing on the integration of science and indigenous knowledge in South African classrooms. In

M.B. Ogunniyi (Ed.). *Proceedings of Systematic Review of South African-Mozambican Published Research on Indigenous Knowledge Systems Conference,* 60-66.

Amosun, O.I., Ogunniyi, M. & Riffel, A. (2013). Conceptual, attitudinal and practical change concerning science and indigenous knowledge integration using argumentation. In S.K. Kwofie, M.B. Ogunniyi, O. Amosun, K.R. Langenhoven, S. Dinie (Eds.). *Proceedings of the 21st Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Cape Town, South Africa: SJR Printers. 348-362.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioural change. *Psychological Review, 84*, 191-215.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman.

Bandura, A. (2000). Self-efficacy: Foundation of agency. In W. Perrig & A. Grob (Eds.), *Control of human behaviour, mental processes, and consciousness,* 17-33. Mahwah, NJ: Erlbaum.

Barcelos, L. (2013). *Towards a BC Science Curriculum Inclusive Of Indigenous Knowledge: Challenges and Recommendations for Reform* (Masters Dissertation). Retrieved from [online]
http://dspace.library.uvic.ca:8080/bitstream/handle/1828/4747/Barcelos_Leanne_MED_2013.pdf?sequence=1

Barnhart, C.L. & Barnhart, R.K. (Eds.). (1989). *The World Book Dictionary*. Chicago: World Book Inc.

Barnhardt, R., & Kawagley, A.O. (2005). Indigenous Knowledge Systems and Alaska Native Ways of Knowing. *Anthropology and Education Quarterly, 36(1),* 8-23.

Battiste, M., & Henderson J.Y. (2000). *Protecting Indigenous knowledge and heritage.* Saskatoon, Saskatchewan: Purich Publishing.

Bell, R.L., Matkins, J. J., & Gansneder, B.M. (2011). Impacts of Contextual and Explicit Instruction on Pre-service Elementary Teachers' Understandings of the Nature of Science. *Journal of Research in Science Teaching, 48(4),* 414-436.

Bell, P., & Linn, M.C. (2000). Scientific arguments as learning artifacts: Designing for learning from the Web with KIE. *International Journal of Science Education, 22(80,* 797-817.

Bernard, H.K. (2011). Research methods in Anthropology: Qualitative and Quantitative approaches. UK: Altamira Press.

Bernstein, B. (2002). On the curriculum. In J. Gultig., U. Hoardly & J. Jansen (Eds.). Curriculum: From Plans to Practices. Cape Town: Oxford University Press 98 – 109.

Bleicher, R.E. & Lindgren, J. (2005). Success in science learning and pre-service science teaching self-efficacy. *Journal of Science Teacher Education, 16*, 205-225.

Bloch, G. (2009). *The Toxic Mix. What's wrong with South Africa's schools and how to fix it.* Cape Town: Tafelberg Publishers.

Bogdan, R.C., & Knopp-Biklen, S. (2007). *Qualitative research for education: An introduction to theories and methods.* New York: Pearson Education Inc.

Boulter, C.J. & Gilbert, J.K. (1995). Argument and science education. In P.S.M. Costello and S. Mitchell (Eds.), *Competing and Consensual Voices: The Theory and Practice of Argumentation.* Clevedon.

Bransford, J.D., Brown, A.L., & Cooking, R.R. (1999). *How people learn: Brain, Mind, Experience, and School. (Eds.)* http://www.nap.edu/books/030907368/html

Bricker, L.A. & Bell, P. (2008). Professional Learning Portfolios for Argumentation in School Science. *International Journal of Science Education* [online], available at < http://www.tandfonline.com/doi/abs/10.1080/09500690701854873#.VEJxLBayg5I>, [accessed 2nd October 2014]

Bricker, L.A. & Bell, P. (2008). Conceptualisations of Argumentation from Science Studies and the Learning Sciences and their Implications for the Practices of Science Education. DOI 10.1002/*sce.20278*

Brooks, J.G., & Brooks, M.G. (1999). *In search of understanding: the case for constructivist classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.

Bruner, J. (1959). Learning and thinking, *Harvard Educational Review, 29(3),* 184-192.

Carter, L. (2008). Socio-cultural influences on science education. Innovation for contemporary times. *Science Education, 92,* 165-181.

Chalmers, A. (1999). What is this thing called Science? An assessment of the Nature and Status of Science and its' Methods.

Chilisa, B. (2012). *Indigenous Research Methodologies*. Los Angeles. SAGE Publications.

Collins, A., Brown, J.S. & Newman, S.E. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing and mathematics. In Resnick, L,B. (ed.), *Knowing, learning and instruction: Essays in honour of Robert Glaser.* Hillside, NJ: Erlbaum.

Cordero, A. (2001). Scientific Culture and Public Education. *Science Education and Culture*, 17-29.

Corsiglia, J. & Snively, G. (2001). Rejoinder: infusing indigenous science into western modern science for a sustainable future. *Science Education, 185(1*), 82-86.

Creswell, J.W. (1998). Qualitative inquiry and research design: choosing among five traditions. Thousand Oaks: Sage.

Creswell, J.W. & Miller, D.L. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39(3),* 124-131.

Cross, R.T. & Price, R.F. (1996). Science teachers; social conscience and the role of controversial issues in the teaching of science. *Journal of Research in Science Teaching, 33(3),* 319-333.

Cubucku, Zuhal (2008).Preferences on internet based learning environments in student-centred education. *Turkish Online Journal of Distance Education. 9*, 154-174.

De Beer, J. & Whitelock, E. (2009). Indigenous knowledge in the Life Sciences classroom: Put on your de Bono hats! *The American Biology Teacher, 71(4),* 209-216. Accessed October 21, 2011. Available http:///www.bioone.org/doi/full10.1662/005.071.0407

De Vos, A.S., Strydom, H., Fouche, C.B. and Delport, C.S.L. (2005). *Research at Grass Roots*. Pretoria: Van Schaik Publishers.

Dekkers, P. & Nbisi, E. (2003). The nature of science – do teachers have the understanding they are required to teach? *African Journal of Research in Mathematics, Science and Technology Education, 7,* 21-34.

Dekkers, P., Ogunniyi, M., Nosimege, H. & Kadjeo-Marenga, H. (2005). South African and Zimbabwean Teachers' Understandings of NOS. Proceedings SAARMSTE 2005, 164-171.

Denzin, N. K., & Lincoln, Y. S. (1998) (Eds). *Collecting and interpreting qualitative materials*. Thousand Oaks: Sage Publication.

Dreyfus, A. (1990). Applying the "cognitive conflict" strategy for conceptual change – some implications, difficulties and problems. *Science Education, 74(5),* 555-569.

Department of Education, (2002). *Revised National Curriculum Statements for Grades R-9 (Schools): Natural Sciences.* Pretoria: Government Printers.

Department of Education, (2004a). *National Curriculum Statements for Grades 10-12 (Schools): Life Sciences.* Pretoria: Government Printers.

Department of Education. (2004b). *National Curriculum Statements for Grades 10-12 (Schools): Physical Sciences.* Pretoria: Government Printers.

Department of Science & Technology. (2004). *Indigenous Knowledge Systems Policy.* Pretoria Government Printers.

Department of Basic Education. (2011a). Curriculum and Assessment Policy Statement (CAPS). Natural Sciences. Pretoria: Government Printers.

Department of Basic Education. (2011b). Curriculum and Assessment Policy Statement (CAPS). Life Sciences. Pretoria: Government Printers.

Department of Basic Education. (2011c). Curriculum and Assessment Policy Statement (CAPS). Physical Sciences. Pretoria: Government Printers.

Dinie, S., Angaama, D., George., Mhakhure, D., van der Linde, P., Paulse, S., Small, C., Gilbert, R., & Goodman, L. (2011). Matter and Materials Curricula Workshop. In M. B. Ogunniyi., Kwofie, S. K., Mushayikwa, E., & O. Amosun (Eds.)., *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS.*

Dinie, S. & Ghebru, S. (2012). Integrating indigenous knowledge practices with modern science practices: Towards sustainability and empowerment. In M.B. Ogunniyi (Ed.). *Proceedings of Systematic Review of South African-Mozambican Published Research on Indigenous Knowledge Systems Conference,* 105-112.

Diwu, C.T. (2010). *Effects of a Dialogical Argumentation Instructional Model on Grade 10 learners' Conception of Fermentation.* (Master's thesis). University of the Western Cape, South Africa.

178

Diwu, C., Meyer, C., February., Philander, L., Magerman, R., Fatoba, B., & Daries, A. (2011). Life and Living Curricula Workshop. *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS.*

Diwu, C. T. & Ogunniyi, M. B. (2011). Realising a science and Indigenous knowledge systems curriculum: A case study of dialogical argumentation-based teaching approach. In M. Ogunniyi & S. Kwofie (Eds.), *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS,* 93-108.

Diwu, C., Ogunniyi, M.B. & Langenhoven, K.R. (2011). Effects of a dialogical instructional model (DAIM) on grade 10 learners' conceptions of fermentation. Proceedings of SAARMSTE, 355-366.

Diwu, C.T., & Ogunniyi, M.B. (2012). Dialogical Argumentation instruction as a catalytic agent for integration of school science with indigenous knowledge systems. *African Journal of Research in mathematics, Science and Technology Education, I6(3)*, 333-347.

DOE. (1995). *White paper on Education and Training.* Pretoria, South Africa: Government Printers.

Dowie, J. (2003). Western science and traditional knowledge – no gap to bridge. *The Environment Times*, 3.
Retrieved from [online] http://www.grida.no/publications/et/pt/page/2579.aspx

Drayton, B., & Falk, J. (2001). Tell-tale signs of the inquiry-orientated classroom. *NASSP Bulletin, 85(623),* 24-34. http://dx.doi.org/10.1177/019263650108562304

Driver, R., Leach, J., & Scott, P. (1996). *Young people's images of science.* Bristol: Open University Press.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*, 287-312.

Duschl, R.A., Schweingruber, H.A., & Shouse, A.W. (Eds.). (2007). Taking science to school: learning and teaching science in grades K-8.Washington: National Academy Press.

Duschl, R.A., & Grandy, R.E. (2008). Reconsidering the character and role of inquiry in school science: Framing the debates. In R.A. Duschl & R.E. Grundy (Eds.). Teaching Scientific Inquiry: Recommendations for research and implementation) pp. 1-37). Rotterdam: Sense Publishers.

Education Labour Relations Council (ELRC). (2003). *Policy Handbook for Educators.* Chris Burton & Associates (ed.). Pretoria: Universal Print Group.

England, V., Huber, R., Nesbit., Rogers, C. & Webb, P. (2008). *Scientific Literacy. A New Synthesis.* Cape Town: Digital Print Solutions.

Erduran, S. (2006). Fuming with reason: towards research-based professional development to support the teaching and learning of argumentation in science. Proceedings of the 14th Annual SAARMSTE Conference, University of Pretoria.

Fakudze, C.G. (2004). Learning of science concepts within a traditional socio-cultural environment. *South African Journal of Education, 24(4),* 270-277.

Fasokun, T., Katahoire, A, A. & Oduraan, A. (2005). *The psychology of adult learning in Africa.* Cape Town: UNESCO and Pearson Education S.A.

Field, A. (2003). Discovering Statistics Using SPSS for Windows. London: SAGE Publications.

Fleer, M. (1999). Children's alternative views: Alternative to what? *International Journal of Science Education, 21(2),* 119-135.

Foulds, S. (2003). Teacher development Challenges in the Context of Curricular Reform: The Case of South Africa. ICP Online.

Francoeur, E. (1997). The forgotten tool: The design and use of molecular models. *Social Studies of Science, 27*: 7-40.

Fraser, B. J. (1981). *Test of Science-Related Attitudes Handbook: TOSRA*. Victoria: The Australian Council for Educational Research Limited.

Friese, S. (2012). Qualitative Data Analysis with ATLAS.ti. London: SAGE Publications.

George, F., & Ogunniyi, M. (2013). Effects of dialogical argumentation in a computer-assisted learning environment on grade 10 learner's understanding of concepts of chemical equations. In S. K. Kwofie., M. B. Ogunniyi., O. Amosun., K. R. Langenhoven., & S. Dinie (Eds.), *Proceedings of the 21st Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education: Making Mathematics, Science and Technology Education, Socially and Culturally relevant in Africa,* 231-245.

Ghebru, S. & Ogunniyi, M.B. (2013). Moving classroom practices beyond the positivist view of scientific knowledge construction. In S.K. Kwofie, M.B. Ogunniyi, O. Amosun, K.R. Langenhoven, S. Dinie (Eds.). *Proceedings of the 21st Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Cape Town: SJR Printers. 468-478.

Gierdien, F. (2005). On the School Mathematics Tradition (SMT) and its implications. *UWC Papers in Education, 3*, 83-91.

Gilbert, J.K. (1995). The role of models and modelling in some narratives in science learning. *International Journal of Science Education*, *22(9),* 891-894.

Glasson, G. E., Mhango, N., Phiri, A., & Lanier, M. (2010). Sustainability science education in Africa: Negotiating indigenous ways of living with nature in the third space. *International Journal of Science Education, 32(1),* 125-141.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The Qualitative Report*, 8(4), 597-606. Retrieved [Insert date], from http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf

Gordon, E.W. (2006) Establishing a System of Public Education in Which All Children Achieve At High Levels and Reach Their Full Potential. In The Covenant with Black America. Chicago, IL: Third World Press.

Gray, BV. (1999). Science education in the Developing World: Issues and consideration. *Journal of Research in Science Teaching*, *36,* 261-268.

Gunstone , R. & White, R. (2000). Goals, methods and achievements of research in science education. In Millar, R., Leach, J. and Osborne, J. (eds.), *Improving Science Education.* Buckingham: Open University Press.

Gutman, A. (1995). Challenges of multiculturalism in democratic education. In A. Nieman (Ed.). Philosophy of Education. Illinois. Urbana: Philosophy of Education.

Haney, J.J., & McArthur, J. (2002). Four case studies of prospective science teachers' beliefs concerning constructivist teaching practices. *Science Education, 86*, 783-802.

Hewson, M. & Ogunniyi, M.B. (2011). Argumentation-teaching as a method to introduce indigenous knowledge into science classrooms: Opportunities and challenges. Cultural Studies in Science Education, D010.1007/611422-010-9303-5.

Hodson, D. (1992). In search of a meaningful relationship: an exploration of some issues relating to integration in science and science education. *International Journal of Science Education, 14,* 541-562.

Hodson, D., & Hodson, J. (1998). Science education as enculturation: some implications for practice. *School Science Review*, *80(290),* 17-24. http://www.education.com/reference/article/teacher-efficay/ Retrieved 2012/12/05.

Hodson, D. (2009). *Teaching and Learning about Science: Language, Theories, History, Tradition and Values.* Rotterdam, The Netherlands: Sense Publishers.

Idowu, E. B. (1967). Olodumare: God in Yoruba belief. Longmans. Ibadan.

ICSU Study Group. (2002). Science and traditional knowledge. Report from the ICSU Study Group on Science and Traditional Knowledge. Accessed at http:///www.icsu.org/Gestion/img/ICSU_DOCDOWNLOAD/220_DDFILE_Traditional_Knowledge_report.pdf

Jansen, J.D. & Christie, P. (eds.) (1999). Changing Curriculum: Studies on outcomes-based education in South Africa. Kenwyn: Juta and Co. Ltd.

Jegede, O.J. (1995). In support of culturally and individually responsive science. *Science Education. 80,*101.

Jenkins, E. (2001). Constructivism in School Science Education: Powerful Model or the Most Dangerous Intellectual Tendency? In F. Bevilacqua, E. Gianettetto and M. R. Matthews. (Eds.). *Science Education and Culture. The Contribution of History and Philosophy of Science*. Doordrecht: Kluwer Academic Publishers.

Jidesjo, A., & Oscarrson, M. (2006). Students' Attitudes to Science and Technology. First Results from the ROSE-Project in Sweden. In RM. Janiuk & E. Samonek-Miciuk (Eds). *Science and Technology Education for a Diverse World. Dilemmas, Needs and Partnerships*. Warsaw: Maria Curie-Sklodowska University Press. pp. 295-307.

Joseph, J. (2010). Does intention matter? Assessing the Science Teaching Efficacy beliefs of pre-service teachers as compared to the general student population. *Electronic Journal of Science Education, 14(1).* Retrieved from http://ejse.souithwestern.edu

Justi, R.S. & Gilbert, J.K. (2002). Modelling, teachers' views on the nature of modelling, and implications for the education of modellers. *International Journal of Science Education, 24(4),* 369-387.

Keane, M. (2008). Science education and worldview. *Cultural Studies of Science Education, 3,* 587-621.

Khine, M. S. (Ed.). (2012). *Perspectives on Scientific Argumentation: Theory, Practice and Research.* London: Springer.

King, A. (1990). Enhancing peer interaction and learning in the classroom through reciprocal questioning. *American Research Association Journal, 27(4),* 664-687.

Kolstø, S. D. (2001a). *Science Education for Citizenship. Thoughtful Decision-Making about Science Related Social Issues*. Oslo: Unipub.

Kolstø, S. D. (2001b). Scientific literacy for citizenship: tools for dealing with the science dimension of controversial socio-scientific issues. *Science Education, 85(3*), 291-310.

Kolstø, S. D. (2006). Patterns in students' argumentation confronted with a risk-focused socio-scientific issue. *International Journal of Science Education, 28(14),* 1689-1716.

Kozulin, A. (1990). *Vygotsky's psychology: A biography of ideas.* New York: Harvester Wheatsheaf.

Kuhn, D. (1992). Thinking as argument. *Harvard Educational Review, 62(2),* 155-178.

Kuhn, D. (1993). Science argument: implications for teaching and learning scientific thinking. *Science Education, 77(3),* 319-337.

Kuhn, D. (2005). *Education for Thinking.* Cambridge MA: Harvard University Press.

Kwofie, S. & Ogunniyi, M.B. (2011). Effects of dialogical argumentation-based workshops on primary and secondary school teachers' ability to co-construct the concept of solubility. Proceedings of SAARMSTE, 277-286.

Kwofie, S. (2009). Implementing a dialogical argumentation instructional model: A South African experience. In M. B. Ogunniyi (Ed.). *Second National Workshop on Science and IKS, pp. 28-46.* University of the Western Cape, RSA.

Langenhoven, K.R. (2006). The Relevance of Science education to boys and girls in Western Cape, South African science classes. In S. Yoong, M. Ismail, A. Nurulazam, F. Saleh, F.S. Fook, L.C. Sam & M.N.L. Yan (Eds.). *Proceedings of the XII International Organisation for Science and Technology Education (IOSTE Symposium).* Penang: Zillion Circle.

Langenhoven, K.R. (2009). Using an argumentation-based pedagogical model to enhance teachers' knowledge of science and indigenous knowledge systems. In M. B. Ogunniyi (ed.). *Second National Workshop on Science and IKS,* (pp. 74-80.* University of the Western Cape, RSA.

Langenhoven , K.R. & Kwofie, S. (2009). An investigation into the use of time on task as a reflexive competence to improve science teaching and academic learning time in primary schools: An Action Research approach.

Langenhoven, K.R., Stone, R., & Riffel, A. (2011). Earth and Beyond Curricula Workshop. *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS.*

Langenhoven, K.R. & Ogunniyi, M.B. (2011*).*Using an argumentation framework to analyze teachers' views of the scientific and indigenous ways of interpreting experience with selected natural phenomena. In T. Mamiala, & F. Kwayisi (Eds.), *Proceedings of the Southern African Association for Research in Mathematics, Science And Technology Education:* MST – A bridge to the future. 397-406. North-West University-SAARMSTE.

Langenhoven, K. R., Saibu, O., & Nkeshimana, E. (2012). Voices emerging from a critical analysis of research papers on indigenous knowledge using the Contiguity Argumentation Theory (CAT) as a meta-cognitive tool for analysis. In M.B. Ogunniyi

185

(ed.). *Proceedings of Systematic Review of South African-Mozambican Published Research on Indigenous Knowledge Systems Conference,* 67-76.

Lazarus, S. (2004). An exploration of how Native American worldviews, including healing approaches, can contribute to and transform support services in education. *Research Report*. NRF. Pretoria.

Lazarus, S. (2011). Creating the melting pot: Some thoughts on the curriculum as a vehicle for integrating diverse knowledges. In M. B. Ogunniyi & S. K. Kwofie, *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS,* 22-31.

Leitao, S. (2000). *The Potential of Argument in Knowledge Building.* [online], http://www.researchgate.net/publication/247701525_The_Potential_of_Argument_in_Knowledge_Building>, [accessed 2nd October 2014]

Le Grange, L. (2008). Challenges for enacting an indigenised science curriculum: A reply to Ogunniyi and Ogawa. *SAJHE, 22(4),* 817-826.

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire (VNOS): Toward valid and meaningful assessment of learners' conceptions of nature. *Journal of Research in Science Teaching, 39*, 497-521.

Le Grange, L.L. (2007). Integrating western and indigenous knowledge systems: The basis for effective science education in South Africa. *International Review of Education*, *53,* 577-591.

Lertzman, K. (2002). Science and Indigenous Peoples' Knowledge (summary). In Michel, H. & Gayton, D. V. (Eds) *Proceedings, Linking Indigenous Peoples' Knowledge and Western science in natural resource management,* (pp. 29–31). Retrieved from [online] http://www.rem.sfu.ca/forestry/publications/PDFs.of.Papers/Science.and.Trad.Mgmt.02.pdf

Liphoto, N.P., Kolsto, S.D., Oluka, S. & Ogunniyi, M.B. (2008). Co-presentations of Science and Indigenous Cosmologies; A challenge for Lesotho science educators. In L. Holtman., C. Julie., O. Mikalsen., D. Mtetwa., & M. Ogunniyi (Eds.), *Some developments in research in Science and Mathematics in Sub-Saharan Africa.* Somerset West, African Minds.

Loggenberg, E.W. (2012). Tecahing and learning electrostatics using everyday knowledge, indigenous knowledge and scientific argumentation. (Masters' thesis). Nelson Mandela Metropolitan University, South Africa.

Low, C. (2004). Khoisan Healing: Understanding, Ideas, and Practices. Thesis. *University of Oxford.*

Lubben, F. (2011). Making sense of the mixture in the melting pot: Developing IKS-based curriculum materials-drawing on experience with contextualisation? In M. Ogunniyi & S. Kwofie (Eds.), *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS,* 68-78.

Lubben, F. (2011). Making sense of the mixture in the Melting Pot: Developing IKS-Based Curriculum materials-Drawing on experiences with contextualization? In M. B. Ogunniyi & S. K. Kwofie, *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS,* 68-78.

Maila, M. W. & Loubser, C. P. (2003). Emancipatory Indigenous Knowledge Systems: implications for environmental education in South Africa. *South African Journal of Education, 23(4),* 276 – 280.

MacDonald, A. (2013). Mapping Sustainability. In S.K. Kwofie, M. B. Ogunniyi, O. Amosun, K. R. Langenhoven., and S. Dinie (Eds.), *Proceedings of the 21st Annual Meeting of the Southern African Association for Research in Mathematics, Science*

and Technology Education: Making Mathematics, Science and Technology Education, Socially and Culturally relevant in Africa, 330-347.

Maree, K. (2008). First Steps in Research. Pretoria: Van Schaik Publishers.

Martin, M.O., Mullis, I.V.S., Gonzalez, E.J. & Chrostowski, S.J. (2004). TIMSS 2003 International Science Report. Findings from IES's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades. United States. TIMSS & PIRLS International Study Centre.

Mason, L. et al. (2012). Listening and Learning from Traditional Knowledge and Western Science: A Dialogue on Contemporary Challenges of Forest Health and Wildfire. *Journal of Forestry* http://dx.doi.org/10.5849/jof.11-006

Millar, R. (2005). Contextualised science courses: Where next? In P, Nentwig and D, Waddington (eds.). *Making it relevant. Context. based learning of science*. New York: Waxmann Publishing Co.

Ministry of Education. (2001). *Manifesto on Values, Education and Democracy.* Wilmot James (Ed.). Pretoria. Cape Argus Teach Fund.

Motala, E. & Pampallis, J. (Eds). (2001). Education and Equity: The Impact of State Policies on South African Education. Cape Town: Heinemann Publishers.

Moyo, P.V. & Ogunniyi, M.B. (2013). A case study using dialogical argumentation to explore grade 10 learners' scientific and indigenous beliefs about lightning. In S.K. Kwofie, M.B. Ogunniyi, O. Amosun, K.R. Langenhoven, S. Dinie (Eds.). *Proceedings of the 21st Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Cape Town. SJR Printers. 435-445.

Mushaikwa, N. & Angaama, D. (2012). Exploring and translating indigenous knowledge practices into formal education using the contiguity argumentation theory. In M.B.

Ogunniyi (Ed.). *Proceedings of Systematic Review of South African-Mozambican Published Research on Indigenous Knowledge Systems Conference, 42*-49.

Mushaikwa, N., Langenhoven, K.R. & Stone, R. (2014). (unpublished). The use of spatial modelling as a creative pedagogy to concretise the concepts of rotation and revolution in the Earth, Moon, Sun system. *Proceedings of the 22nd Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Port Elizabeth.

Mushayikwa, E. & Lubben, F. (2009). Self-directed professional development – Hope for teachers working in deprived environments? *Teaching and Teacher Education, 25,* 375-382.

Naidoo, N. (2007). Indigenous Knowledge in the National Curriculum Statement. From Policy to Practice for Environmental Education. (Master's thesis). University of Witswatersrand, Johannesburg. http://wiredspace.wits.ac.za/handle

Naidoo, P.D. & Vithal, R. (2014). Tecaher Approaches to introducing Indigenous Knowledge in School Science Classrooms. *African Journal of Research in Mathematics, Science and Technology Education,* DOI: 10.1080/10288457.2014.956407

Narayan, R., & Lamp, D. (2010). Me? Teach Science? Exploring EC-4 pre-service teachers' self-efficacy in an inquiry-based constructivist physics classroom. *Educational Research and Review, 5(12),* 748-757.

National Research Council. (2006). Learning to think spatially: GIS as a Support system in the K-12 Curriculum. http://fermat.nap.edu/catalog/11019.html

Newton, P., Driver, R. & Osborne, J. (1999). The place of argumentation in the pedagogy of school science, *International Journal of Science Education, 21(5*), 553-576).

Nhalevilo, E. A. (2011). Systematic Review and Documentation on IKS Research in Mozambique and South Africa. In M. B. Ogunniyi & S. K. Kwofie, *Proceedings of*

the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS, 109-110.

Nhalavilo, E. N. & Ogunniyi, M. (2011). Teachers' deconstruction of the image of science through contiguity argumentation theory - Paving the way for IKS in school curriculum. In T. Mamiala, T. & F. Kwayisi (Eds.), *Proceedings of the Southern African Association for Research in Mathematics, Science And Technology Education* Mathematics, Science & Technology Education – A bridge to the future. (pp.332-341). North-West University- Mafikeng Campus: SAARMSTE.

Nnazodie, I.J. (2009). The integration of Indigenous Knowledge Systems (IKS) in the teaching of conservation of biodiversity & natural resources: A critical case study of Grade 10 Life Sciences educators in the Pinetown District. (Master's thesis). University of Kwazulu-Natal, Durban. http://hdl.handle.net/10413/1161

Ocholla, D.N. & Onyancha, O.B. (2006). The marginalized knowoledge. An information analysis of indigenous knowledge publications 1990-2004. *South African Journal of Libraries and Information science, 71(3,)* 247-248.

Ogunniyi, M. B. (1982). An Analysis of Prospective Science Teachers` Understanding of the Nature of Science. *Journal of Research in Science Teaching*, *19(1),* 25-32.

Ogunniyi, M.B. (1987). Conceptions of Traditional Cosmological Ideas among literate and Non-literate Nigerians. *Journal of Research in Science Teaching*, *21(2),* 107-117.

Ogunniyi, M.B. (1988). Adapting Western Science to traditional African Culture. *International Journal of Science Education*, *10(*1), 1-9.

Ogunniyi, M.B. (1995). Nature of Worldview Presuppositions among Science Teachers in Botswana, Indonesia, Japan, Nigeria and the Philippines. *Journal of Research in Science Teaching, 32(8),* 817-831.

Ogunniyi, M.B. (1997). Science education in a multi-cultural South Africa. In M. Ogawa (Ed.). Report of an international research program on the effects of traditional culture on science education (pp. 84-95). Mito: Ibaraki University Press.

Ogunniyi, M.B. (2002). Border Crossing and the Contiguity learning hypothesis, Proceedings of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE), Durban, pp. 68-75.

Ogunniyi, M.B. (2004). The challenge of integrating scientific and indigenous knowledge systems for learners. Paper presented at a Science/IKS workshop, University of the Western Cape.

Ogunniyi, M.B. (2005). Relative effects of a history, philosophy and sociology of science course on teachers' understanding of the nature of science and instructional practice. *South African Journal of Higher Education*, 19, 283-292.

Ogunniyi, M.B. (2006). Effects of a discursive course on two science teachers' perceptions of the nature of science. *African Journal of Research in Science, Mathematics and Technology Education, 10(1),* 93-102.

Ogunniyi, M. B. (2007a). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum, paper 1. *International Journal of Science Education, 29(8),* 963-985.

Ogunniyi, M. B. (2007b). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum, paper 2. *International Journal of Science Education, 29(10),* 1189-1207.

Ogunniyi M.B. & Onwu G. (2006). Teachers' knowledge of science and Indigenous knowledge: views on the proposed integration of the two knowledge systems in the classroom. *Proceedings of the 14th Annual SAARMSTE Conference*, University of Pretoria. South Africa.

191

Ogunniyi, M. B. & Hewson, M. G. (2008). Effect of an argumentation-based course on Teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environment and Science Education*, *3 (4)* 143-153.

Ogunniyi, M. B. (2009) Implementing a science – Indigenous knowledge curriculum: The Western Cape experience. *Second National Workshop on Science and Indigenous knowledge systems*, 1–9.

Ogunniyi, M.B. (2011). Exploring science educators' cosmological worldviews through the binoculars of an argumentation framework. *South African Journal of Higher Education, 25(3),* 542-542.

Ogunniyi, M.B. (2011). The context of training teachers to implement a socially relevant science education in Africa. *African Journal of Research in Mathematics, Science and Technology Education, 15(3),* 98-121.

Ogunniyi, M. B. (2012). Re-focussing discourses in indigenous knowledge systems. In M.B. Ogunniyi (Ed.). *Proceedings of Systematic Review of South African-Mozambican Published Research on Indigenous Knowledge Systems Conference, 1*-5.

Ogunniyi, M.B., Kwofie, S., & Siseho, S. (2012). Awakening science/educators' awareness of the educational and cultural values of indigenous knowledge using dialogical argumentation instruction. *Journal of Research in Science Teaching,* pp. 1-22.

Onwu, G. & Mosemege, M. (2004). Indigenous Knowledge Systems. *African Journal of Research in Science, Mathematics and Technology Education*, *8(1),* 1 – 2.

Onwu, G; Holtman, L; Vhurumuku; Ogunniyi, M. B; Fakudze, C. and Langenhoven, K.R. (2005). Teachers' knowledge of science and indigenous knowledge and views on the proposed integration of the two knowledge systems in the classroom. *Proceedings of the Southern African Association for Research in Mathematics, Science and Technology Education.*

Onwu, G. (2009). Introducing IKS into the science curriculum: What develops? An exercise with in-service student teachers. In M. B. Ogunniyi (Ed.). *Proceedings of Second National Workshop on Science an Indigenous Knowledge Systems: The Melting Point: Science and IKS,* 21-27.

Osborne, J., Collins, S., Ratcliffe,M., Millar, R., & Duschl, R. (2003). What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching, 40(7),* 692-720.

Osborne, J., Erduran, S. & Simon, S. (2004). Enhancing the Quality of Argumentation in School Science. *Journal of Research in Science Teaching*, *41(10),* 994–1020.

Otulaja, F.S., Cameron, A., & Masimanga, A. (2011). Rethinking argumentation-teaching strategies and Indigenous Knowledge in South African science classroom. *Cultural Studies of Science Education, 6,* 693-703.

Owston, R. (2005). Models and Methods for Evaluation. Toronto: York University (http://www.bing.com/search?q=models+and+methods+fpr+evaluation&FORM=LENIE) Retrieved 1 June 2012, 605-617.

Pallant, J. (2001). SPSS. Survival Manual. Chicago. Open University Press.

Pendergast, D., Garvis, S., & Keogh, J. (2011). Pre-service Student-Teacher Self-efficacy Beliefs: An Insight Into the making of Teachers. *Australian Journal of Teacher Education, 36*(12). http://dx.doi.org/10.14221/ajte.2011v36n12.6

Piaget, J. & Inhelder, B. (1966). Mental imagery in the child. In H.E. Gruber and J.J. Vonleche (Eds.) The essential Piaget, New York: Basic Books (1977). Part VIII, 643-684.

Ramadas, J. (2009). Visual and spatial modes in science learning. *International Journal of Science Education, 31(3),* 1 – 17.

Ramaligela, S.M. (2013). Knowledge production of indigenous technology: learners' understanding of their context. In S.K. Kwofie, M.B. Ogunniyi, O. Amosun, K.R.

193

Langenhoven, S. Dinie (Eds.). *Proceedings of the 21ˢᵗ Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Cape Town. SJR Printers, 457-467.

Ramanathan, S. (1999). *Popularizing Science and Technology. Some Asian case Studies*.

Ramorogo, G. & Ogunniyi, M. (2010). Exploring teachers' conceptions of the rainbow using argumentation-based intervention. *African Journal of Research in Mathematics, Science and Technology Education, 14 (1)*, 24–35.

Ratcliffe, M. & Grace, M. (2003). Science education for citizenship. Teaching socio-scientific issues.

Reddy,V. (2006). *Mathematics and Science Achievement at South African Schools in TIMSS 2003*. Human Sciences Research Council Press. Cape Town.

Riffel, A.D., Langenhoven, K. R., & Ogunniyi, M. (2013). The role of Indigenous Knowledge Systems in enhancing grade 9 learners' understanding of a Natural Science Education Curriculum: A survey in a Geography classroom in Cape Town, South Africa. In S.K. Kwofie, M.B. Ogunniyi, O. Amosun, K.R. Langenhoven, S. Dinie (Eds.). *Proceedings of the 21ˢᵗ Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Cape Town. SJR Printers. 500-512.

Robson, C. (2002). *Real World Research.* 2ⁿᵈ ed. Cornwall: Blackwell Publishing.

Rogan, J. M. (2004). Out of the Frying pan…? Case studies of the implementation of curriculum 2005 in some science classrooms. *African Journal of Research in Mathematics, Science and Technology Education, 8*, 165-179.

Ross, K.N., and Mahlck, L. (1990). *Planning the quality of education. The collection anduse of data for informed decision making*. France: Pergamon Press.

Sadler, T. D. (2004). Informal reasoning regarding socio-scientific issues: A critical review of the research. *Journal of Research in Science Teaching, 41*, 513-536.

Sampson, V. & Grooms, J. (2009). Inquiry, Argumentation, and the phases of the moon, 2009, *National Science Teachers Association* [online], available at < http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/4/ss09_032_08_16>, [accessed 2nd October 2014]

Schreiner, C. & Sjoberg, S. (2003). *Optimists or pessimists? How do young people relate to environmental challenges?* (Work in progress)

Schreiner, C. & Sjoberg, S. (2004). *ROSE The Relevance of Science Education. Sowing the Seeds of Rose.* Department of Teacher Education and School Development, University of Oslo.

Scott, P., Asoko, H., & Leach, J. (2007). Student conceptions and conceptual learning in science. In S. Abell & N. Lederman (Eds.), Handbook of Research in Science Education (pp. 31-74). New Jersey: Lawrence Erlbaum Associates.

Semali, L. & Kincheloe, J. (1999). What is Indigenous Knowledge and why should we study it? In M.L. Semali & J. Kincheloe (Eds.). *What is indigenous knowledge systems? Voices from the Academy.* New York & London: Falmer Press.

Sillitoe, P. (2002). Globalising Indigenous Knowledge. In A. Bicker., A. Pottier & P. Sillitoe (Eds.). *Participating in Development, Approaches to Indigenous Knowledge, Taylor and Francis (Routledge),* 108-136.

Silverman, S., & Davis, H. (2009). Teacher Efficacy. Science methods to student teaching. *Journal of Educational and Developmental Psychology, 1(1)*, 133-145.

Simon, S. (2008). Using Toulmin's Argument Pattern in the evaluation of argumentation in school science. *International Journal of Research and Method in Education*, *31* (3), 277–289.

Simon, S. & Johnson, S. (2008). Conceptualizations of Argumentation From Science Studies and the Learning Sciences and Their Implications for the Practices of Science

Education. *Wiley Inter Science* [online], http://onlinelibrary.wiley.com/doi/10.1002/sce.20278/abstract [accessed 2nd October 2014]

Siseho, S., Angaama, D. & Ogunniyi, M. (2013). Exploring effects of Argumentation Instruction Model on Science-IKS curriculum in teacher education. In S.K. Kwofie, M.B. Ogunniyi, O. Amosun, K.R. Langenhoven, S. Dinie (eds.). *Proceedings of the 21st Annual Meeting of the Southern African Association for Research in Mathematics, Science and Technology Education.* Cape Town. SJR Printers. 318-329.

Sjoberg, S. (2000a). *The disenchantment with science*. Oslo: Appolon 2000.

Sjoberg, S. (2000b). *Science And Scientists: The SAS-study. Cross-cultural evidence and perspectives on pupils' interests and perceptions Background, Development and Selected Results. ILS, Oslo University.*

Sjoberg, S. (2002a). *ROSE Handbook: Introduction, guidelines and underlying ideas*. Oslo: Acta Didactica.

Sjoberg, S. (2002b). Science and Technology Education. Current Challenges and Possible Solutions` In Jenkins, E. (2002) *Innovations in Science and Technology*, 3.

Sjoberg, S. (2002c). *Science for the children? Report from the Science and Scientists-project*. Oslo: Acta Didactica.

Sjoberg, S. (2002d). *Three contributions to Science Education*. Oslo: Acta Didactica.

Skoumios, M. (2009). The effect of socio-cognitive conflict on students' dialogical Argumentation about floating and sinking. *International journal of environmental and science education, 4, (4),* 381-399.

Smith, T.W., & Strahan, S. (2004). Toward a prototype of expertise in teaching: A descriptive Case study. *Journal of Teacher Education, 68,* 202-248.

196

Smolleck, L.A. & Mongan, A.M. (2011). Changes in pre-service teachers' self-efficacy: From science methods to student teaching. *Journal of Educational and Developmental Psychology, 1(1),* 133-145.

Stone, R. (2009). The effect of an argumentation-based instruction and story-telling on educators' indigenous-scientific conceptions of the moon. In M. B. Ogunniyi (Ed.). *Second National Workshop on Science and IKS,* (pp. 69-73). University of the Western Cape, RSA.

Szybek, P. (2005). Science for a democratic society: The Swedish Science Curriculum. In P, Nentwig and D, Waddington (Eds.). *Making it relevant. Context based learning of science*. New York: Waxmann Publishing Co.

Tinnaluck, Y. (2004). Modern Science and Native Knowledge: Collaborative Process that opens new perspectives for PCST. *Quark,* 12.

Toulmin, S. (1958). *The uses of argument.* Cambridge: Cambridge University Press.

Tschannen-Moran, M. & Hoy, A.W. (2001). Teacher efficacy: capturing an elusive construct. *Teaching and teacher Education, 17,* 783-805.

United Nation Environment Programme (N.D.). (2011). *Indigenous Knowledge in Africa. Retrieved 6th May 2011 from* http://www.unep.org/ik/pages.aspid

Upokodu, O.N. (2003). The Challenges of teaching a Social Studies methods Course from a Transformative and Social Re-constructionist Framework, *Social Studies, 94(2).*

Vally, S. & Tleane, C. (2001). The Rationalisation of Teachers and the Quest for Social Justice in Education in an age of Fiscal Austerity. In E. Motala & J. Pampalis, *Education & Equity: The Impact of state policies on South African education.* Cape Town: Heinemann. 178-202.

Van Driel, J.H; Beijaard, D. & Verloop, N. (2001). Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge. *Journal of Research in Science Teaching, 38(2),* 137-158.

Van Wyk, J. (1997). Indigenous Knowledge Systems: implications for natural science and technology teaching and learning. *South African Journal of Education*, *22(4),* 305–312.

Vandeyar, S. (2003). The jagged paths to multicultural education: international experiences and South Africa's response in the new dispensation. *South African Journal of Education, 23(3),* 193-198.

Vygotsky, L. (1962). *Thought and Language*. Cambridge, MA: MIT Press

Warren, D. M. (1991). Using Indigenous Knowledge in Agricultural Development; World Bank Discussion Paper No.127. Washington, D.C.: The World Bank.

Webb, P. (2011). Science, Technology and IKS: What goes into the Melting Pot? In M. B. Ogunniyi & S. K. Kwofie, *Proceedings of the 3rd International Conference on the Integration of Science and Indigenous Knowledge Systems: The Melting Pot: Science and IKS,* 22-31.

Woolfolk Hoy, A., & Burke-Spero, R. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teachers Education, 21,* 342-356.

Yin, R. K. (1994). *Case Study Research: Design and Methods,* 2nd ed. Thousand Oaks, California: SAGE.

Ziman, J. (2000). Real Science. Cambridge: Cambridge University Press.

Zinyeka, G. (2013). Onwu and Mosimege on "Indigenous Knowledge Systems and Science and Technology Education: A Dialogue" Some Remaining Issues. *Greener Journal of Educational Research, 3*(9), 432-437. Retrieved from [online] http://gjournals.org/GJER/GJER%20PDF/2013/November/061713675%20Zinyeka%20and%20Kalenzi.pdf

APPENDICES

Appendix A: My idea about nature

Please fill in the form and answer the questions as honestly as you can. There are no right or wrong answers, but do not guess.

PART A: **GROUP CODE: …………..** **Programme:…………..**   **Age:…………..** **Gender: ………….**   **Highest Qualification:…………….** **Methods:………………………………..**   **Religion: Christian (   ); Jewish (   ); Moslem (   );** **Hindu ( ); Other ( )** **Teaching Experience: 0-5 ( ); 6-10(   ); 11 -15(   ); 16-20(   ); 21-25(   ); 26-30(   ); 31-35(   ); 0ver 35 ( )**

PART B

Read the stories below and tick (√) to show whether you Agree (A) or Disagree (D) or Don't Know (DK) about the following statements. Do not tick more than one response per item.

STORY 1

There is a place in the Atlantic Ocean called the Bermuda Triangle. In that place many aeroplanes and ships have vanished without any trace of their wreckage.

People believe that:	A	D	DK
(a) The planes and ships are caught up into the world of the dead.			
(b) Sea thieves stole the aeroplanes and ships.			
(c) Sea gods and evil spirits carried the aeroplanes and ships away.			
(d) It must be one of those strange things!			
(e) The aeroplanes and ships have been taken away by aliens			

Suggest you own explanation:

STORY 2

You were thinking about a friend you had not seen for a long time and suddenly he/she appeared!

This is an example of:	A	D	DK
(a)Your mind knowing things before you see them.			
(b)Your mind seeing farther than your eyes.			
(c)It is just a coincidence.			
(d)Your mind acting as a magnet or a special kind of computer.			
(e)The strange world we live in.			

Suggest you own explanation:

STORY 3

People who fall into a coma or die for a while often come up with interesting stories about their experience in the 'after life'.

This is because:	A	D	DK
(a)When a person dies his/her soul lives.			
(b)The brain does not stop immediately the heart stops, so 'after life' experiences is like a dream stored up in the brain before it stops.			
(c)A person's spirit does not die with his body, it leaves the body at death.			
(d)People who died and later came back to life have merely visited the other world.			
(e)The soul of a dead person which is unable to find a body in the other world returns to the owner.			

Suggest you own explanation:

STORY 4

Some diseases are very difficult to cure by modern doctors and yet can be cured by Sangomas or traditional healers. A girl suffering from severe fear could not be cured in a hospital was cured within a week by a Sangoma (traditional healer).

Maybe:	A	D	DK
(a)The girl cured herself because she had more belief in the Sangoma than doctors			
(b)Sangomas have special powers			
(c)Doctors used incorrect healing techniques			
(d) Only Sangomas could cast out demons			
(e)Sangomas used stronger muti than western medicine			

Suggest you own explanation:

STORY 5

Often animals are faster than us in knowing about changes around us. Animals are more sensitive to physical changes in the environment than humans. For example, animals will start to run away or look for shelter long before the arrival of strong wind, thunderstorm or certain s such as tsunamis and earthquakes.

This is because:	A	D	DK
(a)Animals have more sensitive body parts than human beings.			
(b)Animals are closer to nature than we are.			
(c)Animals have spirits which warn them about coming dangers.			
(d)Slight changes in wind or earth movement can be detected by the senses of animals.			
(e)Animals were once super-human beings with the ability to know strange things.			

Appendix B: Nature of Science Questionnaire (NOSQ)

Please answer all items of this questionnaire. We would like to know *your views,* this is not a test. Your answers will be used for educational research purposes only. Your responses will be treated confidentially: your identity will not be revealed and is known only to the researcher. The researcher may ask you, later, to clarify your answers verbally: for this purpose only, please provide your ID number below.

Gender: Male ( ) Female ( )   **Age:**…..   **ID:** …………………………………..

Grade you have taught/are still teaching:(**) Years of teaching experience:**……

Religion: Christian( ) Moslem( ) Others:…………   **Home language:** …………………

Race: African ( ) Coloured ( ) Indian ( ) Others:………………..

Please respond to each item in the space provided.

Most questions provide a statement. Please tick one box to indicate whether you agree or disagree with the statement. Next, please give your reasons, **why** you agree or disagree. Also indicate the source(s) of your beliefs or views. Possible sources of your ideas could be Science, Media, Religion, Family, Traditional beliefs, etc.

Example: "China is a beautiful country."

     If you agree because you like the Chinese people and the landscapes in China, and your view is derived from the news media, then write:

I agree: √ **I disagree:** ☐	
Reasons	I like the Chinese people and China has beautiful landscapes
Source(s)	News media

1.   Science tells us the truth about the natural world."

I agree: ☐ **I disagree:** ☐	
Reasons	
Source(s)	

2. Does the statement in Question 1 reflect the way you present science in class? Or do you present science differently? Please explain, provide examples.

………………………………………………………………………………………………..

………………………………………………………………………………………………...

3. "Scientific knowledge is trustworthy because it was proved in experiments."

I agree: ☐	I disagree: ☐
Reasons	
Source(s)	

4 "Scientific facts can be tested, and every test should give the same result."

I agree: ☐	I disagree: ☐
Reasons	
Source(s)	

5 "A learner may fail to understand a scientific topic simply because the language used in class does not match his/her way of thinking."

I agree: ☐	I disagree: ☐
Reasons	
Source(s)	

6. Do you see language barriers in teaching certain topics in science? Give examples.
…………………………………………………………………………………………………...
…………………………………………………………………………………………………...
…………………………………………………………………………………………………...
…………………………………………………………………………………………………...
7. When teaching science, how do you help learners overcome language barriers?
…………………………………………………………………………………………………...
…………………………………………………………………………………………………...
…………………………………………………………………………………………………...

8. "The purpose of school practical work is to confirm scientific theory."

I agree: ☐	**I disagree:** ☐
Reasons	
Source(s)	

9. "In their work, scientists are influenced by their socio-cultural and psychological frameworks (mind set)."

I agree: ☐	**I disagree:** ☐
Reasons	
Source(s)	

10. "To understand what science is, there is no need to consider, e.g., philosophical, religious, psychological, sociological, or linguistic questions."

I agree: ☐	**I disagree:** ☐
Reasons	
Source(s)	

11. All teachers who use demonstration experiments in class know that the results are sometimes unexpected, and do not always confirm the theory. What do you do when an experiment does not work out as expected? (Give examples if you can.)

…………………………………………………………………………………………………...
…………………………………………………………………………………………………...
…………………………………………………………………………………………………...

12. "Before a scientific discovery is accepted, many scientists have to test and confirm the discovery, and reach agreement about it."

I agree: ☐	**I disagree:** ☐
Reasons	
Source(s)	

13. Does the statement in Question 12 reflect the way you present science in class? Or do you present science differently? Please explain, provide examples.

…………………………………………………………………………………………..

…………………………………………………………………………………………...

14. "The truth of science is the same for everybody. It does not depend on anyone's personal beliefs or situation."

I agree: ☐	I disagree: ☐
Reasons	
Source(s)	

15. Does the statement in Question 14 reflect the way you present science in class? Or do you present science differently? Please explain, provide examples

…………………………………………………………………………………………...

…………………………………………………………………………………………...

16. "Scientific theories are like maps of reality. They help us see order and structure in a very complicated and confusing world."

I agree: ☐	I disagree: ☐
Reasons	
Source(s)	

17. "Scientists do not listen to just anyone. Whether they accept what you say depends on who you are."

I agree: ☐	I disagree: ☐
Reasons	
Source(s)	

18. Only for Post-test: Based on your experiences in the workshops what is your new understanding of the Nature of Science (NOS)

Appendix C: Characteristics of Indigenous Knowledge Systems Questionnaire (CIKSQ)

Name:

Read through the following statements on scientific and indigenous beliefs and provide and opinion from your scientific understanding as well as your personal understanding of these worldviews

Also indicate the source(s) of your beliefs or views. Possible sources of your ideas could be **Science, Media, Religion, Family, Traditional beliefs, etc.**

Q 1 Many scientists believe that the universe occurred by chance, and since then has been undergoing continuous evolution. On the other hand, many people adhere to the religious or cultural view that a supernatural being created and controls the workings of the universe. Express your candid opinion on both worldviews:

    (a)   **Scientific understanding:**

    (b)   **Personal understanding:**

Q 2 A girl suffering from severe hysteria (excessive or uncontrollable fear) could not be cured in the modern hospital but was cured within a week by a traditional healer. What is you view kin terms of your:

    (a)   **Scientific understanding:**

    (b)   **Personal understanding:**

Q 3 Various opinions and explanations have been expressed about 'after life' such as: (a) when a person dies, his/her soul and/or spirit lives; (b) the brain does not stop immediately the heart stops, so 'after life' experience is like a dream stored up in the brain before it stopped working; (c) a person's soul and/or spirit does not die with his/her body; (d) the soul and/or spirit leaves the body at death but may return to the same body if it cannot find a body in the other world.

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

Scientific understanding:

(a) When a person dies, his/her soul and/or spirit lives.

Agree

Disagree

(b) The brain does not stop immediately the heart stops, so 'after life' experience is like a dream stored up in the brain before it stopped working.

Agree

Disagree

Others

(c) A person's soul and/or spirit does not die with his/her body.

Agree

Disagree

Others

(d) The soul and/or spirit leaves the body at death but may return to the same body if it cannot find a body in the other world.

Agree

Disagree

Others

Personal understanding:

(a) When a person dies, his/her soul and/or spirit lives.

Agree

Disagree

Others

(b) The brain does not stop immediately the heart stops, so 'after life' experience is like a dream stored up in the brain before it stopped working.

Agree

Disagree

Others

(c) A person's soul and/or spirit does not die with his/her body.

Agree
Disagree

Others

206

(d) The soul and/or spirit leaves the body at death but may return to the same body if it cannot find a body in the other world.

Agree

Disagree

Others

Q 4   Scientists describe the occurrence of the rainbow as a result of a refractive dispersion of sunlight. However, in many traditional beliefs, the rainbow is seen as a good or bad omen. What is your view in terms of your:

    (a)   **Scientific understanding:**

    (b)   **Personal understanding:**

Q 5 Lightning is an electric discharge in the atmosphere. The very large and sudden flow of the charge that occurs in lightning has enough energy to kill people or do serious damage to buildings or infrastructures. In many traditional beliefs lightning can come from other sources. What is your view in terms of you

    (a)   **Scientific understanding:**

    (b)   **Personal understanding:**

Q 6 A learner asked her classmate, "How did the world come about?" Her classmate replied, "Science state that it probably occurred by chance or due to the force of a big bang or something like that." The first learner then asked further, "Where did the force that produced the bang come from?" Her classmate retorted, "I don't know, ask the science teacher."

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

Scientific understanding:

Personal understanding:

    (d) Do you or your learners ask similar questions?

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

    (e) How would you deal with such questions if they were asked in class?

Appendix D: Nature of Science and Indigenous Knowledge Systems questionnaire (NOSIKSQ)

An Evaluative assessment of prior knowledge of Pre-service teachers on

Ethics Statement: All information provided will be treated confidentially. Anonymity is guaranteed.

You may withdraw from participation at any time.

Part A: Biographical Profile

Gender: Male ( ) Female: ( )   Age: Student No.

Grade you have taught/are still teaching: ( )   Years of teaching experience:

 Religion: Christian () Moslem ( ) Others:

Home Language:

Part B

Question 1

Specific Aim 3 of the new Curriculum and Assessment Policy Statements (CAPS) for the Natural Sciences, life Sciences and Physical Sciences states that: "The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment." The same statement also acknowledges the need for the curriculum to be sensitive to other worldviews, including the indigenous knowledge that learners hold.

       1.   Do you agree with this statement?   Yes   No

Give reasons for your answer:

According to CAPS learners hold different views about the natural world and people use different ways of thinking in different situations. Scientists can observe and measure things objectively without being influenced by what is being observed and/or measured. What difficulties do you think your learners may have with the scientific way of knowing?

a. Give one example

c. How would you help learners deal with this difficulty?
d. Do your learners show any relationship between home culture and the science you teach in class?

    Give one example

Question 2.

Some people claim: "Science is problem solving." People who have this view often think that problem solving in science develops in the following cycle: (1) *recognize the problem (2) try solutions and (3)* if successful *retain the solution and use it later to solve other problems.*

2.1 Do you think this is applicable to IKS?   Yes   No

Explain your answer

Question 3

(a) Tick off the statements in the Table below which you think belong to science, IKS or to both.

Item	Statement	Science	IKS	Both
1	Space is real and has definite dimensions.			
2	Regular events in nature depend on supernatural forces.			
3	A Supreme being created and controls the universe.			
4	Space is real and has definite and indefinite dimensions.			
5	Time is real and has a continuous, irreversible series of duration.			
6	Matter is real and exists within time, space and the spiritual realm.			
7	Sensory perceptions are not the only means of understanding nature, i.e., certain experiences defy sensory perceptions.			
8	Nature is real, observable and testable.			
9	All events have natural causes only.			
10	Humans are capable of understanding nature.			
11	Language is an important tool that can be used to explain, predict and even create natural phenomena.			
12	Sensory perceptions are the only valid and reliable means to understand nature.			
13	Nature is real, partly observable and partly unobservable.			
14	The universe is orderly, partly predictable and partly unpredictable			
15	Language is an important tool that can be used to describe, explain but not to create natural phenomena.			
16	It is highly probable that the universe occurred by chance and undergoes continuous evolution.			
17	Humans are capable of understanding only part of nature.			
18	Regularity of many events can be taken for granted.			
19	Time is real, continuous and cyclical.			
20	Events have both natural and unnatural causes.			
21	Humans should harmonize with nature rather than exploit nature.			

3(b) In view of the way you have categorized the two sets of assumptions above, do you think that the goal of Specific Aim 3 to integrate science and indigenous knowledge systems is realistic?

Explain:_____
_____

Question 4.

Science teachers are dealing with different fields of science. In addition, they are dealing with indigenous knowledge.

4.1 Should teachers emphasize the boundaries between the different fields of science such as Biology, Physical science, Earth Science, etc.? Yes   No

Explain your answer

_____
_____

4.2 In your view, what distinguishes a science from indigenous knowledge?

._____
_____
_____

Question 5
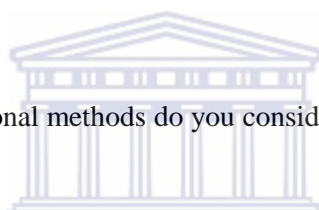
5.1 Which of the following instructional methods do you consider to be critical for integrating science and indigenous knowledge?

Tick the *ten most critical (Top ten)* instructional methods for integrating science and IKS in the 3rd column, then r*ank* them in the 4th column from the most critical = 1 to the least critical = 10.

Item	Instructional methods for integrating science and indigenous knowledge	Top ten	Rank
1	Frequent use of provocative, argumentative or inquiry-based questions.		
2	Using a holistic or an integrated instructional approach.		
3	Emphasizing 'showing' or modeling rather than lecturing.		
4	Involving learners actively in problem-solving activities.		
5	Developing or extending lessons to include current issues such as HIV/AIDS, genetic engineering, drugs & sports, plastic surgery, etc.		
6	Starting lessons with learners' ideas before presenting the scientific view.		
7	Extending science classroom discussions to include the IKS modes of inquiry, e.g. inviting IKS experts into class on some topics.		
8	Do not present indigenous knowledge as primitive science that is under development.		
9	Reject the claim that science works in the physical world while indigenous knowledge is only concerned with the social, cultural and spiritual worlds.		
10	Assess each knowledge claim with its own assumptions and standards rather than using science to judge indigenous knowledge as true or false.		
11	Emphasize cooperative learning rather than competitive leaning.		

5.2 (a) How would you personally 'bridge' the two worlds of science and IKS in the science classroom?

_____

_____

 (b) What in your view is the difference between superstitions, IKS and science? (Explain and give reasons or examples).

_____

Appendix E: TEST OF SCIENCE RELATED ATTITUDES (TOSRA) (modified)

Kerlinger & Kay (1959) developed an Education scale used to measure attitudes to education practices. The scale has been modified to measure more specifically, attitudes of pre-service and in-service educators to science teaching practices relevant to the Curriculum and Assessment Policy Statements in the Natural Sciences, Life Sciences and Physical Sciences Learning Area Curriculum for Senior Phase and FET learners in South Africa

> ➢ In developing items for the test of attitudes to science teaching practices, reference was also made to TOSRA – Test of Science Related Attitudes developed by B.J. Fraser (1981). Some of the items from the following categories were adapted for use in the current test.
> ➢ Attitudes to scientific inquiry
> ➢ Adoption of scientific attitudes

Particular attitudes that have been emphasised include:
> ➢ Attitudes to the value of hand's on practical investigations
> ➢ Attitudes to constructivist methods of inquiry
> ➢ Attitudes to child-centred versus educator centre education practices
> ➢ Attitudes to the value of school outings and experiential learning
> ➢ Attitudes to the incorporation of indigenous knowledge in the sciences curricula.

Scale allocation and scoring for each item

Items orientated towards constructivist learning and outcomes based education are designated as positive items (+). The responses SA, A, N, D and SD are scored 5, 4, 3, 2, 1 respectively. Items orientated towards traditional practices are designated negative items (-). The responses SA, A, N, D, and SD are scored 1, 2, 3, 4, 5 respectively. Omitted or invalid responses are scored 3.

Positive items (+)	Negative items (-)
1	2
3	5
4	6
7	9
8	11
10	13
12	14
16	15
18	17
20	19
21	22
24	23
25	26
28	27
29	30

Student number _____   Date of birth

TEST OF SCIENCE RELATED ATTITUDES (TOSRA)

INSTRUCTIONS

This test contains a number of statements about educational ideas and problems about which all educators have beliefs, opinions and attitudes. You will be asked what you yourself think about these statements. There are no 'right' or 'wrong' answers. Your opinion or personal response is what is wanted.

. For each statement, **draw a circle** around **only one** of the following responses:-

SA if you **STRONGLY AGREE** with the statement

A is you **AGREE** with the statement

N if you as **NOT SURE**

D if you **DISAGREE** with the statement

SD if you **STRONGLY DISAGREE** with the statement.

EXAMPLE:

It would be interesting to learn about rockets

SA   A   N   D   SD

o Suppose you agree with this statement then you would circle A as shown above.

o If you change your mind about an answer, cross it out and circle another one.

o Although some of the statements in this test are fairly similar to other statements, you are requested to indicate your opinion about all the statements as separate entities.

1. The content of the natural Science learning area curriculum should be determined first and foremost by the **interests and social nee**ds of the learners and should **acknowledge indigenous knowledge practices** of different communities in South Africa.

    SA   A   N   D   SD

2. Knowledge of **facts about natural science phenomena** is **more important** for learners to know than to do science investigations that focus on developing science process skills such as observation, measurement, experimental design, data handling and interpretation.

    SA   A   N   D   SD

3. Science educators should encourage learners **to think about, challenge and criticise** the science concepts and theories in their textbooks

    SA   A   N   D   SD

4. The development of the learner's **problem-solving and thinking skills** is more important than teaching the factual core content of the curriculum for the natural science learning area.

    SA   A   N   D   SD

5. It is better to **tell and drill** the learners about scientific facts and concepts than to let them do investigations and find out for themselves.

    SA   A   N   D   SD

6. It is the primary role of a science educators **to plan, direct, guide and control** all the learner's learning experiences and investigations.

    SA   A   N   D   SD

7. In natural science lessons it is usually better to design activities that enable learners to **solve a problem by designing experiments** and doing investigations and internet searches, than it is to tell them the answers to a problem.

    SA   A   N   D   SD

8. I enjoy teaching natural science lessons and believe that it is important to try to develop learning experiences that **involve hands on practical investigations** that include **reference to indigenous knowledge** of local communities

    SA   A   N   D   SD

9. The natural science core curriculum should contain an orderly arrangement of science topics that represent the main ideas of modern scientific knowledge.

    SA   A   N   D   SD

10. The natural science educator should encourage learners to **question concepts and theories and through argumentation** to thoroughly investigate the available evidence and alternative theories before accepting any ideas.

 SA   A   N   D   SD

11. I am often reluctant to **change my ideas** and my tried and tested methods about teaching natural science even when the evidence shows that my teaching practices can be improved.
 SA   A   N   D   SD

12. The **emotional and social development of learners** is as important in the evaluation of their progress as their academic achievement in natural science classes.

 SA   A   N   D   SD

13. The learning of natural science is, for the most part, a **process of increasing the learners' store of information** about various fields of scientific knowledge.

 SA   A   N   D   SD

14. It is better to only use those natural science **teaching methods** that have proved to be s**uccessful** in the past.

 SA   A   N   D   SD

15. Using a **textbook** is the best and most successful way to teach natural science in the General Education Band (GET).

 SA   A   N   D   SD

16. Learners **learn more** about natural science concepts by doing practical **hands-on investigations** that develop science process skills and help them to **construct their own science knowledge**, than by **learning abstract concepts from a textbook.**

 SA   A   N   D   SD

17. I **dislike teaching natural science** and prefer to **avoid doing investigations** that involve practical work.

 SA   A   N   D   SD

18. I **enjoy a challenge** and like trying out new natural science teaching methods which I have not used before such as argumentation using Toulmin's Argumentation Pattern (TAP).

 SA   A   N   D   SD

19. Maintaining **strict discipline** in the science laboratory is more important than letting learners do practical activities that involve **peer collaboration and group discussion.**

   SA   A   N   D   SD

20. Planning and doing well designed natural science practical investigations with precise assessment standards, helps learners to construct a better understanding of **targeted science concepts**.

   SA   A   N   D   SD

21. Natural Science **field excursions and outings** are a waste of time and energy because learners do not really gain much from the experience.

   SA   A   N   D   SD

22. When learners of all ages are exposed to well **organised outings** to places of scientific interest that promote experiential learning, they develops **positive attitudes towards natural science.**

   SA   A   N   D   SD

23. **Positive experiences during practical work and field excursions** as a natural science pre-service or in-service student have encouraged me as an educator to promote **experiential outcomes based learning** in my classroom.

   SA   A   N   D   SD

24. Mostly **negative experiences during practical work and field excursions** as a natural science pre-service or in-service student have discouraged me as an educator and I will **avoid experiential outcomes based learning** in my classroom.

   SA   A   N   D   SD

25. Natural Science is **fun and relevant** to the understanding of the physical, social and technological world we live in.

   SA   A   N   D   SD

26. Natural Science is **boring** and is not relevant to modern 21st Century life

   SA   A   N   D   SD

27. Natural science concepts should be taught as a body of facts that have been empirically proven and thus represent **absolute truth.**

   SA   A   N   D   SD

28. Learners should be given the opportunity t**o challenge existing natural science concepts and theories** with the understanding that a given theory or scientific model stands of falls on the basis of current empirical evidence.

   SA   A   N   D   SD

29. The wisdom of ancient cultures, and beginnings of scientific enquiry is imbedded in the **stories of myths, legends and indigenous folklore** of most cultures, and **storytelling** can provide insight and stepping stones that aid the understanding of selected natural science concepts

   SA   A   N   D   SD

30. **Myths, legends and indigenous folklore** have no place in a 21st Century natural science classroom

   SA   A   N   D   SD

SCORE TALLY

NUMBER	RESPONSE	SCORE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
TOTAL		

Suggest your own explanation:

PART C

Write your idea or view about nature in 5 sentences

1.………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………..

2.………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………..

3.………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………..

4.………………………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………………………………………

5.………………………………………………………………………………………
………………………………………………………………………………………

Appendix F: Reflective Diary Questionnaire (RDQ)

PGCE Reflective Diary on teaching an integrated science–Indigenous Knowledge curriculum topic using the Dialogical Argumentation Instructional Model (DAIM) as pedagogy

Dear Student

You have successfully completed your Teaching Practice programme. You received lectures and demonstrations of the Nature of Science (NOS), Nature of Indigenous Knowledge Systems (NOIKS), Characteristics of Indigenous Knowledge Systems (CIKS), Integrated Science and Nature of Indigenous Knowledge Systems (NOSNIKS) and Dialogical Argumentation Instructional Model (DAIM).

Please answer the following reflective diary questions as honestly and in deep critical reflective mode. Use the answer book provided.

(1) When did you first become aware of Indigenous Knowledge Systems?

(2) Specific Aim Three of CAPS and Learning Outcome Three of NCS suggest the importance of relating science to IKS. In other words considering the science in IKS and/or the IKS in science. Reflect on your experiences prior to teaching practice during the method classes and mention specific examples of engagement with this field of study.

(3) To what extent were you able to use DAIM as pedagogy in your science lessons? Discuss the successes and/or challenges.

(4) Give your honest opinion of the viability with reason for the use of DAIM as a pedagogy for integrating science and IKS.

(5) As an initial science teacher what is your view on implementing an integrated-IKS lesson? Give examples that worked or did not work in your teaching and learning environment.

Appendix G: A Bandura Teacher Self- Efficacy Scale: <u>Identification Code:</u>

This pre-test/post-test questionnaire is designed to help us gain a better understanding of the kinds of things experienced by you the teacher in using a **Dialogical Argumentation Instructional Model (DAIM) as a pedagogical framework to integrate Science and Indigenous Knowledge in a science lesson.**

Please rate how certain you are that you can do the things stated below by writing the appropriate number in the space provided. Your answers will be kept confidential and will not be identified by name.

SECTION A: Rate your degree of confidence by recording a number from 1 to 100 using the scale below:

0	10	20	30	40	50	60	70	80	90	100
Cannot					Moderately				Highly certain	
do at all					can do				can do	

Confidence

Level

(1-100)

1. Ability to plan integrated science-indigenous knowledge lesson   ___

2. Ability to select a socio-cultural-scientific issue   ___

3. Your understanding of DAIM as a pedagogical model   ___

4. Ability to create teaching and learning spaces using DAIM   ___

5. Provide quality resources   ___

6. Successful integration of a science-indigenous knowledge concept   ___

SECTION B: An additional question added for the post-test:

Provide a description of your experience in using the Dialogical Argumentation Instructional Model for teaching science/Indigenous Knowledge Systems concepts.

Appendix H: PGCE Biographical Information

The following biographical information in Table G1 and Table G2 provides a summary of the PGCE group.

Table G1

Biographical information of Purposive Sample of Post Graduate Certificate of Education (PGCE) students involved in the study according to gender, language, age, religion, method study combinations and teaching experience

Criteria	Purposive Group (n=30)
Gender: Females	12
Males	18
Language of instruction during Teaching practice:	
English	5
English/isiXhosa	7
English/Afrikaans	18
Home Language Total:	30
English	11
Afrikaans	8
English & Afrikaans	1
Xhosa	7
Other	3
Age: 20+ years	20
30+ years	8
40+ years	2
Religion: Christian	28
Muslim	2
Method Studies Combinations:	
Natural Science/Life Science	17
Natural Science/Physical Sc.	3
Life Science/Physical Sc.	4
Physical Sc./Mathematics	6

Teaching experience	24 (None)
	Less than 12 weeks (4)
	4 years (1)
	8 years (1)

Table 4 provides a more detailed profile of the prospective students' qualifications as well as their initial expectations of the course modules specifically. This information points to the diverse content background with which student teachers started the teacher training programme in science. Approval for the science methods was dependent on meeting entrance criteria which was a Bachelor's degree having content rigour in at two science teaching subjects up to minimum second year level as identified by the National Department of Education (NDOE) in the Policy Handbook for Educators (ELRC, 2003).

Table G2

Biographical information of prospective science teachers enrolled for the Post Graduate Certificate of Education (PGCE-2012). Qualifications and expectations of the method modules in science (Natural Sciences; Life Sciences; Physical Sciences) at the start of their study

Programme: Post Graduate Certificate of Education (PGCE) - 2012
Modules: Method of Natural Sciences; Method of Life Sciences; Method of Physical
      Sciences
Purposive Sample: 30

<u>**Legend**</u>:
Alpha Code – Group (A, B, C …)
Numeric Code – Pre-service teacher (1,2,3 …)
Gender: 1 = male; 2 = female
Language: 1 = English; 2 = Afrikaans; 3 = isiXhosa; 4 = isiZulu; 5 = Tshavenda;
        6 = Sotho;   7 = Sepedi; 8 = French
Qualification Code: BA = Bachelor of Arts; BSC = Bachelor of Science;
        BSC(Hons) = Bachelor of Science Honours.;
        B.Tech. = Bachelor of Technology; MSC = Master of Science;
        ND =   National Diploma

No	Code	Sex	Age	Lang	Qual	Exp	Expectations
1	A1	1	22	2/1	BA (HMS)	0	To Become comfortable in teaching methods
2	A2	1	29	1/2	BA (Hons)	0	Enjoy learning how to teach
3	A3	1	23	3/1	BSC	0	Learn how to teach science, manage classroom, time manage tasks

					(Geo)		
4	B1	1	27	6/1/5 /7/8	BSC	0	Find more ways to make students understand science. To know more about science
5	B2	1	23	1/3	BSC MBS	0	Learn how to introduce and teach biology better in an enjoyable easy to learn fashion
6	B3	1	24	3/1	BTech (Elect)	Tutor	To gain more knowledge than the one I got from school, able to work as part of a team, have enough teaching skills
7	C1	1	21	3/1	BSC (Biotech)	Tutor	To be empowered to be a confident science teacher
8	C2	1	22	3/1/2	BSC (Biosc)	0	Enable one to conduct a lesson.
9	C3	1	22	3/1	BSC(Phys	Tutor	To be able to deliver the content of science more experimental, than theoretical
10	C4	1	25	3/1/4	BSC MBS	0	To gain experience on teaching and obtaining confidence to speak free and openly in front of and without nervousness. Obtain skills.
11	D1	1	33	1/8/9	BSC (Hons)	4	How to carry out simple methods of conveying information to learners and students. Understand the syllabus of learners
12	D2	2	28	3/1	BSC	0	Able to teach science and biology
13	D3	1	22	3/1/2	BSC(Geo)	Tutor	To be taught some excellent teaching techniques to communicate all my science knowledge in order to get the best from the students
14	E1	2	28	1/2	BSC	0	Acquire skills necessary to become science educator, exposure to various aspects of science education
15	E2	2	25	2/1	BSC	0	To develop skills that will help me once I start teaching at a school
16	E3	2	26	1/2	Junior Lecturer MSC	2	To develop methods of teaching to equip me with skills by which I can communicate the work in the classroom efficiently, effectively. Ideas on lesson plans, or provide resources that will provide lesson plans

					BCB		
17	E4	2	25	2/1	BSC BCB	0	Blank
18	F1	1	40	2/1	ND (Mech. Eng.)	1	Obtaining various methods of teaching learners and interest them in understanding the physical science aspects of their physical environment and hopefully a career in sciences
19	F2	2	26	2/1	BSCBiotec	0	To build on the knowledge of science and to present this knowledge to students in the next creative manner so that it sparks an interest in subject matters. Also to equip myself with knowledge beyond my discipline to ensure that most students are able to reflect on what they have learned.
20	F3	2	25	1/2	BSC(Med)	0	Expectations are to learn effectively to teach the subject in an interesting way. How to keep pupils captivated, how to plan a lesson and build confidence in my method.
21	G1	1	48	1	BSC Fisheries	0	To understand the methodology of teaching and develop my confidence of handling a class with update knowledge in science
22	G2	1	32	3/1/2 /4	ND: Civil Eng	8	To learn more ways of solving problems of physical science. Also in chemistry side I would like to learn more about experiment. So that I can be able to teach learners with confidence. Also professional way of doing things.
23	G3	1	26	2/1	BSC(Geo)	0	To teach science in a way I may help others to understand
24	H1	2	23	1	BSC(Med)	0	To gain experience in what I would be teaching at school and learn fun experiments like today whereby we can enlighten students and let them be amazed by it and not bored while doing it
25	H2	2	22	1/2	BSC(Med)	0	To learn how to conduct a science lesson at a high standard that teaches pupils about science but that is also interactive. To gain confidence when addressing a class. To learn how to prepare a good lesson. At the end of the course, to be a well- balanced confident and informed science educator.
26	H3	2	22	2/1	BSC(Med)	0	My expectations are to obtain effective and fun teaching methods for biology and science to make learning more exciting. Also to find cool ways of doing experiments. I would also

|							
							like to broaden my own knowledge of science and not be limited to what I have done in my degree.
27	H4	2	24	3/1	BSC(Geo)	0	I expect to come out here equipped with the ability to teach science, be able to communicate it across to my students in a manner that will stimulate their thinking and interest such that they may make it part of their lives.
28	I1	1	23	2/1	MSCBiot e	0	To be a good quality science teacher
29	I2	1	22	3/1	BSC(Geo)	0	I expect to get relevant information, practical work experience in order to give back to learners of Grade 10, 11 & 12. To be able to communicate with everyone
30	I3	2	25	2/1	BSC(Hon s	0	To be able to communicate work with students. To be able to teach, to be able to relay relevant information to students.

Preliminary Summary:

Gender: Male = 18; Female = 12
Home Language: English = 9; Afrikaans = 9; isiXhosa = 11; Other = 1
Second Language: English = 21; Afrikaans = 5; isiXhosa = 1; Other = 3
Qualifications: National Diploma Science = 2; Bachelor in Science (3yrs) = 21; Bachelor in Science (Hons) = 3; B.Tech. = 1; BA = 1; Masters in Science = 2
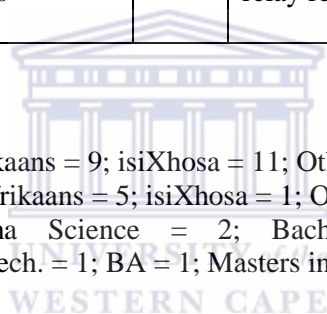
Appendix I: **Results of a Bandura Teacher Self- Efficacy Scale (modified) for pre-service science student Teachers using DAIM to teach an integrated science – IK curriculum lesson**

No	Criteria (N = 30)	10 Low	20	30	40	50 Ave	60	70	80	90	100 High	No response
1	Ability to plan an integrated science-indigenous knowledge lesson				4 13%	6 20%	2 6%	6 20%	7 23%	3 10%		2 6%
2	Ability to select a socio-cultural-scientific issue				5 17%	6 20%	5 17%	4 13%	5 17%	5 17%		3 10%
3	Your understanding of DAIM as a pedagogical model				2 6%	2 6%	4 13%	5 17%	4 13%	7 23%	6 20%	-
4	Ability to create teaching and learning spaces using DAIM		2 6%			1 3%	4 13%	3 10%	8 26%	9 30%	3 10%	-
5	Ability to provide quality resources				5 17%	4 13%	5 17%	5 17%	6 20%	2 6%	3 10%	-
6	Successful integration of a science-indigenous knowledge concept		5 17%			4 13%	7 23%	5 17%	5 17%	4 13%		-

*No of pre-service science teachers in %: 1 = 3%; 2 = 6%; 3 = 10%; 4 = 13%; 5 = 17%; 6 = 20%; 7 = 23%;

Appendix JA: Statement 14 Responses: NOSQ

"The truth of science is the same for everybody. It does not depend on anyone's personal beliefs or situations".

Tr	agree	disagree	
1	x		Pre: science cannot change my personal beliefs or situation
		x	Post: personal beliefs can contribute to what science say and that can influence my beliefs.
2	x		Pre: Science is facts
		x	Post: Science is concrete. It is real, some theories are debatable because of personal beliefs eg. Big bang theory
3		x	Pre: Everybody does not have the same beliefs on a certain topic of science.
		x	Post: I present science differently because my beliefs are not the same as my students beliefs.
4		x	Pre: people can think differently about science. Everyone has their own beliefs and reasoning.
		x	Post: yes and no . You can't teach something you don't know if it's not according to the book.
5		x	Pre: Science will mean or be perceived differently for everyone. It all depends on your own understanding & views of science. And also what your experiences with science has been.
		x	Post: A lot of your own science background determines how you will teach science and I also believe that your own views influences your teaching. Although it should not be in such a way that it completely alters what you are saying to mean something differently You should still teach the scientific facts
6		x	Pre: Your beliefs influence the way you interact with scientific theory
		x	Post: yes need to be sensitive to cultural differences
7		x	Pre: Everyone has their own opinions and thinking so science truth is not seen as the same
		x	Post: Before I engage science facts I try to engage and find out what the people already know about it.
8	x		Pre: Personal beliefs is not always science orientated and always true.
	x		Post: Science is based on facts which are proven, whereas other beliefs are from stories nor proven
9	x		Pre: Even though our beliefs may differ or situations may differ, we cannot ignore the same facts therefore if something is true it is true even if it may change,
	x		Post: learners should acknowledge the truth, that is what I will teach of science, no matter what they believe but they should also consider others who might feel differently eg evolution and religion.
10		x	Pre: Most of the time religious people disagree with the things that scientist come up with or believing it to be true
		x	Post: There are learners who believe that it is only God who is the vreator of everything, so definitely they will be confused, so they must be a way to make everyone understand.
11		x	Pre: Those who are pro-religion tend to disagree with scientists about how the universe started eg. Big Bang theory
		x	Post: I would present science as truthful but always maintain that it is open to charge as new evidence of different theories may come to light leading to them being discarded or entrenched.
12		x	Pre: Not everybody believes in science
		x	Post: Science is not the same to everybody
13	x		Pre: Science gives an explanation about nature which is universal.
	x		Post: Reflects the way I would present science
14		x	Science is one view of how the world has become as it is and religious people has a different view of how the world has come as it is comparing to scientists.

		x	Post: If you have different beliefs a science will teach it differently because science always clashes with religion and my religion beliefs is stronger over my beliefs in science.
15	x		Pre: The world and the nature will still occur irrespective of who is alive or dead.
		x	Post: Science is different for everybody-depending on own belief s and situations.
16		x	Pre: Circumstances and conditions under which people live determine what they believe. Some believe in witchcraft others not
		x	Post: Your personal belief is how you see the truth and vice-versa
17		x	Pre: people are different in their ways of thinking and believing
		x	Post: Some of the people believe in their own indigenous knowledge
18		x	Pre: Is not the same for everyone it depends on personal; beliefs
		x	Post: People are living in a vacumn but in context of their culture, tradition and belief systems.
19	x		Pre: The scientist discuss it and agree to the same thing.
		x	Post: modern science has been around for many years but even today there are personal disputes
20	x		Pre: No grey areas in science
		x	Post: Some cultures who are illiterate have their own way of doing things which might not be aligned to the truth of science.
21	x		Pre: sometimes scientists get influenced by their own personal ideas.
		x	Post: Some religious beliefs disagree with science
22	x		Pre: The science knowledge must be something where scientists have approved.
		x	Post: Pure scientific facts should be universal
23		x	Pre; It depends on anyone's personal belief
		x	Post:
24		x	Pre: People differ and each individual has their own perception and understanding of certain things
		x	Post: There is many different scientific beliefs which are only substantiated by practical work.
25	x		Pre: Scientific discoveries will impact on everybody's life and so personal beliefs do play a role
	x		Post: Although there will be differences scientists will agree after deliberation with one another
26		x	Pre: Everyone may be different in their way of conducting research.
		x	Post: many people have scientific as well as religious beliefs
27		x	Pre: Religion tradition has influence.
		x	Post: We are not one dimensional but multi-dimensional, therefore we are all perceived things differently
28		x	Pre: In my experience people interpret things differently.
		x	Post: Personal beliefs play a role in whether to accept certain theories cause it might contradict their beliefs
29		x	Pre: Truth is subjective and depends on context and belief
		x	Post: Science is a human endeavour it is influenced by humans beliefs.
30	x		Pre: What science says is what is known by everybody and is what is understood by everybody.
	x		Post: If it would depend on anyone's personal beliefs then it would be bias. So it does not have to consider only beliefs or situations
TOT	18/60 30%	42/60 70%	

Appendix JB: Responses to Question 6 of CIKSQ

Q6 A learner asked her classmate, "How did the world come about?" Her classmate replied, "Science state that it probably occurred by chance or due to the force of a big bang or something like that." The first learner then asked further, "Where did the force that produced the bang come from?" Her classmate retorted, "I don't know, ask the science teacher."

(a) **What is your view about the ideas expressed above in terms of your scientific view and your personal view :**

Scientific	Personal
T1: The earth occurred by chance. The force that produces big bang is a plate movement produced by slab-pull or ridge-push force.	T1: God first created the earth and the evolution occurred, although the age of the religious culture does not correspond with the scientific age. I think the age of the earth given by religious culture is not correct.
T2: I also have same question. The universe was said to be young billions years back and there is no one who lives that time, so only calculation are used to determine the age and how the universe was formed which may be wrong or just used to justify the formation of the universe. (S)	T2: I personal believe in God and everything that's writing in the bible and if you look at science things are always changing. Once it was believed that the universe has no beginning or end and was truly infinite, and then after the big bang theory the universe was no longer considered infinite. According to science anything that can be justified or proved is considered true. (S; R)
T3: It was a free flowing force or energy since everything in the world is formed by energy. (Scientific)	T3: The free flowing force is/was the holy spirit. (Religious)
T4: Well one should tell the scholars that the truth of worlds come to be is not yet discovered but theoretical explanations have being made on the subject of world coming to be and from that you can decide whether it's true or not. (S, M)	T4: Still yet to be discovered and science is getting close to the truth. (S, M)
T5: According to scientists it began with one enormous explosion of energy and light, which we now call the Big Bang. This was the singular start to everything that exists. The beginning of the universe, the start of space, and even the initial start of time itself.	T5: I would say there is an argument that the universe was created by god but scientists believes it began with one enormous explosion of energy and light. Thus this cannot be proven; there are only myths behind this.

229

T6: No Comment

T7: Scientific understanding: to my scientific knowledge the big bang occurred because of forces in the atmosphere.

T8: I sincerely think the Big bang existence of the universe does not make any sense just like the first student from the above conversation thinks.

T9: Big bang theory and the on-going research surrounding it.

T10: Scientifically speaking the above mentioned ideas would be correct. A lot of research goes into trying to prove a certain theory and it would not be an easy thing to do. (Science Source)

T11: As science teachers we have to provide students with the knowledge/content focused on the subjects. We cannot ignore the fact that overwhelming evidence supports evolution, hence why it's now referred to as a principle and not a theory. It is our duty as teachers to provide students with this knowledge, despite any cultural/traditional/religious beliefs and them as knowledgeable people can make their own educated decisions about the origin of life. We also as teachers have to have sufficient knowledge on the subject to give a student such as in the example a decent and educated response, we have to be able to engage with such discussions.
Source: science, media, education

T12: The big bang theory is a theory or a model that explains the formation of the universe. It is believe that the universe come into existence about 13.7 billion years ago and this is when the "big bang" started according to many scientists. The big bang theory or model has been tested by several scientists and is supported worldwide. When the universe cooled down the first gas to form was hydrogen together with helium and lithium. Eventually over time the galaxy's

T6: No Comment

T7: world was created by God

T8: On my personal understanding the Universe was created by God.

T9: In the classroom setting as science teacher, I would also have referred to the scientific theories surrounding the creation of the universe in answering the question.

T10: Children tend to ask a lot of question especially to those questions which they don't understand. However, I personally believe the earth came about because God created it. (Religious Source)

T11: On a more personal take on the above scenario I would explain that it is possible to reconcile religion and science, as I have in my own experience, the two concepts can complement each other. I would reinforce the idea that it is possible to be a scientist and have faith.

T12: Big bang theory in my opinion has occurred due to God being the driving force behind it. A million years in our time (minds), perception could in fact be one day in God's time or perception. The big bang theory sounds very farfetched for myself, however one can grasp the concept as to what these scientists are trying to say and put in into perspective with one beliefs and see if what they saying can be true or not.

starting forming as well as the planets. The idea expressed by the learner was correct however she didn't have all the facts but have a slight understanding as to the theory of how the earth and universe was form. Clearly there is a lack of knowledge from the student regarding the topic.

T13: Currently science cannot answer this to the satisfaction of all. I need to research this question further to gain a clear evolutionist understanding thereof. My current perception is that science investigates this question from the presupposed stance of "NO CREATOR – AND NO CREATOR SHOULD BE FOUND!" Thus, when this question was held up by creationists as proof of a Creator, suddenly there is a state in which no physics laws exists, and this has been proven with physic laws. As the saying goes "if you look long enough for what you want to see, eventually you will see it."

T13: God created the universe and all within it in 6 days.

T14: If it is all proven through scientific analysis and experiments it is then true. If there is sound evidence which until now there has not been it cannot be seen as fact. There are also many theories and assumptions.

T14: If there is evidence it should be true but once again then it would have been controlled by God and His will.

T15: The big bang came as a result of the spark of particles from galaxies and other structures.

T16: Our current understanding of physics does not extend all back before the Big Bang event. Thus there is no real answer, at least not yet. Scientists have made one speculation, if you have two conditions: an inflating space and an empty, zero-energy field, then after a very, very long time, you will get a spontaneous big bang as a result of quantum fluctuations.

T15: I remain with the belief of creation that Supreme being (God) created the Earth within six days with reference to the bible.

T16: There was matter and there was anti-matter, after a long time and a period of fluctuation, the matter and anti-matter collided causing a massive destabilization event and finally exploding. All that I can speculate is that if it happened before it would happen again.

T17: That even in a scientific view the World could not of been in existence through a big bang. And living organisms cannot just seem to arrive and be alive.

T18: Evolution has played a big role in explaining how humans for example came into existence. Science may have an explanation for many things, but I do not think that science has the ability to answer all these questions.

T17: There has to be a greater force, and force beyond our understanding, known as "master of creation" God. Therefore at his mercy, with his power and knowledge, created and architected the world as we know it.

T19: As a scientist I believe there is always a

T18: I often wonder the same thing. If the world was

room to grow and develop, science changes I believe we are yet to discover the source of that power as well as explain further beyond atoms. Science is yet to explain that properly	created by chance or collisions of atoms etc. where did those atoms come from. This is a question for which no-one really has the answers.
T20; The students do have an understanding of the subject world. They are using the right scientific terminology, sharing ideas similar to the answer and they do have an idea of the subject/object.	T19: As a Christian I would tell my learner everything is governed by a greater power, As much as science explains the origin of the earth it has some short comings so I believe that's where ones faith comes in to explain and justify for one's self
T21; The solar system as a whole started as a huge cloud of matter known as the solar nebula. As it was being rotated, it flattened into small meter-kilometer sized-bodies, called planetisimals, which formed and grew in the solar system. That's how the Earth and any other planet in the solar system are circular.	T20: The learners are on the right track in terms of recognizing the subject/object, the language used in their discussion and the perception applied.
T22: The Big Bang theory explains the early development of the Universe. Universe was once in an extremely hot and dense state which expanded rapidly. This rapid expansion caused the young Universe to cool and resulted in its present continuously expanding state. According to the most recent measurements and observations, this original state existed approximately 13.7 billion years ago, which is considered the age of the Universe and the time the Big Bang occurred.	T21: Since it was created by god, he designed it to be circular so that one does not get to the edge of the Earth, but instead goes back to the starting point, or for some reasons which is only known by Him.

T22: The big bang assumes that the creation of the universe is from a singularity, a violation of the law, that mass cannot be created. |

(b) Do you or your learners ask similar questions?
   If yes, please give an example, if no, please try to explain why you think this is so:

   T1:   *Yes: Where does God comes from? And who created and give him such power?*
           Because the bible start with God being alive and it does not mention why he comes
           from. In terms of science: The universe was said to be young billions years back and
           there is no one who lives that time, how can one be sure on how the universe come
           about. (EQw)

   T2:   *No.*

   T3:   *No because the learner hasn't engaged that much on the topic and this would explain*
           that's some of the questions posed would be question you already have answered or
           encountered and concluded on a certain result. (Ew)

   T4:   *Yes I do, because as a child I was curious to know where I come, what I'm made of,*
           and so forth. (Ew).

232

T5:   *No comment*

T6:   *No Comment*

T7:   *Even if mine students would ask the same question I would introduce to them all the scientific theories that scientists implies resulted in this world's formation and I would also introduce to them the Biblical aspect of creation then they would have to make their choice. (EQw).*

T8:   *I do not ask these kind of questions because while I am aware of the scientific research and understand it to a certain extent. I believe in the holy trinity and in Gods supreme and ultimate power and the "role" he played in the creation of the universe. (IKSw)*

T9:   *No, because I have personally never been in a teaching position, therefore such a question has not been posed to me. I also personally believe that God created Earth and everything on it, therefore I have no question in my mind as to how Earth was created. However I do consider myself an open-minded person therefore I would listen to what science has to say on certain topics but it does not mean I share every scientific view out there. (IKsw)*

T10:   *No, I think possibly because there's this notion of God remaining in church and science in the classroom. I have hardly ever had a teacher or lecturer bringing a religious or cultural take on a scientific topic, unless when religion was actually part of the historical context of the scientific principle. Only a rare occasion have I heard a botany lecturer making a religious statement about the presence of God an all things beautiful, and another botany lecturer stating something very contradictory. But this was literally two occasions, so far apart, in my years of study. Educators could possibly try to stay clear of it, possibly to avoid conflict. Religion and tradition can stir up heated emotions. (Sikw/IKsw)*

T11:   *Yes, people have asked this question. E.g.: why are we so closely related to chimpanzees? And why do scientists believe we have evolved from them?*
         Express my opinion as an individual, however not to impose on the learners religious beliefs and understanding. In addition make sure that I find out and have attained adequate knowledge of scientific evidence to answer these types of questions asked or imposed on me in a class. Try to maintain a neutral perspective when answering a question of such a nature or content. (EQw)

T12:   *See answers above*

T13:   *Due to my religious beliefs if there was a proven big bang then it would have been because of God's will (IKsw).*

233

T14: *I belief with the explanations given that they are correct. (NC)*

T15: *No comment (NC)*

T16: *Yes, these are questions I continuously ask, not to only understand but become a stronger believer. What happens to our souls when we sleep, does it sleep with us or does it dwell? And if you sleep walk, who is in control of your body? You're subconscious, or your soul? (ESw)*

T17: *I have not taught yet. But I ask myself similar questions. (Ew)*

T18: *As much as science explains things it goes to a certain extent, so it is during that time that one needs to tap into their faith and validate their beliefs (EQw).*

T19: Yes I do ask questions of that nature. Examples would be: (Sikw)

    I.   *What is a big bang?*

    II.   *Is there a theory behind it?*

    III.   *How did it develop?*

    IV.   *Ever since it formed, has the world have any changes?*

    V.   *If any, what are they?,....etc.*

T20: *No. As a geologist I already know why the Earth is circular, and as a Christian, God designs things the way he wants and he does not tell us why, looks like he does not owe us any explanations. (EQw)*

T21: *Yes. They curious and need find answers.*

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

T1: *I can answer them in a scientific understanding and religious understanding, but I will not go deep in a religious way because they have to understand science more than a religious. (DSw/SIKw) (S,B,M,R)*

T2: *I really don't know how I can deal with question like this. Hopefully I will do before start teaching student science. (Ew)*

T3: *Always for the scientific explanation because it is a worldwide accepted theory in the science world and I am a science teacher not a preacher. (DSw) (S,B,M)*

T4: *I would be open minded to the beliefs of the individuals being taught provide all information on religious and scientific aspects on the topic and let the learners know that from these explanations and reports one can decide which are to be true to you and also to note that it is now the truths of truth and that is being discussed till today. (EQw) (B,I,F,R)*

T5: *I would tell the learners what science is telling us and what the religion is telling us, thus I could accommodate each and every believer (learners). (EQw) (B,M,R)*

234

T6:   *No comment*

T7:   *No comment*

T8:   *Even if mine students would ask the same question I would introduce to them all the scientific theories that scientists implies resulted in this world's formation and I would also introduce to them the Biblical aspect of creation then they would have to make their choice. (EQw) (B,M,I,R)*

T9:   *In the science classroom, any questions related to scientific subject matter should be answered or dealt with by sound, scientifically proven answers. The basis of science is posing questions, hypothesizing and proving the answers whether the actual outcome is the same or different to what the "researcher" initially thought. The setting in the classroom should be such that the student is able to gain the most from his science education and develop critical thinking without it inferring with personal or religious beliefs. (DSw) (S,B,I,M).*

T10:   *As answered above.*

T11:   *As a teacher one must remember that in a classroom setup, you deal with a group of learners whom are all individuals in their own right. When dealing with question where science and religion are concerned one must remember to be objective, listen to both sides of an argument and respect all opinions on the subject at hand. (EQw)(B,I,M).*

T12:   *I would try to provide students with as much evidence/ scientific proof of the phenomenon being discussed. As we are teachers we HAVE to provide the scientific explanations for these, if there was something I was unsure about I would ask my students to go research the topic, so would I and I would propose we have a discussion about the matter as it would be futile to "dump" certain concepts/theories on them, especially if you feel there is a strong opposition from the class. It would be better to discuss the topic, try to direct them into why it is necessary to examine all the evidence before making a decision, especially for future scientists. (DSw)(S,B,M,I)*

T13:   *I will explain the scientific facts regarding the widely acceptable "Big Bang" theory. In addition give outlines of alternative scientific theories regarding the creation of the universe (e.g., Steady State Theory, The Incredible Bulk Theory, Parallel Universes Theory, etc.) and let the class come up with debates for and against each theory using logical and deductive reasoning, as well as applying indigenous knowledge where applicable. (DSikw) (S,B,M,I)*

T14: *The way in which I answer the question would be based on the pupil's cultural or religious stand point. I would make sure he/she tries to grasp my understanding as well as theirs which could also teach them tolerance. I will try to be as objective as I could be trying to focus on the factual science and help them slot it into their beliefs if necessary. (ASw)(R,C,F)*

T15: *Whether you know the answer or whether you do not, always try to answer the question in such a way that it would formulate into a healthy classroom discussion. In this way you would obtain various views from different people but it may also broaden your knowledge of the content. (Ew).(B,M)*

T16: *If I was asked these questions in the classroom, I would treat it firstly with an open mind considering why the learner is asking it. Secondly I would try to keep the answer simple enough for the learner to understand, and interested in waiting to keep an open conversation, as answering in too much detail would lose the learners interest. (Ew).(B,M)*

T17: *Even though I am educated to an extent, I do not have the answers to everything and I don't think anyone does. If I were asked this question, I would answer from a scientific and educated perspective and would tell the learners what I have been taught and have studied. I cannot answer from a religious point of view because I have not studied the bible and everyone has different religious practices and beliefs. I would however, encourage the learner to find out from his/her religious leaders what their own bible states, and would tell the learner to compare the two and then make their own conclusions. At the end of the day, a person may be highly educated in science but may still believe that a higher power created everything. It's a matter of personal belief. (DSw/SIKw (S,B,M,C,R,F).*

T18: *It is my duty as teacher to get the child's perspective and understanding of the issue at hand, so both as a teacher and a mentor I have the responsibility to guide and help them understand things form the scientific perspective. At school my faith and my beliefs don't really count what matter is my duty to be a teacher to the learner empower them with scientific knowledge and also to show them that science most of the time contradicts their cultural and social beliefs. (DSw)(S,B,M)*

T19: *I was going to first set-up a sort of a debate or discussion with the learners so that they can have clear understanding, see ideas, opinions and then share all those ideas and come up with solid answers and conclusion because at least I would be having much more knowledge about the subject . (Ew).(B,M,I).*

T20:   *I would give that as homework to any of them, that they should use any source they have in mind, library, internet, etc., and bring that discussion for the following day, because discussion without clue, only ends with noise making and kiosk in my classroom. In the meantime I will need to prepare myself for that topic as I am the one with the final say. (EQw)(S,B,I,M)*

T21:   *I do not believe in the big bang theory. As a teacher I think I would give the leaners a chance to discuss the topic while listening to what the leaners understand. Then I would bring in my religious beliefs and explain why I do not belief in this theory. (DIKw)(R,C,F,M)*