The epistemological basis of indigenous knowledge systems in science education

by

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Submitted in partial fulfilment of the requirements for the degree

Doctor of Philosophy

in the

Department of Science, Mathematics and Technology Education

of the

Faculty of Education

University of Pretoria

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November 2014

DECLARATION OF ORIGINALITY

I **Gracious Zinyeka** declare that the thesis, which I hereby submit for the degree **PhD** at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other higher education institution.

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INVESTIGATOR(S)	Gracious Zinyeka
DEPARTMENT	Science, Mathematics and Technology Education
DATE CONSIDERED	6 October 2014
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ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to all the people who assisted me in completing this thesis. First, I would like to thank Almighty God for giving me the health, strength, courage, wisdom and finance for this undertaking. Second, I would like to extend my sincere gratitude to the following people for the valuable roles they played towards the completion of my study.

My sincerest gratitude goes to my supervisor, Professor G.O.M. Onwu, and co-supervisor, Professor M. Braun, who patiently and tirelessly guided me throughout the study. I would like to thank them not only for making me believe in myself, but more importantly for their scholarly guidance throughout the period of my studies. I appreciate their constant encouragement, fatherly assistance, and motivation at various stages of the study. Their persistent piquing of my intellect and prodding of my thinking led me to a new and deeper understanding of my research. This work would not have been a success without their expert knowledge, valuable suggestions and constructive criticism.

I thank Ms Jeannie Beukes, Head of Post-graduate Student Administration, and Professor Fraser, Head of the Department, for believing in me, and for according me time, on a number of occasions, especially when I was not feeling well, to continue working on my study.

My greatest appreciation goes to my lovely children, Isheunesu, Tinotenda, Tapiwa and Brenda, who sacrificed parental care, guidance and attention, as well as their happiness, to afford me the opportunity of concentrating on my study. Their understanding, unflagging support, unwavering faith in me, and constant love, gave me the determination to carry on. My children have always been my inspiration for wanting to excel in life. I thank my children for the times that they listened to me when I needed someone to talk to while ill and working on my thesis. I especially thank Isheunesu for his patience and understanding during the thesis-writing process.

I am very grateful to my dear friends and colleagues Dr Monde Kazeni, Dr Gift Nyanhi and N. T. Chinomona and my brothers, Believe Zinyeka, Pearson Zinyeka, Douglas Zinyeka and Jinock Zinyeka, who always provided emotional support and technical support whenever I needed it, and without which my journey through my study would have been unbearable. Their encouraging and supporting words contributed to the successful completion of my study.

I would especially like to thank the Ministry of Education, the principals and those science teachers in Zimbabwe who allowed me to undertake my research. The science teachers' willingness to participate in the focus-group discussions was greatly appreciated; their contributions made a great significance to the understanding of IK integration into school science curricula.

Last, I thank Chief Chikwanda for allowing me to undertake my research in his district and all IK practitioners who made themselves available to be interviewed for my data-collecting process. I would like to express my appreciation of their willingness to share their knowledge and skills in the field of IK.

ABSTRACT

Integration of indigenous knowledge into the school science curricula is useful for pedagogical reasons, particularly for improving learners' performance in science. However, the lack of universal and specifically stated epistemology (ies) of indigenous knowledge (IK) is undoubtedly a major challenge for inclusive science-IK curriculum integration. In this study, with the aim to resolve this epistemological challenge, an epistemological framework based on truth theories was developed.

Some IK practices were collected and the framework was tested with some science teachers to assess its effectiveness as a tool for identifying IK epistemologies for establishing suitable teaching methods for some specific IK practices. Argumentation was used in conjunction with the epistemological framework in the attempt to enhance teachers' logical reasoning skills during focus group discussions.

In detail, the study consisted of three parts. The first was an attempt to develop a truth-theory-based-knowledge-framework-for-identifying-epistemology(ies)-of-indigenous-knowledge systems. Desk-top philosophical analysis was undertaken with the aim of developing a framework for analysing and identifying IK epistemologies.

Second, some selected local knowledge, technologies and practices from a rural community in Zimbabwe were systematically documented by means of personal observations and interviews with key informants and stakeholders from the participating community. The result was a collection of community-based IK practices that formed a coherent set of knowledge themes on health, agriculture and technology. A preliminary analysis using the framework was done to gain insight into the characteristic features that underpin the scientific way of thinking that manifest themselves in IK practices and would allow for the incorporation of the IK practices.

Third, a group of secondary school science teachers used the framework to engage with and explore the ways in which the identified local knowledge and practices might be integrated into school science education in a valid and effective way. The views of the participating teachers on the usefulness and efficacy of the approach were explored.

The main findings of the study showed the framework was useful and efficacious in addressing teachers' philosophical concerns about the inclusion of IK in the science curriculum, moreover, the framework was useful in developing effective teaching approaches for integrating indigenous knowledge into science education for improved learner performance. IK-science curriculum integration, it is argued, provides contexts that are familiar and relatable to learners, thus those features are likely to enhance interest and improve performance and in turn increase the socio-cultural relevance of science and science education.

Key words: epistemology, correspondence theories of truth, coherence theory of truth, pragmatic theory of truth, nature of science, indigenous knowledge, Science-IK integration, indigenous knowledge epistemologies, teaching methods in science, teachers' views of science-IK integration.

DEDICATION

This work is dedicated to my special parents and children. First, my father, Wycliffe Zinyeka, and my mother, Suzan Zinyeka, who did not live to see me reach this goal. In the early years of life, my parents taught me by example the virtues of hard work and the moral value that good things in life do not come easily. Second, to my lovely children, Isheunesu, Tinotenda, Tapiwa and Brenda, who, without realizing it, encouraged me to appreciate continued education and aspire to excel.

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LIST OF ACRONYMS AND ABBREVIATIONS

CAT	Contiguity Argumentation Theory
FAO	Corporate Document Repository
IK	Indigenous Knowledge
IKP1 to 24	Indigenous Knowledge Practitioner 1 to 24 (P1toP24)
IKS	Indigenous Knowledge Systems
LEK	Local Ecological Kowledge
NOIK	Nature of Indigenous Knowledge
NOS	Nature of Science
SIKP	Science and Indigenous Knowledge Project
T1 to T12	Teacher 1 to Teacher 12
TAP	Toulmin's Argumentation Pattern
TEK	Traditinal Ecological Knowledge
TK	Traditional Knowledge
ZIMSEC	Zimbabwe School Examinations Council
ZNTMP	Zimbabwe National Traditional Medicine Policy

DEFINITION OF TERMS

The following terms are operationally defined as used in this study:

Epistemology: epistemology is that part of philosophy that deals with knowledge for analysing the notions of truth, beliefs, and perceptions.

Correspondence theory of truth: correspondence theory, posits that a knowledge claim or a belief is true, provided there is a fact (empirical basis) corresponding to that claim.

Pragmatic theory of truth: views truth in terms of what would solve a problem.

Teaching methods in science: methods such as experiments, observations, practicals, theory, and projects, used by teachers to teach science subjects.

The coherence theory of truth: posits that a belief is taken as true when it is part of an entire system of beliefs and knowledge that is consistent and 'harmonious'. In other words, when a belief fits well with already accepted systems of beliefs, it is accepted as true.

Nature of science: Nature of science refers not only to "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Lederman, Lederman & Antink, 2013 p. 140) but also to the ontological assumptions of science (Webb, 2007).

Indigenous knowledge is: evolving, cumulative experience gained by continuously and carefully observing nature and by trial-and-error experiments, privileges the community to validate it using multi-theories of truth over many generations as it is transmitted orally, and through imitation and demonstration.

Science-IK integration: incorporation of science-related indigenous knowledge into the school science curricula and science teaching.

Indigenous knowledge epistemologies: characteristic features of IK which describe its nature and justification, mainly focusing on how this body of knowledge is produced and validated.

Teachers' views of science-IK integration: teachers' perceptions about epistemologies of IK and how it should be integrated into the school science curricula.

CHAPTER 1

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction to the chapter

This chapter provides an introductory background to the study, which focuses upon identifying, developing and suggesting a pedagogical approach to integration of Indigenous Knowledge (IK) into the school science curriculum in a valid and legitimate way. The study investigates some aspects of the possibility of integrating IK into Zimbabwe's school science teaching as a strategy for improving learners' performance in science education at secondary school level. The performance of Zimbabwean learners in science subjects, particularly in integrated science has been abysmal for several years; results from the Zimbabwe School Examinations Council (ZIMSEC, 2013) for the four year period 2010-2013 are shown in Table 1.1 below.

Table 1.1 Zimbabwe School Examinations Council pass rate analysis and enrolment in science subjects, ordinary-level examinations: 2010–2013.

Year	Pass rate and enrolment per subject						
		Integrated Science	**Human and Social Biology**	**Physical Sciences**	**Biology**	**Physics**	**Chemistry**
2010	Pass Rate	16.45%	28.94%	46.97%	38.38%	80.19%	84.75%
	Enrolment	*167079	*4136	*8436	*22038	*1050	*1187
2011	Pass Rate	31.74	23.88%	52.17%	52.92%	72.72%	85.57%
	Enrolment	*183116	*4632	*9359	*22075	*1272	*1455
2012	Pass Rate	27.91	21.62%	48.81%	52.92%	74.7%	70.49%
	Enrolment	*193968	*3854	*9050	*21685	*1905	* 2135
2013	Pass Rate	23.58	12.7%	49.1%	62.87%	82.81%	Not in the analysis
	Enrolment	*202592	*2692	*8859	*20912	2408	
Source ZIMSEC Pass Rates Analysis 2010–2013 November sessions. *enrolment in the subject							

Data from Table 1.1 show that integrated science with highest enrolment or entries had the lowest pass rate compared with the other science subjects for the period 2010–2013. Thus the majority of candidates for public examinations in Zimbabwe's secondary education sector underachieve in science.

In recent times various arguments for addressing the issue of learner poor performance in science have been put forward at a global level, one of which is that of addressing the challenge by using the prior knowledge that learners bring to the classroom as teaching points on learners' behalf (Brown, Friedrichsen & Abell, 2013; Kibirige & Van Rooyen, 2007; Ogunniyi, 2013). This suggestion implies finding legitimate ways of incorporating learners' worldviews, indigenous or local knowledge into the school curricula for improved learner performance and interest. In the context of Zimbabwe, generally, rural-dwelling learners are the ones whose worldviews and preconceptions are often derived in part from traditional indigenous beliefs and practices and their socio-cultural background and diversity may be viewed as a potential point of leverage in finding ways of improving their performance in school science education (Chiwiye, 2013).

The literature shows there has been increasing interest in how IK can be incorporated or integrated into school science curricula (Abrams, Taylor & Guo, 2013; Moji & Hattingh, 2008; Kibirige & Van Rooyen, 2007; Onwu & Mosimege 2004, Ogunniyi, 2013; Webb, 2014). Some of these researchers have highlighted the epistemological difficulties or challenges in undertaking such initiatives, but at the same time they have emphasised the pedagogical need for such integration. This study therefore sought to gain insight into how teachers could begin to integrate IK into the school science curricula for the benefit of the learners. The epistemological differences between the nature of science (NOS) and nature of indigenous knowledge (NOIK) coupled with a lack of a universal and specifically stated epistemology of IK are undoubtedly major challenges for an inclusive science and indigenous knowledge pedagogy in school science curriculum.

1.2 Background to the study

The performance of Zimbabwean learners in science subjects, particularly in integrated science, has been abysmal for the four year period 2010-2013 as shown in Table 1.1. The data displayed in Table 1.1 show that the majority of learners from rural schools underperform (ref.1.1).

The Zimbabwe Schools Examinations Council (ZIMSEC) offers chemistry, physics, biology, physical science, integrated science and human and social biology options to ordinary-level science learners (form 1 to form 4). About 70% of science learners in Zimbabwe are from rural schools that offer only integrated science, because of the non-availability of physical facilities such as laboratories, science equipment needed for teaching single science subject matter of physics, chemistry, physical science or biology in these schools (Chiwiye, 2013). In consequence, learners in rural communities are constrained to taking integrated science as the only viable option offered in their schools. Science subjects such as chemistry, physics, physical science, and biology are traditionally offered by urban schools, well-funded private schools and mission schools, which have the necessary human and material resources including physical facilities for teaching these subjects.

It is against this backdrop that a major concern in science education in Zimbabwe is finding multi-faceted solutions to the singular problem of improving learners' performance in learning science (Chiwiye, 2013). This concern at a global level, for instance, has come about partly as a result of learners' underachievement in public examinations in science subjects (Hernandez, 2013; Kazeni & Onwu, 2013; Middleton, Dupuis & Tang, 2013; ZIMSEC, 2013), and partly as a result of the low take-up of science-related studies at tertiary level (Barmby, Kind & Jones, 2008; ZIMSEC, 2013). Zimbabwe has not been an exception to the challenge of a decline in young people's interest and low enrolment in science-related courses (Chiwiye, 2013). Several scholars in the African regional setting are of the view that school science seems to be failing to attract and cultivate interest in many learners or to enact ways of enhancing science learners' performance (Kazeni & Onwu, 2013; Ogunniyi, 2013; Sunzuma, Ndemo, Zinyeka & Zezekwa, 2012). Since science has turned out to be a primary feature in national trade and industry and social progress, poor achievement in science subjects is likely to impact negatively on scientific research, as well as trade and industry in developing nations (Economic and Social Research Council, 2008) including Zimbabwe. Science education is seen as a means of producing a critical mass of scientists and scientifically literate citizenry (Sjøberg & Schreiner, 2005) which is considered mandatory for an improved financial system and emancipation from social ills such as poor quality of life, crime and disease (Kazeni, 2012).

1.2.1 Learners' performance in science: what research says

There may be several reasons why the majority of candidates who sit for public examinations in Zimbabwe, most of whom are from rural communities in Zimbabwe, do not perform well in the natural sciences. These reasons may be derived from various sources. For example, those emanating from the learners themselves such as lack of interest, poor motivation, poor language facility, the nature of the subject matter itself, learner worldviews that may be in conflict with the ways of knowing in science say (Malcolm, 2007; McKinley, 2005; Abrams, Taylor & Guo, 2013; Aikenhead, Calabrese & Chinn, 2006). Other reasons may have to do with teacher factors, such as a poor qualifications and an inadequate knowledge base of teachers, as well as non-educational factors such as under-resourced large size classes (Chiwiye, 2013).

This study's research interest however is to contribute to the development of a culturally relevant pedagogy for improved performance as one way to support learning among learners in rural communities in Zimbabwe. In the context of this study culturally relevant pedagogy is construed as the use of society or community-based resources and integration of local practices and issues into the school science teaching (Holbrook, 2009; Onwu & Kyle, 2011). To do this would first require the description of epistemologies that define the indigenous knowledge system, if that at all is feasible. Thus identifying epistemologies of IK may assist practitioners to determine the extent to which some of the characteristic features that underpin the scientific way of thinking or knowing (Lederman, Lederman & Antink, 2013) may reasonably be manifest in IK practices. If some of the characteristic features that underpin the scientific way of thinking show themselves in IK practices these features may create opportunities for IK-Science integration for improving learners' performance in science (Kibirige & Van Rooyen, 2007).

Learners' poor performance in science subjects is accounted for partly by empirical evidence which suggests that learners perceive school science lessons as uninteresting and equally irrelevant to their daily life or aspirations (De Jager, 2000; Holbrook, 2005, 2013; Ogunniyi, 2011, Onwu & Kyle, 2011). Learners' poor performance in science subjects could also partly be a result of barriers and difficulties faced by learners such as misunderstanding (Hodson, 2009) 'border crossing' (Kibirige & Van Rooyen, 2007) and clashes between the culture of school science and the learner's local culture worldview (Malcolm, 2007) matters that will be addressed later in section 1.2.2.

Grounding their work in various studies on how to increase the socio-cultural relevance of science and science education, Onwu & Kyle, (2011) note how these various studies (Anderson, 2006; Jenkins & Pell, 2006; Schayegh, 2007) have shown that learners do not perceive the study of science as being relevant to their lives. This failure to be relevant to learners seems to be as a result of science education topics being mostly taught in ways that make learners fail to realize the link between the science that is taught and their day-to-day experiences (Kazeni & Onwu, 2013; Onwu & Kyle, 2011). As pointed out by Onwu & Kyle (2011) the failure of learners to see the relevance of the science that is taught in their science lessons may be attributable to teachers' failure to enact a relevant science education that takes cognizance of learners' background experiences. In essence, to a student-relevant approach involving perhaps the incorporation of community-based issues and contexts into the science curriculum for learner decision making, may enhance the perceptions learners have towards science.

In Zimbabwe, research on science and mathematics teaching at secondary-school level has highlighted some of the shortcomings of current teaching approaches and strategies, that including for example teaching continues to centre on lecturing, which is predominantly subject-content centred and indentifies with an academic science rather than student-relevant content (Sunzuma, et al., 2012). This deficiency is primarily a result of teachers' lack of skills and knowledge needed to change their ways of teaching (Sunzuma, Ndemo, Zinyeka & Zezekwa, 2012). Chiwiye (2013), following his analysis of the ZIMSEC pass rate over the past five years, has put forward a number of suggestions for improving learners' performance in science. Among these is the argument that teaching should take into account that learners actively construct knowledge concomitant with social and cultural settings. This argument is in agreement with a view that when learners realize the link between what they learn and their day-to-day experiences, they are likely to be more motivated to learn science, which in turn is likely to lead to improved performance in the sciences (De Jager, 2000; Fakudze, 2004; Holbrook, 2005; Kazeni & Onwu, 2013).

For the science education community, the most crucial and fundamental reason for advocating the incorporation of indigenous knowledge into the curriculum of school science is pedagogical. Integration of IK into school science curricula is also in synchronization with constructivist views on teaching and learning (Gullberg, Kellner, Attorps, Thoren & Tarneberg, 2008; Treagust & Duit, 2008; Michele, Cliff, & Lavine, 2003). Using community-based resources and integrating local practices and issues into school science teaching could help in engaging learners in science (Abrams, Taylor & Guo, 2013). Fakudze (2004) argues that for learners to realize the link between what they learn and their day-to-day experiences, learning science concepts should take place within a traditional socio-cultural environment. Sadler (2009) is of the view that socio-scientific issues should be included in science teaching. Kyle (2006) points out that learners' experience through science should be self-involving, socially acceptable, and liberating. To this end, several science curriculum policy documents in science education in Africa such as those presented in the next section (ref 1.2.2) explicitly acknowledge the significance of discourses and worldviews other than that of orthodox science with respect to IK integration into the science curriculum.

1.2.2 Arguments for integrating indigenous knowledge into the school science curriculum

Some national policy documents in science and science education, such as the Zimbabwe National Traditional Medicine Policy (2007), the Zimbabwe Ministry of Science and Technology Development Position statement (2010), the South Africa National Curriculum Statement (Department of Education, 2002; and as revised: Department of Basic Education, 2011), and Swaziland Ministry of Education National Policy (1998), encourage the inclusion of other worldviews and knowledge systems in school science curricula. In Lesotho, the science curriculum recommends that everyday local knowledge and practices must be included in the curriculum (Hewson, 2013). In parts of the world such as Canada, Australia and New Zealand, it has become important to document and include IK in the school curriculum (Aikenhead & Ogawa, 2007; Barnhardt & Kawagley, 2005; Hewson, 2013). This reflects the growing interest in Africa and elsewhere in integrating IK systems into the science curriculum.

Although many national policy documents reflect growing interest in integrating IK into the school science curriculum, many reasons have been cited for such efforts such as political, axiological, and pedagogical considerations (ref. figure 1.1 below). For instance, political reasons are usually given to argue for anti-racial and multicultural education and these emanate from the philosophy of humanism and principles of equality and the need to observe the worthiness of education that respect all cultures and traditions (Taylor, 1994; Webb, 2014). Utility reasons for the inclusion of IK in the science education have also been cited by scholars (Taylor, 1994; Webb, 2014; Rich, 2011). The desire to exploit indigenous knowledge in relation to development (Bell, 1979), and the need to utilize alternative ecological knowledge (Rich, 2011; Webb, 2014) seem to be the main utility reasons for the inclusion of IK in the science education.

Besides political and utility reasons, as hinted in section 1.2.1, there are a variety of arguments that are premised on pedagogical considerations. These arguments include barriers and difficulties faced when learning science by learners of non-Western background (Jegede, 1995; Aikenhead, 2002, 2006; Webb, 2014) or in other situations by science learners who hold pre-existing worldviews that are not in harmony with scientific worldviews (Hodson, 2009). For instance, barriers and difficulties that may be faced are misunderstanding (Hodson, 2009), ‘border crossing’ and clashes between the culture of school science and local culture worldview (Malcolm, 2007; Webb, 2014). For science education researchers the most fundamental reason is pedagogical. Figure 1.1 below illustrates the major three reasons for the inclusion of IK in the science education curricula.

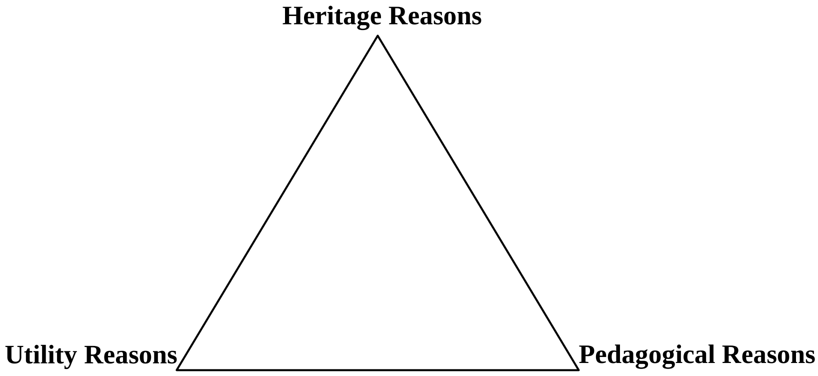

Figure 1.1 Arguments for the inclusion of IK into the school science curriculum

Worldviews with which learners come into the classroom could either hinder or promote a better understanding of science concepts, depending on how the teacher handles the situation (Hodson, 2009). As Moji & Hattingh (2008) argue, learners' prior knowledge and experiences influence learning and understanding of concepts in a significant way, either as a helping or hindering factor.

Kibirige & Van Rooyen (2007) note that many learners are frequently confronted with the challenge of 'border crossing' in the teaching of science which they explain as crossing over from IK worldview to classroom science worldview. Malcolm (2007) and Webb (2014), for instance, note that at times learners opt out of school science due to alienation and discomfort caused by clashes between aspects of their cultural worldview and that of the scientific worldview. And precisely for this reason he has argued for the need for teachers to acknowledge learners' prior knowledge, preconceptions and alternative frameworks in the teaching of science as one way of addressing learners' difficulties and dwindling interests in the learning of science. Generally arguments for the inclusion of IK into the school science curriculum, which are premised on pedagogical reasons are centred largely on the notion of improving learners' performance and interest in science (Aikenhead & Ogawa, 2007; Barnhardt & Kawagley, 2005; Gumbo, 2003, 2008; Hewson, 2013; Onwu & Kyle, 2011; Hodson, 2009).

1.2.3 Nature of science

Hodson (2009 p.23) has pointed out that "students will, of course, use their existing NOS views as a lens through which to make sense of events in the classroom, with considerable potential for misunderstanding if the teacher plans her/his lessons in accordance with one view of science and students interpret the activity in accordance with a different one". The nature or identity of school science is based on the logical positivist-empiricist (positivism) epistemology (Abrams, Taylor & Guo, 2013; McErlean, 2000; Rosenberg, 2012), which perceives scientific knowledge as a product from an empirical base which is universal, and rational (Aikenhead & Ogawa, 2007; Sandoval & Millwood, 2008). It is this specifically stated aspect of the nature of science (but just one aspect from among many others) that has been used as a guiding principle for the choice of methods of teaching and learning in science. This aspect of the nature of science has also been used as a 'gate-keeping' device for determining aspects of knowledge forms to be excluded or included as science (ref. Onwu & Mosimege, 2004). The nature of science is discussed in detail in the literature review (ref. 2.2).

In this study, focusing on the nature of science was meant to provide the conceptual background to understanding how the teaching and learning of school science can be improved and enhanced in "ways consistent with the nature of science and at the same occasion being responsive to the divergent beliefs and traditional views that students hold" (McDonald, 2013 p. xix). It becomes crucial then to find out to what extent some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that allows for the incorporation of IK practices into school science teaching.

The epistemology of science is foundational to understanding the nature of science (Lederman, 2007; McDonald, 2013). Lederman, Lederman & Antink, (2013 p.140) are of the view that scholars generally agree that "scientific knowledge is tentative (subject to change), empirically-based (based on and/or derived from observations of the natural world), subjective (theory laden), necessarily involves human inference, imagination, and creativity (involves the invention of explanations), and is socially and culturally embedded".

In summary, science as a way of knowing or thinking is underpinned by the following characteristic features and values: scientific knowledge is derived from observations of the natural world, tentative, subjective, involves human inference, imagination, and is socially and culturally rooted.

1.2.4 Nature of indigenous knowledge

IK tries to understand systems as wholes and spirituality is deeply embedded in indigenous ways of knowing (Rich, 2012). Indigenous communities often rely on collective, cumulative and spiritual means of validating IK and this body of knowledge is continually reinterpreted. IK generally represents an intuitive and qualitative thinking mode (Kibirige & Van Rooyen, 2007). The nature of IK is discussed in detail in the literature review (ref. 2.3).

In the context of this study, IK is knowledge gained by continuously and carefully observing nature and by trial-and-error experiments, it is cumulative knowledge, based on experience, evolving, privileges the community to validate it over many generations based on using the knowledge, with aspects of spirituality and philosophy, is seen in practices and is transmitted orally, and at times through imitation, demonstration, paintings, writing, and other artefacts

(Berkes, 2004; Grenier, 1998; Kibirige & Van Rooyen, 2007; Stevenson, 1996; Onwu & Mosimege, 2004; Ogunniyi, 2013). While science is concerned only with testable phenomena and all knowledge that is logically deducible from it, the production and validation of indigenous knowledge is based on various theories of truth such as pragmatism (Audi, 1995; O'Hear, 1985; Lynch, 2012), but in many cases without reference to empiricism.

The differences between the two bodies of knowledge do not necessarily imply a disjunction between IK and science classroom practice (Aikenhead & Ogawa, 2007). There are areas of convergence and non-convergence between IK and modern science (Hewson, 2013; Loubser, 2013; Kibirige & Van Rooyen, 2007). Various, scholars agree that there are areas of overlap between them (Rich, 2011, 2012) and Emeagwali (2003) for instance has identified several intersections of mainstream science and indigenous knowledge. Ogunniyi (2011) however insists that science is based largely on a mechanistic and reductionist worldview, while IK is based essentially on an anthropomorphic, pluralistic and holistic worldview.

No doubt, a dialogue between IK and science proponents has become more urgent, at least for the sake of inclusiveness, notably the recognition of other knowledge forms at the service of education and humanity (Onwu & Mosimege, 2004). This refers to the heritage pole of figure 1.1. It is important to find out to what extent some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that allows for the incorporation of IK practices into school science teaching.

1.2.5 Integrating IK into science teaching

Arguing for the incorporation of indigenous knowledge into school science curricula tends to give rise to some crucial questions, first, whether two apparently different perspectives of 'the world', chiefly in their ways of thinking and knowing, are in rivalry or harmony (Onwu & Mosimege, 2004). Second, whether science (education) is in effect universal or multicultural (Le Grange, 2004). These debates seem unending, but Le Grange (2004) notes that even though these debates exist among scholars, many scholars appear to agree that school science and indigenous knowledge should be taught to learners of all cultures.

Universalists have posited that indigenous knowledge has lesser explanatory powers of understanding or rationalizing the natural world when compared with mainstream science, which has been successful in producing knowledge which is predictive, testable and explanatory (Le Grange, 2004). Abonyi (2013) also points out that many western scientists have played down the validity of ethnoscience and indigenous knowledge, arguing that these forms of knowledge do not submit totally to their laid-down methods and procedures of verification. While those who hold the logical positivist-empiricist epistemology reject the validity of other forms of knowledge within science that are not produced and validated within positivism, the proponents of IK suggest another corridor, which calls for an amalgamation between the accountable use of methods appropriate to the empirical sciences and valid aspects of indigenous knowledge systems (Rich, 2012; Kibirige & Van Rooyen, 2007).

Universalist epistemology holds that 'reality' is constructed upon the correspondence theory of truth (Aikenhead & Ogawa, 2007). A multiculturalists' position, on the other hand, embraces that the process of producing and validating science is culturally done and that cultures contain different traditions of perceiving the natural world and that these dissimilar ways of knowing should be accepted as science (Le Grange, 2004).

However, even though the canons of the NOS are tentative and at times strongly contested by philosophy of science scholars, the epistemological grounds of science, and the ontological features of the knowledge obtained, are steady and strong enough to demarcate science from other ways of knowing (Webb, 2013).

Hodson (2009 p.118) argues that although there are valid and sound pedagogical arguments for the inclusion of IK into the school science curriculum, there is need to be cautious not to include "anything and everything in the curriculum under the banner of science" and he further calls for rigorous academic considerations. Observing this call, Webb (2013, p.106) points out that "such statements raise questions as to what these rigorous academic considerations are and what criteria indigenous knowledge must meet in order to be reconcilable within the context of science curricula". For this study, an examination of IK's epistemology would be necessary to determine which aspects are compatible with science and which aspects are not.

Given the nature of science, and that of IK, it is important to consider first the epistemological challenge of integrating the two bodies of knowledge, since these are pivotal to the incorporation of IK into formal school science. Understanding epistemological differences and similarities between indigenous and mainstream scientific knowledge became important in this study to find out what features in IK would allow for this body of knowledge to be incorporated into school science teaching.

In this study, it is argued that one way to address these questions and challenges is to try to develop theoretical frameworks for identifying epistemologies of IK. Further, in an attempt to resolve theoretical and conceptual issues about the identity of IK, which is one of the major challenges for integration (Emeagwali, 2003), it is envisaged that valid and legitimate arguments could be advanced for the kind of status IK ought to be accorded in any attempt to facilitate its inclusion in mainstream school science curricula.

Deriving as it does from epistemological principles of production and acceptance of knowledge, this study is about a pedagogical approach to integrating indigenous knowledge (IK) into school science curricula. A method for integrating IK into school science is proposed by first attempting to develop a truth-theory-based conceptual framework for identifying epistemology(ies) of indigenous knowledge. Then, some local knowledge and practices within a rural community in Zimbabwe are documented as part of a coherent theme(s) of an IK system. Lastly, a group of science teachers used the conceptual framework to explore how this local knowledge might be integrated into the school science curriculum in a valid and effective way. Argumentation was used in conjunction with the epistemological framework in the attempt to enhance teachers' logical reasoning skills during focus group discussions.

It is suggested in this study that it is suitable to focus on aspects of IK that describe, explain, predict and try to negotiate nature (Emeagwali, 2003) that have to do with socio- scientific issues (Onwu, 2005, 2009; Onwu & Kyle, 2011) and are compatible with science (Ogunniyi, 2011), because the issue is about the integration of IK into science education, not about religion or history.

1.3 The problem of the study

From the discussion so far, learners' poor performance in science subjects may be attributable to their perception of the science taught in schools as uninteresting and irrelevant (De Jager, 2000; Holbrook, 2005; Kazeni & Onwu, 2013, Kazeni, 2012; Ogunniyi, 2011, Onwu & Kyle, 2011).

Learners' poor performance in science subjects could also partly be as a result of barriers and difficulties faced by learners such as misunderstanding (Hodson, 2009) 'border crossing' (Kibirige & Van Rooyen, 2007) and clashes between the culture of school science and the learner's local culture Malcolm (2007). Additionally, constructivist views on teaching and learning (Gullberg et al., 2008; Treagust & Duit, 2008) suggest that teachers should include knowledge of learners' prior conceptions, worldviews and alternative frameworks in teaching various science topics, which could be used as the basis for good teaching points in helping learners for instance to appreciate the relevance of school science to their lives, say.

But there are challenges in seeking to include IK in science classroom teaching. Not least by the fact that their epistemologies as expressed in the nature of IK and the nature of science differ in their ways of knowing. In agreement with Yore (2011), Webb (2013) points out that epistemological challenges are posed when teaching science whose nature demarcates it from other ways of knowing in those science classrooms were teachers ought to acknowledge learners' prior knowledge about science as well as to respect individual learners' beliefs.

There is need then to find out "criteria indigenous knowledge must meet in order to be reconcilable within the context of science curricula" (Webb, 2013 p.106). The issue basically is, how can the conceptualisation of IK and the differences where these exist with school science, be productively used in the science classrooms? In agreeing with Ogunniyi (2011, p. 102) that for IK "to be worthy of inclusion into the curriculum a better interrogation of its epistemology would be necessary to determine which aspects are compatible with science and which aspects are not".

Given the ongoing discussion and debate on how to integrate IK into the school science curriculum in a valid and legitimate way (Onwu & Mosimege, 2004) what is required are frameworks for identifying IK epistemologies which are reconcilable with the framework of science teaching and learning. Against this background, it was necessary to develop an appropriate logical framework for identifying epistemologies for IK practices, and furthermore to give teachers an opportunity to use the former to determine whether a teaching approach (es) for integrating IK with school science in a valid and legitimate way could be developed.

1.4 Problem statement

Given the epistemological differences between the nature of indigenous knowledge and the nature of science, the problem of this study was to determine how teachers could integrate IK into the school science curriculum in a valid and legitimate way. With this in mind, one of the major aims of this study was to find out the possibilities of using theories of truth (O'Hear, 1995) as a criterion other ways of knowing separate from science must meet in order to be reconcilable within the framework of science curricula (Webb, 2013). The statement of problem gave rise to the following research questions.

1.5 Research questions

1. How can, from a theoretical perspective, epistemologies of indigenous knowledge be identified for integrating IK into school science teaching in a valid and legitimate way?

2. What indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture in the Chikwanda district in Zimbabwe can be identified and documented?

3. How should the identified indigenous knowledge and practices be integrated into school science teaching?

1.6 Significance of the study

The significance of this study lies in its methodological implications and outcomes. First, appropriate methods and techniques for gaining entry into the field (i.e., the community) and collecting IK practices, beliefs and technologies could possibly be used by teachers to successfully gather local knowledge and related practices in the communities surrounding their schools. Second, the developed framework for epistemologies appropriate to indigenous knowledge founded in the philosophical considerations of epistemology may be used by teachers to identify features of IK practices that are compatible with school science. Third, the study is likely to provide science teachers with the teaching approaches needed for selectively integrating IK into the school science curriculum in a logical way. Fourth, IK integration into the school science curricula is likely to provide contexts that are useful, familiar and relatable to learners that could generate interest and relevance and in turn enhance learners' performance. Finally, the findings of the study are likely to provide a prototype for integrating IK into science curricula elsewhere.

1.7 A short overview of the study

The study aimed at i) developing a framework for epistemologies appropriate to indigenous knowledge founded in the philosophical considerations of epistemology for identifying epistemology(ies) of indigenous knowledge; ii) collecting and documenting some science-related IK practices and technologies that impact on the community where they are practised using an ethnographic case study method; and iii) have a group of secondary school science teachers use the framework to engage in focus-group discussions on how the selected practices and local knowledge may be integrated into the school science curriculum in a valid and legitimate way.

A pilot study was conducted (with four practitioners for phase 2 of the study and with five teachers for phase 3 of the study) to determine the reliability and validity of the research instruments, as well as aspects of practicability of administering the instrument (Cohen et al., 2007).

1.8 Limitations of the study

The first delimitation of this study is that some indigenous knowledge practices and technologies go beyond the physical realm, which not only makes the study in this field too broad, but necessitates demarcation before its incorporation into the area of science education. Selection of socio-cultural issues that have a scientific basis was the solution to this limitation.

The research focused on aspects of IK practices that describe, explain, predict and try to explain and predict nature (Emeagwali, 2003) that have to do with socio-scientific issues (Onwu, 2009; Onwu & Kyle, 2011) and are compatible with science (Ogunniyi, 2011). Most of these issues are found in the areas of health and medicine, technology, and agriculture, which are three major spheres from which the practices and beliefs that were studied were selected.

Second, secrecy among some of the indigenous people could have been one of the major obstacles for the researcher in this study. Gaining trust was one solution to this limitation, as well as making participants understand that information obtained from them was merely for the purpose of the study and nothing else.

Thirdly, the use of the framework in enhancing teachers' knowledge and skills in integrating IK into the school science curricula was not investigated in the context of real science classroom learning activities.

1.9 Main assumptions about the notion of knowledge construction

Because of the nature of the problem being studied, constructivism (Von Glasersfeld, 1984, 1995) is assumed as a theory of learning to provide the basic tenets for purposes of understanding how human minds integrate novel knowledge into knowledge they already have and there after try to make sense of that constructed knowledge (Tobin, 1990; von Glasersfeld, 1984, 1995; Ferguson, 2007).

In this study, it is assumed that there is 'meaning making' or knowledge construction and generation in the communities where indigenous knowledge practices are found. It is also assumed that the learners living within that community bring this knowledge and/or knowledge system into the science classroom.

The philosophy underpinning social constructivism (Vygotsky, 1986; Solomon, 1987; Ferguson 2007) could perhaps explain how these learners construct knowledge, how they add new knowledge into existing cognitive structures through social interaction, and finally make sense of the outcome of the constructed knowledge (Ferguson, 2007; Tobin, 1990; Von Glasersfeld, 1984). In the 1940s, Piaget argued that learning takes place when the learner as an individual interacts with the environment (Ferguson (2007). Learning is a complex process that takes place within a social context as social constructivists insist, but ultimately it is the individual who is responsible for and does the learning.

1.10 Summary

Chapter 1 presented and discussed some introductory issues and expected processes about integrating IK into school science curriculum in a valid and legitimate way. Arguments were first presented for the integration of IK into school science based on what research has to say regarding learner enrolment and performance in science education generally. The statement of problem was clearly stated from which the research questions were derived. The chapter concluded with a narration of the significance of the study, as well as its delimitations.

Chapter two presents a review of the literature, chapter three is about the research methodology and other procedures used to collect and analyse data, in chapter four the results of this study in line with the study's research questions are presented, in chapter five the results are discussed and finally in chapter six the summary, major findings, recommendations and conclusions of the study are given.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature on indigenous knowledge and scientific knowledge integration, focusing on the various approaches that have been used in an attempt to integrate the two bodies of knowledge in school science with the aim of improving learner performance in science. It begins with a review of stances on the nature of science and the nature of IK as contexts for the teaching and learning of school science. It also seeks to briefly illustrate the lack of consensus among philosophers of science scholars with regards to NOS and to point out that despite of this lack of consensus some science scholars are of the view that there is a good enough level of generality as regards NOS that is easily reachable to K-12 learners and appropriate to their every day realities (Lederman, 2007: 832). The review also seeks to argue that taking into consideration that NOS demarcates science from other ways of knowing (Good & Shymansky, 2001; Webb, 2013) perhaps the concept of truth could serve as one good starting points for seeking answers to the question: "what criteria other ways of knowing must meet in order to be reconcilable within the context of science curricula?" (Webb, 2013 p. 106). The review also seeks to examine how scientific knowledge and indigenous knowledge are produced and validated; and the differences and similarities, if any, between the two knowledge systems. Thereafter, the chapter focuses on research on integration of indigenous and scientific knowledge as a means through which the improvement of science teaching and student science achievement and motivation may be fostered.

2.2 Nature of science and science learning

Advocacy for learners' understanding of NOS can be traced back by more than fifty years ago, largely for pedagogical reasons, even though at that period the expression 'understanding the nature of science' was not plainly stated, a few features and elements of science were noted as goals crucial for pursuing in science teaching (McComas, Almazora & Clough, 1998). More recently, in line with these goals, several research projects have been carried out focusing on teachers' and learners' understanding of science and its nature, mainly to find ways for improving learners' performance in science (Hodson, 2009) and for achieving scientific literacy (Webb, Cross, Linneman & Malone, 2005; Lederman, Lederman & Antink, 2013; Simonneaux, 2008; McDonald, 2013; Tytler, 2007). Several scholars have argued that learners' understanding of the nature of science facilitates content mastery, develops their critical thinking skills, helps them to realize the relevance of science (application), and is likely to arouse willingness to apply acquired knowledge in responsible and informed decision making (Lederman, 2007; Onwu & Kyle, 2011). In the framework of this study, focusing on the NOS was meant to provide the conceptual background to understanding how the teaching of school science can be improved and enhanced in ways which are reliable that make science accessible to all learners of different backgrounds (McDonald, 2013).

The question 'What is science?' needs to be answered as a starting point for discussions on what NOS is or is not. The most common view of science found in literature is that science is i) a body of knowledge; comprising both the content or product dimension, that is, the library of knowledge made up of facts, concepts, theories, principles and major conclusions and ii) the process dimension concerned with the ways by which this knowledge is acquired and accumulated (Onwu, 2000).

In this study, nature of science "refers not only to "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge" (Lederman, Lederman & Antink, 2013 p. 140) but also to ontological characteristics of scientific knowledge (Webb, 2014). The nature of science as a way of knowing or thinking refers to knowing or thinking with a particular lens. This particular way of thinking is underpinned by certain characteristic features such as values: curiosity, objectivity, suspending judgement, creativity, all attempts at reducing bias.

The meaning of the construct NOS is pluralistic (Linneman, Lynch, Kurup, Webb & Bantwini, 2003), and there is no consensus among scholars about the basic tenets of the nature of science (Alters, 1997; Linneman, Lynch Kurup, Webb & Bantwini, 2003; Matthews, 1994; McComas, Almazora & Clough, 1998) - a matter to be briefly addressed, later in this chapter). Despite noteworthy advancement toward understanding and characterizing science, a great deal of disagreement still persists.

2.2.1 Some major historical perspectives of NOS

A brief look at some major historical perspectives of science is presented here to illustrate the lack of consensus among philosophy of science scholars with regard to NOS. Logical positivists and pragmatists take different positions with regards to answering the question: 'what is the NOS of science?' Presenting, Warnocks' (1969) description of Logical positivism, Webb (2007, p. 63) notes that the popular notion of Logical Positivism of the early twentieth-century is the view that "meaningful propositions are those which can be reduced to propositions about empirical reality and that these propositions can be verified or falsified through empirical testing". This is known as the popular notion of Logical Positivism of the early twentieth-century defended by a group of philosophers and scientists such as Carl Hempel, A. J. Ayer and

Hebert Fiegl (known as the Vienna Circle) (Webb, 2007; Kourany, 1989). A re-examination of the history of science reveals the view that scientific knowledge is not absolutely and entirely determined by empirical data, and that there are serious challenges to the philosophy of justificationism (the view that scientific theories and laws can be sufficiently confirmed and justified on the basis of observations) (McComas, Almazora & Clough, 1998).

In the early mid-twentieth century, Karl Popper challenged the previously held popular philosophy of Logical Positivism (Hutcheon, 1995). Chalmers (1976) points out that as Popper (1957) grappled with the problem of induction raised by Hume, he worked hard to find answers to the question 'What makes a scientific theory a good one?' For Popper, theories are tentative until they are falsified (Popper, 1934 in Hutcheon, 1995). The aim of scientists in testing scientific theories is "to select the one which is … the fittest, by exposing them all to the fiercest struggle for survival … not to save … untenable systems" (Popper, 1934, 42 in Hutcheon, 1995). Hutcheon (1995 p.9) reads Popper as arguing that "the more a theory survives attempts to refute it, the more highly corroborated it becomes". Figure 2.1 below shows Popper's line of progression with regards to how bad theories improve to become good theories. The implication is that theories are possibly true and "they are genuine conjectures about the world" (Popper, 1983, 110) until falsified. Popper rejected classical inductivist and classical justificationist approaches and replaced them with falsificationisim, he:

> "contended that it is impossible to demonstrate that a scientific law is universally true without carrying out an infinite number of observations, but that such a law can be disproved by a single properly-authenticated observation that does not fit in with its prediction, in other words one can never verify a law but it is possible to falsify one" (Webb, 2007 p. 2).

Thus, according to Popper, scientific laws lost their special status of absolute truth and were reduced to working hypotheses (Chalmers, 1976 in Webb, 2007).

A bad theory	Method that should be used to improve on theories	What qualifies as a good theory?
Is a theory not yet subjected to falsification and with no precision and universality	Falsificationism (for a theory which is falsifiable)	The many times a theory survives attempts to refute it, it becomes more corroborated

Popper's line of progression with regards to the improvement of theories

Figure 2.1 Popper's views on theory refutation survival and corroboration progression

For Popper (1968) in Cohen, Manion & Morrison (2011 p. 10) "a theory should demonstrate precision and universality, and set the grounds for its own falsification". This is one type of framework that can be used by teachers to demarcate other ways of knowing from science simply by determining the precision, universality and falsifiability of a theory or claimed knowledge. The challenges to the use of this framework by teachers are discussed in section 2.6.

Kuhn, (1970) also argued that many of the positivist views on issues of how scientific knowledge is produced and about its status are untenable. According to Hutcheon (1995 p. 9), Kuhn contended that "while guiding the research in a specific problem area, … a scientific theory is continuously elaborated, revised and refined, until it is superseded by the very hypothesis-generating and testing process that it had defined and sharpened". Kuhn rejected justificationism as a means by which scientific theories can be confirmed as true.

To further illustrate the point on lack of consensus among scholars with regards to NOS, it is necessary to address the questions such as those raised by Kourany (1989): Do scientific theories provide true representations of what the world is like (the scientific realist position), or only with representations that are helpful for a variety of purposes (the instrumentalist position)? Realists and instrumentalists take different positions in answering this question.

According to Cacioppo, Semin & Berntson (2004 pp. 214), "Scientific realism holds that scientific theories are approximations of universal truths about reality". More firmly, realism is the view that scientific theories should be treated as a set of literally true descriptions of observable and unobservable phenomena (Rosenberg, 2012).

Contrasted to the foregoing, instrumentalism argues that theories of science are "just intellectual structures that provide adequate predictions of what is observed and are useful frameworks for answering questions and solving problems in a given domain" (Cacioppo, Semin & Berntson, 2004 pp. 214). Instead of the instrumentalists concerning themselves with the truth of scientific theories, instrumentalists employ pragmatic criteria and look upon scientific theories as heuristic devices for facilitating scientific research but not as true representations of the way the world is (Kourany, 1989; Rosenberg, 2012).

In short, understanding how science functions is essential for evaluating its boundaries and strengths, as well as for valuing other worldviews for possible integration into the school science curriculum. In the case of Zimbabwe it has recently been pointed out that learners are learning hypotheses, theories, facts, and major conclusions of science, - the 'what' of science - but are not learning where and how this knowledge is produced and validated - the 'how' of science (Sunzuma, Ndemo, Zinyeka & Zezekwa, 2012). Discussions about a role of NOS in school science have increased significantly, and some now argue that school science ought to of necessity pay more attention to how we know (Sunzuma, Ndemo, Zinyeka & Zezekwa, 2012).

Some scholars have argued that the disagreements or lack of consensus that continue to exist about the meaning of NOS are immaterial to K-12 teaching of science (Lederman, 2007; Lederman, Lederman, & Antink, 2013). For instance, Lederman (2007) claims that evidence for an adequate level of generality of understanding concerning NOS that is within reach to K-12 learners and applicable to their daily reality in life exists. Lederman, Lederman & Antink, (2013 p.140) are of the view that scholars generally agree that "scientific knowledge is tentative (subject to change), empirically-based (based on and/or derived from observations of the natural world), subjective (theory laden), necessarily involves human inference, imagination, and creativity (involves the invention of explanations), and is socially and culturally embedded". Lederman et al. (2013) tend to ignore the ontological assumptions of science (focussing rather on epistemology) but Webb (2014) is of the view that NOS has also to do with the ontological assumptions of science.

Taking a view different from that of Lederman, Hodson (2009), is of the view that understanding of what might serve as an 'adequate' or inadequate view of NOS certainly involves evaluations about rival merits of verificationism and falsificationism, realism versus instrumentalism, Popperian views as well as Kuhnian views, and such debates. A full review of the long-standing debate on the meaning of NOS is outside the scope of this study. What is of concern in this study are those main arguments in the disagreements about nature of science which are necessary for enhancing a good understanding of the nature of science as shown above.

While it is argued in this study that specific philosophical issues as well as the substance and tenets of the NOS will at all times be to some extent contentious, views concerning pedagogical issues most essential for science education are far less controversial. Having made this observation about the lack of consensus among scholars concerning what the nature of science is, it was found important for this study to review literature on aspects that demarcates science from other ways of knowing.

2.2.2 Demarcating science from other ways of knowing

McDonald (2013, p. 2) describing the epistemology of science concurs with Sandoval & Millwood (2007), that “the epistemology of science can be viewed as the logical and philosophical grounds upon which scientific claims are proposed and justified”. Agreeing with Good & Shymansky (2001) about NOS, Webb (2013 p. 90) points out that “the epistemological underpinnings of the activities of science, and the ontological characteristics of the resulting knowledge, are stable and robust enough to demarcate science” from other ways of knowing, say as in IKS.

Horsthemke (2004, 2008) and Hodson (2009) warn of the dangers of legitimization of opinions, assertions, superstitions, beliefs, and bias under the banner of pursuit of other ways of knowing. This is because science by its very nature demarcates itself from other ways of knowing and aspects such as superstitions, assertions, and beliefs do not meet the criteria for ‘knowledge’ which is the demand for truth and adequate justification (Horsthemke (2004, 2008). This frames what is not considered ‘Science’, and is a ‘negative frame’ meaning that it states ‘what is not science’ rather than ‘what is science’ none-the-less it remains an important frame considering demarcation issues. In consequence other ways of knowing without those characteristic features of science may have no place in the science curriculum as scientific knowledge, but may have a position as an area for debate (Vhurumuku & Mokeleche, 2009).

Webb (2013 p. 91) quotes Yore (2011) when positioning that “epistemological dilemmas are posed when teaching science (as a clearly demarcated discipline) in constructivist-oriented, diverse, multi-cultural classrooms which require teachers to both access and challenge prior knowledge about science while honouring and respecting individual students' beliefs". Hodson (2009) suggests that thorough academic considerations become necessary for resolving these epistemological dilemmas. The concept of truth then perhaps may serve as a feasible starting point for resolving these epistemological dilemmas and for seeking answers to questions such as those raised by Webb (2013), specifically the question: *What criteria other ways of knowing must meet in order to be considered within the perspective of science curricula*? It is against that background that this study considered the theories of truth as the logical grounds necessary for resolving the epistemological dilemmas posed when teaching science in relation to integration with IK.

Knowledge is justified true belief and the justification should be upon some reasonable theory of truth (O'Hear, 1995) a crucial issue for this study. Bernecker & Pritchard (2012) describe epistemology as that part of philosophy that deals with knowledge for analysing the notions of truth, beliefs, and perceptions. In philosophy, epistemology focuses on the study of knowledge; for this reason philosophers of science are concerned with the study of knowledge specifically focusing on the truth value of knowledge claims within the discipline of science (McDonald, 2013). For this study, such descriptions raise questions as to what these logical and philosophical grounds are and what criteria of truth other ways of knowing such as IK must meet in order to be reconcilable within the context of science. According to Bowell & Kemp (2010 p. 60) "the fundamental concept of logic is the concept of 'truth'. … one might worry that perhaps there is no one truth … but to say an argument is valid is to say: If the premises are (or were) true, the conclusion would also have to be true" (p. 64). Within philosophy, two overlapping constructs 'logical grounds' and 'truth value' have commonly been used to describe validity of knowledge claims (Bowell & Kemp, 2010).

Having made an observation about the lack of consensus among scholars concerning what the nature of science is (ref. 2.2.1), and provided the argument that NOS demarcates science from other ways of knowing which are not scientific, the crucial questions that remain to be answered are: what are the differences and similarities between science and other ways of knowing?, and what effective tools could teachers use to demarcate science from other ways of knowing?

2.2.3 Nature of science, pre-theoretical and theoretical interrelations: integration framework

Understanding the background of 'theoretical' systems and penetrating to the true epistemological differences and similarities between theoretical and pre-theoretical knowledge as illustrated "could shed light on the interrelations between the two frameworks, and explain how they could cohere with one another" with regards to knowledge integration (Loubser, 2013 p. 22). Loubser (2013) argues that 'pre-theoretical' systems are usually the starting point in science which then develops to 'theoretical' systems. Figure 2.2 below shows Loubser's line of progression in the development of scientific theories.

E.g. IK	E.g. Some IK practices and some aspects of science	E.g. Science
Pre-theoretical Knowledge systems which in most cases are based on aspects which are purely beliefs (contain mysticism) (science has these 'pre-theoretical' roots) →	Knowledge systems with less mysticism, explanations based on coherence and pragmatism but not based on empirical evidence →	Theoretical knowledge: power to describe, explain and predict

Loubser's line of progression in the development of knowledge →

Figure 2.2 Stages of knowledge development from 'pre-theoretical' to theoretical

To classify the two types of epistemic frameworks correctly, on the one hand, scientific knowledge is 'theoretical' and is produced through a process of abstraction, and the scientific way of thinking emphasizes observation, experimentation and universal principles (Sankey, 2008; Snively & Corsiglia, in Abrams et al., 2013). This can be interpreted to mean that theoretical knowledge focuses on one aspect of life, whilst simultaneously leaving the other aspects out temporarily. An example of this would be a medical doctor treating a patient by doing surgery. For the moment of the surgery, the doctor focuses only on the physical and biological aspects of the patient, whilst not worrying about other aspects, like the historical, religious, artistic, etc. The doctor seems to have 'clinical distance' and 'objectivity'.

On the other hand, knowledge such as IK belongs to the 'pre-scientific' class of knowledge. This class of knowledge is usually considered to be forms of knowledge that are experiential, holistic, community based (whilst being simultaneously held very subjectively), traditionally transmitted (rather than through formal study), etc. (Battiste, 2002; Odora-Hoppers, 2002; Ogunniyi, 2013; Kibirige & Van Rooyen, 2007). The beliefs comprising these systems are usually held on religious, worldview, cultural and community level base and assist the community in meaning-making whilst also providing normative direction, i.e. "worldviews provide a cognitive orientation towards the whole in the form of a description and normative guide to life" (Loubser, 2013 p. 22). 'Pre-theoretical' knowledge is rich, i.e. comprises the fullness of human existence (all the aspects of life) (Ogunniyi, 2013).

Understanding the relationship between pre-scientific and scientific in the teaching of science is found useful in explaining that "worldviews are recognised frameworks in scientific thinking" (Loubser, 2013 p. 21). While it is agreed that the awareness of the relationship between pre-scientific and scientific frameworks could be useful in the teaching of science, it is argued in this study that this awareness does not help the teacher with regards to how to handle aspects of other worldviews which do not fit into science. Certainly, while 'Western' science has 'pre-theoretical' roots, one major aspect of NOS is the separation of elements which are not scientific from the pre-scientific as it develops to the 'theoretical' level. As already argued, notwithstanding lack of agreement among scholars of philosophy of science about the tenets of science, NOS demarcates science from other ways of knowing such as IK, say.

What is necessary is to have a clear understanding of characteristic features that underpin the scientific way of thinking and then understand features of other worldviews that might be useful or addressed in science and determine methods suitable for integrating these.

2.2.4 Summary

As alluded to (ref. 1.3), the epistemological underpinnings of the activities of science and the ontological features of the resultant knowledge, are established and forceful enough to differentiate science as something separate from other ways of knowing such as IK (Webb, 2013; Good & Shymansky, 2001). With this in mind, one of the major aims of this study was to investigate whether theories of truth are useful to establish criteria that other ways of knowing separate from science may meet in order to be reconcilable within the structure of science curricula (Webb, 2013).

Another major aim of this study, in a sense converse and complementary to the first aim, was to find out to what extent some of the characteristic features that underpin the scientific way of thinking manifest themselves or are embedded in IK practices in a way that could possibly facilitate integration of IK practices into school science teaching. Examining the nature of indigenous knowledge practices, beliefs and technology themselves has the possibility to engender better understanding of how IK systems may be integrated into the science curriculum.

2.3 Characteristic features of indigenous knowledge

Different labels, such as local ecological knowledge (LEK), ‘traditional ecological knowledge’ (TEK), ‘traditional knowledge’, (TK), and ‘indigenous ecological knowledge’ (IEK) have been used by authors to refer to the phenomena of IK (Loubser, 2005; Ngulube & Lwoga, 2007; Vhurumuku & Mokeleche, 2009; Kibirige & Van Rooyen, 2007; Davis & Ruddle, 2010). In some instances these terms have been used interchangeably by scholars (Bohensky, & Maru, 2011). However, IK is broader than IEK and TEK and better reflects the holistic worldviews that frequently underline indigenous knowledge systems (Rotarangi & Russell, 2009). In this study, the term IK is favoured.

This study observes a difference between the meaning of IKS and IK. IKS is about epistemology (nature and justification of knowledge), metaphysics (reality), axiology (values), and the logic (correct and complete process of reasoning) of a given community or people (Ogunniyi, 2013). Drawing from this scholarship, Ogunniyi (2013) points out that IK is just one component of the whole system of IKS but generally it is the language that represents knowledge claims about IKS. Additionally, although some scholars use the constructs IK and IKS interchangeably, in this study the two constructs IK and IKS are not used interchangeably because specific IK claims might not encompass all aspects of an IKS. In this study, the focus is on IK. It is operationally defined as that knowledge which includes technological (agriculture, engineering, medicine), mathematical and social knowledge (Onwu & Mosimege, 2004), which a local community uses for its social and economic activities and progress. In the context of this study, providing a working definition of indigenous knowledge is a major starting point in examining the nature of IK.

An analysis of definitions of IK could be one source of characteristic features of IK. Because definitions carry commonly understood meanings, the nature or scope of something, or at least, the characteristics of a phenomenon (Davis & Ruddle, 2010) the literature review here presents definitions of IK generally cited in the literature in an attempt to gain some insight into its nature. Further, if characteristic features that underpin the scientific way of thinking are manifest in IK practices, then this manifestation could facilitate IK-Science integration in school science teaching.

In this review of IK definitions three questions are examined that are believed could significantly contribute to a better understanding of the epistemological underpinnings of the nature or characteristic features of IK:

- How is IK produced in a particular community?
- How is IK validated by people who practise it?
- How do members in a community transmit IK?

A variety of definitions have been proposed for IK. Kibirige & Van Rooyen (2007 p. 236) have defined IK as "a legacy of knowledge and skills unique to a particular indigenous culture involving wisdom that has been produced and developed from an interface involving people and their environment and passed on over generations". They further, point out that this locally based knowledge, is experience-driven, tacit, constantly changing, learned through repetition, transmitted orally and, in many cases, through imitation and demonstration.

Stevenson (1996) points out that IK is a outcome of years of shared experiences, customs and values, spiritual and cultural beliefs, as well as traditions of a given people and is passed on generation to generation chiefly by means which are oral, and in some cases through paintings, writing, and other artefacts.

Onwu & Mosimege (2004, p. 2) have defined IK as “local, community-based systems of knowledge which are unique to a given culture or society and have developed as that culture has evolved over many generations of inhabiting particular ecosystems and it encompasses knowledge commonly known within a community of a people”. This definition resonates well with Grenier’s (1998) description of IK as distinctive, traditional, confined knowledge existing within and developed around the particular circumstances of people indigenous to a specific geographic area through trial-and-error, watchful observations and experiment, is cumulative and representative of generations of experiences.

Ogunniyi (2013, p. 13) views IK as a component of IKS and IKS as a “conglomeration of thought systems or worldviews that have evolved among various communities over a considerable length of time”. He further notes that, IK is the product of human observation, inquiry, reflection, critical thinking, creativity, and resourcefulness and in many cases is the sum total of logical and well-organized human interactions with nature and is represented in various forms: verbal, graphic or written (Ogunniyi, 2013). Ogunniyi (2011 p. 106) indicates that “IK embraces both testable and non-testable metaphysical phenomena” and that it attempts to describe, explain, predict and control phenomena “as well as harmonize with phenomena”. Unlike modern science, the construct ‘IKS’ is holistically defined with a nest of natural sciences, technology, social, economic, religion, language, and educational or philosophical learning (Battiste, 2002; Odora-Hoppers, 2002).

Definitions of Traditional Ecological Knowledge (TEK), given by some scholars also provide the characteristic features of IK. For instance, Usher (2000) defines TEK as those types of traditional knowledge concerning the environment produced from the experiences and traditions of a specific group of people. Huntington (1998) also defines (TEK) as that system of knowledge based on experience gained by continuously observing nature and is transmitted among the members of a given community. Similarly, Berkes (2004: p. 627, in Davis & Ruddle, 2010) defines TEK as "a cumulative body of knowledge, practice, belief, evolving by adaptive processes and handed down through generations by cultural transmission".

These definitions of IK/TEK provide some essential characteristic features of IK, which were analysed and categorised according to where IK is normally located, how it is produced, validated, and transmitted, as presented in Table 2.1 below.

Table 2.1 Characteristic features of IK extracted from definitions presented in the literature review

Author	**How IK is produced**	**How IK is validated**	**Where IK is located**
Huntington(1998)	**IK is developed based on experience** and **gained** by **continuously observing nature**	Validated by **continuously observing nature**	**TEK** is that system of knowledge based on experience gained by continuously observing nature and is located **in a particular community**
Kibirige & Van Rooyen (2007)	**IK is developed based on experience; it** involves wisdom that is tacit, and **constantly changing,** produced from **interface involving people and their environment**	**IK privileges the society to validate it over generations**	**IK** is local knowledge, a legacy of knowledge and skills **unique to a particular indigenous culture**
Onwu & Mosimege (2004)	Developed as that culture has **evolved over many generations of inhabiting particular ecosystems**	**IK privileges the society to validate it over many generations**	**IK** is local, community-based systems of knowledge which are **unique to a given culture or society**
Grenier's (1998)	Produced cumulatively, and is representative of generations of **experiences, careful observations, and trial-and-error experiments**	IK is validated through representativeness of **generations of experiences**	**IK** as unique, traditional, local knowledge **existing within a specific geographic area**
Ogunniyi, (2013)	IK is a product of human **interactions with nature** over a considerable length of time-product of human **observation, inquiry, reflection, critical thinking, creativity**, and resourcefulness **reflection on sensory data, formulation of hypotheses and generalizations**	**Validated by society over a considerable length of time'**	**IK** is a component of IKS and IKS is a 'conglomeration of thought systems or worldviews- in a **particular community** and is holistic
Berkes (2004)	**Evolving by adaptive processes and ccumulatively produced**	**Cumulatively validated**	**TEK** is a cumulative body of knowledge, practice, belief
Stevenson (1996)	IK results from years of shared experiences, customs and values, cultural and spiritual beliefs, and traditions of a given people	Validated as it is passed on from one generation to the next	IK is passed on from generation to generation chiefly through oral means, and in some cases through paintings, writing, and other artefacts
Battiste, 2002; Odora-Hoppers, 2002	Using **methods from various disciplines** such as natural sciences, technology, social, economic, religion, language, and philosophy	**Philosophical means** of validating knowledge	IKS is is **holistically defined with a nest of** natural sciences, technology, social, economic, religion, language, and educational or philosophical learning

Based on the above analysis of the characteristic features of IK (ref. Table 2.1) the following points could save as a summary:

- IK is gained by continuously and carefully observing nature and by trial-and-error experiments, it is cumulative and evolving knowledge, based on experience.
- IK privileges the community to validate it over many generations based on using the knowledge that include aspects of spirituality and philosophy.
- IK seen is in practices and is transmitted orally, and at times through imitation, demonstration, paintings, writing, and other artefacts.

In this study, it has been recognised that there is no one definition of indigenous knowledge that could be construed as all embracing and so elected in the context of this study is to provide a working definition in order to be able to proceed with the investigation (ref. 1.2.4).

The definition of IK presents both ontological and epistemological propositions about its nature. This study chose to focus on the integration of IK into the school science from an epistemological point of view because as already alluded to (ref. 2.3 paragraph 2), IKS is about epistemology, metaphysics (which has ontological assumptions), values, and the logic of a given indigenous community, and that IK seems to represent many of these aspects of the system of IKS. In other words, discussions on epistemological propositions presuppose the ontological assumptions.

The phrase 'nature of indigenous knowledge' typically refers to the epistemology of indigenous knowledge (just as 'nature of science' typically refers to epistemology of science) as a way of knowing or the values and beliefs inherent in the development of indigenous knowledge. Over and above these general characterisations, presently no agreement exists amongst researchers and practitioners on a precise definition of nature of science or nature of indigenous knowledge. This lack of agreement nevertheless should neither be considered an impediment nor startling given the multi-faceted complexity and nature of indigenous knowledge.

With regards to nature of science (NOS) and nature of IK (NIK), the differences about the meaning or definition of NOS or of NIK that continue to exist among science educators and philosophers may be largely immaterial in school science teaching and learning.

The view taken in this thesis is that there is an acceptable level of generality regarding NOS and/or NIK that is accessible to secondary school science students and relevant to their everyday lives. Among the characteristics of the scientific enterprise and indigenous knowledge corresponding to these levels of generality are that for instance, scientific knowledge is tentative, empirically based and that IK is both empirically and mystically based, unique, etc. The critical point here is that the focus of the study is on school science teaching and learning and how student performance could be improved through the integration of IK into science education.

From the characteristic features of IK, as displayed in Table 2.1 (ref. 2.3) there are many aspects of IK that are empirically based in which observations and human inferences, inquiry, experiments; imagination and creativity might have been used in the production of this body of knowledge. It is also interesting to note that IK covers all aspects of life (Hewson, 2013) and include aspects such as superstitions, assertions, and beliefs which is one major challenge for scientific and indigenous knowledge integration (ref. 2.4) taking into consideration the NOS.

2.4 Epistemological differences and similarities between indigenous and mainstream scientific knowledge

Ogunniyi (2011, p.102) notes that "Science is concerned with testable phenomena" and it considers the universe as knowable "while IK embraces both testable and non-testable metaphysical phenomena" as it considers some aspects of the universe as mysterious. "Also while science attempts to describe, explain, predict and control phenomena, IK attempts to do the same as well as harmonize with phenomena" (Ogunniyi, 2011 p. 102) and incorporates mystery in its explanation of the universe. He adds that this distinction poses serious challenges for a curriculum that attempts to incorporate IK into science.

Aikenhead (2006) points out that there are similarities and differences between indigenous knowledge and science. With regards to the differences, Webb (2014 p. 4) agrees with Aikenhead (2006) that the "most important is that indigenous knowledge sees the universe as mysterious while modern science sees it as being knowable; IKS values coexistence with the mystery of nature and celebrates this mystery while science attempts to eradicate mystery" and further that the basis for validating IKS is its use over a long period of time while that of science is essentially its predictive validity. Webb (2014) argues that the ontological base of the two ways of knowing marks a sharp difference and that coexistence with the mystery of nature inherent in IKS remains the major epistemological problem when considering integration of these knowledge systems.

Understanding of epistemological differences and commonalities between IK and mainstream school science is a prerequisite to knowledge integration (Bohensky & Maru, 2011; Davis, 2006; Webb, 2014). This understanding or knowledge was important because one of the aims of the study was to determine the characteristic features in IK that could facilitate its introduction into school science teaching. Further, to locate areas of tensions inherent when attempting to integrate indigenous knowledge into the school science curriculum considering its challenges to demarcation of science (Webb, 2013, 2014).

There are some sharp differences between IK and school science. IK is largely a holistic way of knowing (Ogunniyi, 2013), it tries to understand systems as wholes (Rich, 2012) and not as isolated parts like mainstream science does (Kibirige & Van Rooyen, 2007). Spirituality is deeply embedded in indigenous ways of knowing (Rich, 2012), which is another critical difference between IK and mainstream science. The spiritual phenomena and explanations postulated by IK are rejected by mainstream science because they are empirically unobservable (Onwu & Mosimege 2004). Indigenous communities often rely on collective, cumulative and spiritual means of validating IK and this body of knowledge is continually reinterpreted as compared with science, which relies on hypothesis testing, laws and theories. Also mainstream science represents a quantitative or analytical mode of thinking, while IK generally represents an intuitive and qualitative thinking mode. (Kibirige & Van Rooyen, 2007). A summary of the epistemological differences between IK and school science (ref. Table 2.2 below) illustrates major challenges to an inclusive science-IK curriculum.

Table 2.2 Summary of epistemological differences between indigenous knowledge and school science

School Science	Indigenous knowledge
"Science is concerned with testable phenomena" and it considers the universe as knowable "Also while science attempts to describe, explain, predict and control phenomena" Ogunniyi (2011, p.102)	"IK embraces both testable and non-testable metaphysical phenomena" as it considers some aspects of the universe as strange … IK attempts to describe, explain, predict and control phenomena as well as harmonize with phenomena" (Ogunniyi, 2011 p. 102) and incorporates mystery in its explanation of the universe.
School science is in written form and is taught in an abstract context (Kibirige & Van Rooyen, 2007)	Generally IK is orally and experientially transmitted and is learnt through hands-on-experience (Kibirige & Van Rooyen, 2007)
Knowledge validation in school science is fixed upon the logical positivist empiricist epistemology (Sandoval & Millwood, 2008). Empiricism and the use of the useful methods of science including scientific inquiry are specifically stated as means of validating scientific knowledge	IK privileges the community to validate it. The epistemologies of IK are not specifically stated which necessitates a better interrogation of IK epistemologies (Ogunniyi, 2011)
Science is based largely on a mechanistic and reductionist worldview (Ogunniyi, 2011); mainstream science tries to understand systems as isolated parts (Kibirige & Van Rooyen, 2007)	IK is based essentially on an anthropomorphic, pluralistic and holistic worldview (Ogunniyi, 2011); IK tries to understand systems as wholes (Rich, 2012) and not as isolated parts like mainstream science does (Kibirige & Van Rooyen, 2007)
Science is concerned only with testable phenomena and all that is logically deducible from these testable phenomena; as a means of validation, science relies on hypothesis testing, laws and theories; science represents a quantitative or analytical mode of thinking (Kibirige & Van Rooyen, 2007)	Empirical, spiritual, and pragmatic ways are used in the production of indigenous knowledge. IK often relies on collective, cumulative and spiritual means of knowledge validation as this body of knowledge is continually reinterpreted. IK represents an intuitive and qualitative thinking mode (Kibirige & Van Rooyen, 2007).
Science is universal, objective and knowledge production is based on empirical evidence only. The problem of subjectivism in the production of knowledge in science can be dealt with by ensuring inter-subjective validation	IK is unique, local, relative, subjective, multicultural and contextual knowledge. Knowledge production is based on empirical, spiritual, and pragmatic reality
"Modern science sees the universe as being knowable … science attempts to eradicate mystery" and further that the basis for validating science is essentially its predictive validity. Webb (2014 p. 4)	"Indigenous knowledge sees the universe as mysterious ... IKS values coexistence with the mystery of nature and celebrates this mystery" and further that the basis for validating IKS is its use over a long period of time (Webb, 2014 p. 4)

Arguing for the integration of indigenous and scientific knowledge into the school science curriculum invites two major critical questions: i) Are these two bodies of knowledge, which differ considerably from one another, though with some similarities, complementary or competing? (Onwu & Mosimege, 2004; Le Grange, 2004); ii) considering the epistemological differences between the two bodies of knowledge, is bridging the gap between them helpful and in what ways? (Webb, 2014). Webb (2014) suggests a framework that can be used to demarcate knowledge systems while bridging the gap between them as presented in figure 2.3 below.

Loubser's Line of Development of Knowledge

Similar to Loubser's one dimensional representation				
A) Theoretical knowledge: power to describe, explain and predict	**B)**	**C)**	**D)** Science	
E) Knowledge systems with less mysticism, explanations based on coherence and pragmatism but not based on empirical evidence	**F)**	**G)**Technology; IK practices in the area of technology and IK medicine etc with no spiritual elements	**H)**	
I) Pre-theoretical Knowledge systems which in most cases are purely based on beliefs (contain mysticism) (science has 'pre-theoretical' roots)	**J)** IK practices with spiritual elements	**K)** Some IK practices based on utility but contain mysticism	**L)** Some IK practices based on on empirical evidence	
	Practices that can not be falsified and are based on 'faith'	Practices based on facts that have been tested and that work	Theories that have survived refutations; are highly corroborated with predictive power; and practices based on empirical evidence	Similar to Popper's views on falsificationism

Similar to Popper's thory of refutation survival and corroboration progression adapted from (Webb, 2014)

Figure 2.3 Demarcating while bridging the gap framework: Webb's point of view

Webb (2014) seems to suggest that by combining Loubser's framework on how knowledge develops with Popper's requirements for demarcating bad from good theories it becomes possible to map where different knowledge claims should lie. For example, those IK practices with spiritual elements belong to the pre-theoretical class and are practices that can not be falsified. This is one type of framework that can be used by teachers to map other ways of knowing against demarcations of science. The challenges to the use of this framework by teachers are discussed in detail in section 2.6.

Webb (2014) is of the view that studies on epistemological differences between science and IK are likely to establish common understanding with respect to integration which is likely to promote teaching of science that makes it accessible and interesting to all learners. It is also suggested that technology may be a better interface for addressing the different views that exist around IK and science (Yore, 2011; Webb, 2014).

From the foregoing discussions, the major challenge for indigenous and scientific knowledge integration in school science seems to be the epistemological difference between the two systems of knowing. In short, science is concerned only with testable phenomena and all knowledge that is logically deducible from it whereas IK embraces both testable and non-testable metaphysical phenomena.

2.5 Research on integration of indigenous and scientific knowledge

This section reviews methods that have been used by scholars to try to integrate indigenous and scientific knowledge. The review considered integration of indigenous and scientific knowledge with respect to improvement of learners' performance in science.

In a study by Hewson (2013), two groups of African traditional healers (one in Western Cape in South Africa and the other in Lesotho) were interviewed in order to explore their IK concerning natural science topics and science teaching. Hewson then interviewed the Western Cape group about specific aspects of their IK that could usefully be taught at high-school level, and invited them to demonstrate how they would teach the topics if given the opportunity. Later she developed integrated IK-science lessons based on the information contributed by the Xhosa traditional healers with the aim of finding out how integration might be possible in classroom situations.

Hewson's (2013) study revealed that both traditional healers groups viewed integration as desirable and possible, and emphasized that collaboration between classroom teachers and the elders of the society and the traditional healers is crucial for such efforts. Both groups stated that IK should be documented and then be used in science teaching. They wanted research that should be undertaken to establish health-related IK, as well as general IK that relates to community life. Hewson (2013) points out that before IK can be included in the curriculum, more must be found out about the content and the processes by which indigenous people think, which still remains a daunting task. She is of the view that researchers should try to identify commonalities and differences between IK and science, since understanding of epistemological differences is likely to provide important indicators of ways in which to proceed with integration of indigenous and scientific knowledge.

In this study, similar to the approach used by Hewson (2013), practitioners were interviewed to find out aspects of science in the areas of health, agriculture and technology to see how integration might be possible. Further, this study partly addressed the concerns of traditional healers about research that must be done to establish health-related IK, as well as general IK that relates to the field of life by documenting IK practices and technology related to science. This study also developed an epistemological framework as a possible strategy that would enable science teachers to deal with the challenge of the absence of epistemologies for IK.

In another study, Kidman, Yen & Abrams (2012) carried out a cross-national comparative study, which involved 31 Taiwanese indigenous students and 32 New Zealand indigenous students, all at primary school level. The participants were interviewed about their experiences with the science curriculum in order to identify the socialization processes by which patterns of indigenous learners' under-achievement in elementary science are maintained and reproduced. Their ultimate aim was to identify factors that contributed to pedagogy and indigenous and scientific integration that fairly selected, regulated and monitored 'valid' curriculum content and knowledge without placing IK in a peripheral position. Findings from their study suggest that this peripheral positioning of IK in science curricula is partly a result of failure to perceive what 'legitimate' school science is. Kidman *et al*. (2012) suggest that policies and pedagogical practices in science should avoid peripheral positioning of IK.

This study has a similar aim to that of Kidman *et al*. (2012) in investigating how an indigenous culture and the culture of mainstream science might harmonize each other in learners' everyday world experiences in science education. In this study, traditional IK practitioners were used to collect data on IK-related themes on health, agriculture and technology. The choice of using practitioners instead of students was based on the reason that rich data about IK come from people steeped in IK traditions (Emeagwali, 2003).

Emeagwali (2003) has explored the multiple linkages between IK and the school curricula and has explained various strategies and instructional resources that can be used by teachers to integrate IK into school curriculum. She strongly recommends the use of instructional strategies such as discussions, debates, symposia, interviews. She is of the view that oral tradition is a very important IK source when using these strategies. The researcher used oral tradition in this study.

In another study, Lee, Yen, & Aikenhead (2011) used interviews to undertake an ethnographic investigation in an indigenous clan in Taiwan, focusing on how indigenous wisdom could be included in school science teaching. They started by developing written materials in science that described indigenous worldviews of time. They went into the community of local tribal elders and knowledge keepers with specific topics and content to be vetted by them in order to gain a good understanding of the indigenous knowledge. These topics were then used to teach and develop Grade 4 (10 years old) students' conception of time in a science lesson.

The findings from Lee et al. (2011) showed that the learners become more informed and refined in conceptualizing time through their engagement with an indigenous and science integration exercise and their interest in learning was increased. What was suggested was that integrating indigenous and scientific knowledge can help to improve learners' performance in science. Lee et al. (2011) stress that an adequate understanding of the students' worldviews helps the teacher to use these worldviews as a resource for improving their academic achievement.

Argumentation as a teaching tool is one of the methods that have been used to see how integration of indigenous and scientific knowledge in school science can be done (Ogunniyi, & Hewson, 2008; Ogunniyi, 2011). Osborne & Patterson (in McDonald, 2013), state that an argument attempts to justify uncertain conclusions that people arrive at by using a claim that is supported by data, with reasons acting as links to explain how the data support the claim.

Ogunniyi (2011) carried out a study exploring how teachers can use argumentation as a teaching tool to integrate indigenous and scientific knowledge. He began his study by stating that argumentation is necessary for creating intellectual space for self-expression and is effective in allowing teachers and learners to support their views, to clear their doubts, and, if convinced, to change their views or beliefs on a given subject matter, in this case IK and science integration. In his study, he first describes these two processes to explain cognitive shifts.

Second, he exposed a group of 21 science teachers in seminars to argumentation skills with the aim of equipping them with the knowledge and skills to incorporate science and IK in their classrooms. Having exposed the teachers to the process of argumentation, he requested them to select topics in their science curriculum that were amenable and relevant to both IK and science, such as food processing,) and the concept of lightning. The findings revealed the argumentation could be used to analyze and categorise different types of worldviews that are possessed by learners and teachers, which could have a positive or a negative impact on the success of indigenous and scientific knowledge integration.

In this study an argument is taken simply as a conclusion that is arrived at based on reasons. A good argument is that whose conclusion follows from the given reasons, which are true (Bowell & Kemp, 2010; Jimenez-Aleixandre, & Erduran, 2008).

The effects of argumentation as a teaching tool for indigenous and scientific knowledge integration are very significant. However, the epistemological difference between scientific and indigenous knowledge is a major remaining issue. Ogunniyi (2011) declares this a major remaining issue as he realizes that for IK to be worthy of inclusion into the school science curriculum, a better interrogation of its epistemology would be necessary to determine which aspects are compatible with school science and how they ought to be taught. But, regardless of teachers' ability to use argumentation, not dealing with epistemological issues will remain a haphazard way of doing integration. As reflected in the literature there are no frameworks for identifying epistemologies for IK practices, especially for assisting the teachers to determine appropriate teaching methods for interfacing IK with mainstream science. Based on this observation, this study used argumentation in conjunction with epistemological frameworks in the attempt to enhance teachers' logical reasoning skills during focus group discussions.

In a comparative study of teaching practices that bring indigenous ways of knowing together with environmentally related programmes, Rich (2012) interviewed and documented the work of nine elders (in institutions that deal with preservation and use of traditional knowledge) and faculty in universities in northeast USA and Canada to find out how much value and space IK is given in students' environmental science learning. Although the findings revealed that most of the elders and faculty framed the purpose of their work in broad terms, it was important that 'students were seen as developing more complex perceptions of the environment and more critical thinking skills' as a result of indigenous and scientific knowledge integration (Rich, 2012, p. 310). Covering significant groundwork in teaching practices, Rich's study, together with the literature reviewed (Karim-Aly Kassam, in Rich, 2012; Kimmerer, 2011; Cajete, 2008), suggests that teaching with both knowledge forms is feasible and valuable. Her literature review suggests ways in which it can be done:

- Sharing the results of a participatory research project with a class, especially those done in collaboration with a locally based indigenous researcher. If possible, including students directly in these research projects on integration of IK in solving environmental problems, as revealed in extensive research with indigenous peoples by Karim-Aly Kassam (in Rich, 2012)

- The teacher explicitly telling students in class which knowledge he/she is teaching from for a given course or occasion (Kimmerer, 2011, in Rich, 2012)
- Inviting indigenous students to act in class as anthropologists learning about another culture (Cajete, 2008 in Rich, 2012).

While the literature reviewed by Rich (2012) provides ways of how indigenous and scientific knowledge integration can be done, it does not specifically address the major challenge of epistemological differences between indigenous knowledge and mainstream science, which are prevalent in the literature reviewed.

In summary, the review of methods that have been used by scholars to try to integrate indigenous and scientific knowledge revealed two important points for this study. First that integrating indigenous and scientific knowledge can help to improve learners' performance in science. Second, that researchers should try to identify commonalities and differences between IK and science, since understanding of epistemological differences is likely to provide important indicators of ways in which to proceed with integration of scientific and indigenous knowledge. Indeed, as Hewson (2013) points out, before IK can be included in the curriculum, more must be found out about the content and the processes by which indigenous people think, namely their ways of knowing in the generation of knowledge, which still remains a daunting task.

2.6 Frameworks and approaches for characterising knowledge systems

Literature has shown the increasing desire among science scholars to find ways to improve the quality of education and specifically to improve learners' performance. Arguments for the necessity to integrate IK into the school science curriculum presented in chapter one (ref. section 1.1.2) showed the need for understanding the Nature of Science specifically with the aim of making science accessible and interesting to all learners. However, the challenge was lack of agreement among scholars on the meaning of NOS, with some arguing that the disagreement is irrelevant to science instruction and others arguing that it is important for developing a good understanding of NOS in the minds of learners (ref. section 2.2.1). Despite the lack of consensus, it may be said that science can be demarcated from other ways of knowing. With this in mind, an examination of the epistemological differences and similarities between IK and science has value.

Although there are some similarities between IK and science, there are some sharp differences which pose serious challenges to integration of the two bodies of knowledge. Against this background, some frameworks and approaches summarised below for characterising knowledge systems which were previously reviewed in this chapter are briefly discussed here with the aim to show the necessity for the framework that was used in this study.

- The use of argumentation as a teaching tool (approach) to integrate indigenous and scientific knowledge (Ogunniyi, 2011) (ref. section 2.5).
- Understanding the nature of 'theoretical' systems for purposes of illuminating the interrelations between the pre-theoretical and theoretical frameworks. (Loubser, 2013) (Ref. section 2.2.4).

- Precision, universality and falsifiability as requirements for good scientific theories (Popper, 1957) (ref. section 2.2.1).
- Demarcating while bridging the gap between science and indigenous knowledge systems framework: (Understanding the differences and similarities between/among knowledge systems keeping in mind that science demarcates itself from other ways of knowing: Webb, 2013, 2014) (ref. section 2.2.2).

Starting with the argumentation approach to knowledge integration, literature revealed that the effects of argumentation as a teaching tool with respect to indigenous and scientific knowledge integration are very significant (ref. section 2.5). However, the epistemological difference between scientific and indigenous knowledge remains a major challenge. In short it is argued here that though useful and necessary, it is not sufficient.

Although Ogunniyi & Hewson's (2008) study showed some potential in integrating IK and scientific knowledge, the study failed to resolve the contradiction between scientific argumentation and indigenous African argumentation. Using argumentation as a strategy to integrate IK into school science curriculum could be to implicitly accept the epistemological criteria of scientific knowledge as a measure upon which indigenous knowledge (and other ways of knowing) could be judged. Although Ogunniyi & Hewson (2008) recognise there may be different types of argumentation they concluded that whose version of argumentation should be used to integrate IK needs further research. Based on this observation, this study used argumentation in conjunction with the truth theories framework as a framework for knowledge integration in the attempt to enhance teachers' ability to demarcate what is scientific from what is not while at the same time developing their logical reasoning skills during focus group discussions.

The first framework that was reviewed is: (Loubser, 2013) 'understanding the relationship between pre-scientific and scientific frameworks' (ref. figure 2.2). While it is agreed that the awareness of the relationship between pre-scientific and scientific frameworks could be useful in the teaching of science, it is argued in this study that this awareness does not help the teacher with regards to how to handle aspects of other worldviews which do not fit into science (demarcation). Certainly, while 'Western' science has 'pre-theoretical' roots, one major aspect of NOS is the separation of elements which are not scientific from the pre-scientific as it develops to the 'theoretical' level.

The second framework that was reviewed in this study that which sets precision, universality and falsifiability as requirements for good scientific theories (Popper, 1957) (ref. 2.2.1). The framework implicitly accepts the epistemological criteria of scientific knowledge as a measure upon which indigenous knowledge (and other ways of knowing) could be judged. The challenge that teachers may face when using this framework is that while teachers could map knowledge systems using falsificationisim, their training does not include philosophies of science such as falsificationisim and justificationism and it might be too involving to use such theories. Crucial for this study, this framework does not provide teachers with a tool to demarcate IK for purposes of determining suitable teaching methods.

The third framework that was considered in this study is demarcating while bridging the gap between science and indigenous knowledge systems framework (ref. figure 2.3). It seems Webb's (2014) distinction between pre-theoretical and theoretical knowledge is similar to Loubser's, and further that his falsifiability distinction is also similar to Popper's falsificationism requirement for good theories. However, though Webb's framework (ref. figure 2.3) is better than Loubser and Popper's frameworks in the sense that the combination makes it possible for mapping where different knowledge claims should lie, this framework does not provide the teachers with a tool to determining the reasons why it is suitable to place the different knowledge claims and practices on the terrain. With this challenge in mind, it was found necessary to explore the possibility of using theories of truth as a framework for dealing with this epistemological challenge.

Against this background, the epistemological differences between IK and science remain a major challenge to integration. With this challenge in mind, it was found necessary to explore the possibilities of using theories of truth as a framework for dealing with this epistemological challenge. It was equally important to find out whether some of the features that underpin the scientific way of thinking manifest themselves in some IK practices in ways that could possibly make possible facilitate the integration of IK practices into school science teaching.

2.7 Conceptual framework for the study

In this study the development of some form of epistemological framework based on truth functional logic (ref. fig. 2.4) was chosen as a workable conceptual framework for integrating IK practices and school science teaching. A conceptual framework is descriptive tool, which explains the main things to be studied, the main issues, constructs or variables and the supposed associations among them (Bell, 2005). In simple terms, the construct 'conceptual framework' refers to the concepts or worldviews based on philosophical assumptions that inform, and guide reasoning and thinking of the study (Creswell, 2007, 2009; Loubser, 2013).

In this study the aim was to identify the epistemologies of some traditional practices and technologies in order to study how IK can be integrated into school science. Thus, three related activities were found necessary, in the application of the framework as pointed out in Chapter 1:

- First, to develop a framework for identifying and analysing IK epistemologies by way of philosophical analysis
- Second, to collect certain IK practices and technologies from a community where they are practised
- Third, to sample secondary school science teachers to identify the epistemologies of these IK practices and technologies during focus-group discussions using the designed framework and exploring ways in which the IK may be integrated into the school science curricula.

This study, deriving as it does from epistemological principles, sought to use theories of truth to examine the epistemological basis of selected IK practices, in order to determine their compatibility with school science, and how to incorporate them in science teaching in a legitimate and valid way. Three theories of truth were used in the framework for analysing and identifying epistemologies for IK. The three theories are the pragmatic theory of truth, the correspondence theory of truth, and the coherence theory of truth. The three theories were chosen because these often frame the basis upon which knowledge justification is done when providing epistemological grounds for the acceptance of any knowledge claim as true (Bernecker & Pritchard, 2012; Lynch, 2012). Since part of this study was about analysing and identifying the epistemologies for IK in order to integrate it into school science, epistemology became a suitable theoretical framework. Desk-top analysis of theories of truth was found necessary. The aim was to develop a framework for epistemologies appropriate to indigenous knowledge founded in the philosophical considerations of epistemology.

Bernecker & Pritchard (2012) describe epistemology as that part of philosophy that deals with knowledge for analysing the notions of truth, beliefs, and perceptions. In the domain of philosophy, epistemology is an area which focuses on the study of knowledge (McDonald, 2013). More precisely epistemology is about the nature and justification of knowledge. Knowledge is justified true belief, and epistemology is concerned with the grounds for accepting such beliefs (statement, sentence, proposition, etc.) about the world as true (O'Hear 1985). As Kirkham (1992, p. 47) puts it, "beliefs … can be true or false … it is the truth of beliefs with which an epistemologist is ultimately concerned". Certain conditions of truth should therefore be met or satisfied if a claim to knowledge is to be a genuine one (Audi, 1995; Bernecker & Pritchard, 2012; Dodd, 2008; Kirkham, 1992; O'Hear, 1985). More importantly for our purposes, the question is: are the conditions met, under which it is appropriate for one to be said to be in possession of knowledge, specifically local knowledge?

There is no consensus among philosophers about what truth is. As pointed out by Bowell & Kemp (2010 p. 60), "one might worry that what is true for one person or group need not be true for another person or group". As a result, truth has been conceptualized in a variety of ways. In this study, there is no one theory of truth that may be construed as a universal theory of the underlying nature of truth. The various definitions presented in this study, which are commonly considered the traditional and substantive ones, provide three categories of truth, namely the correspondence, pragmatic, and coherence theories of truth (Bernecker & Pritchard, 2012; Johnson, 1992). The correspondence, pragmatic and coherence theories of truth purport to offer what are in some sense criteria for truth. The correspondence theory of truth and its historical rivals, the coherence and pragmatist accounts of truth, are traditional (classical) theories of truth (Johnson, 1992; Lynch, 2012). These three theories of truth have stood the test of time since the era of Socrates, Plato and Aristotle. These three theories are also considered substantive because it seems they often frame the basis upon which knowledge claims are produced and are validated in many contexts (Audi, 1995; Bernecker & Pritchard, 2012; O'Hear, 1985).

Perhaps the most natural and widely held traditional and substantive theory of truth is the correspondence theory, which posits that a knowledge claim or a belief is true, provided there is a corresponding fact (empirical basis) (Audi, 1995). Lynch (2012), grounding the starting point of his survey of some traditional theories in Aristotle (1993), indicates that 'To speak truly is to say of what is, that it is'. Objectivity is one of the common assumptions about this theory. Lynch (2012) adds that contemporary theoretical descendants of this traditional correspondence theory express its central truism slightly differently. Truth is defined from a contemporary correspondence theory position in terms of the representational features of its component concepts which Lynch (2012) calls 'denotation'. However, in his final analysis, Lynch (2012) points out that the correspondence theory of truth fails to account for all forms of reality such as moral and mathematical propositions. Because of this failure, the correspondence theory, he concludes, may not be construed as a universal theory of the underlying nature of truth.

The second traditional and substantive theory of truth is the pragmatic theory. The pragmatic theory views truth in terms of what would solve a problem. In other words, truth from a pragmatic point of view is seen in terms of its practical bearing on human interests (Audi, 1995; O'Hear, 1985; Lynch, 2012) and in our interest in many indigenous knowledge practices and beliefs.

A third traditional and substantive theory of truth is the coherence theory. The coherence theory posits that a belief is taken as true when it is part of an entire system of beliefs and knowledge that is consistent and 'harmonious' (Audi, 1995). In other words, when a belief fits well with already accepted systems of beliefs, it is accepted as true.

These traditional and substantive theories of truth have been used to develop the conceptual framework (Ref. Figure.2.4) in order to assist teachers to map IK practices against the various components of the designated theories of truth and any others for the purposes of identifying their epistemologies based on applicable theory (ies) of truth.

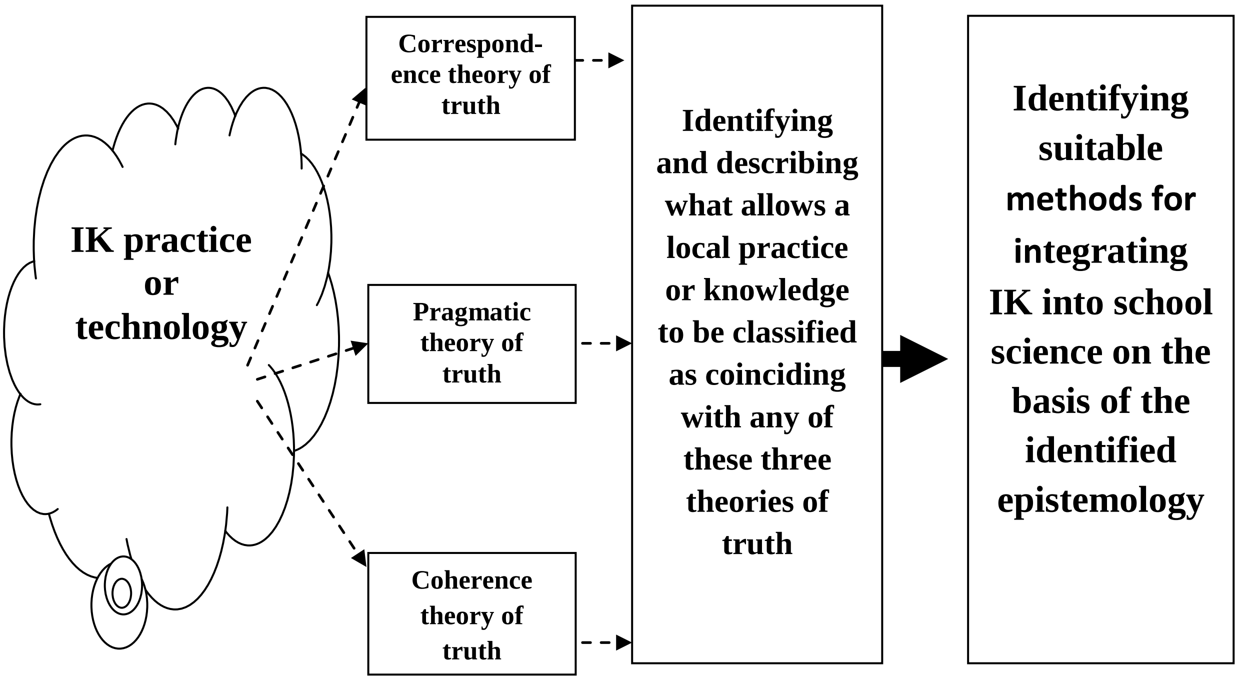

Figure 2.4 Framework for identifying epistemologies for IK practices and integration into school science teaching

The framework (Figure 2.4) was intended to assist the users (teachers) to determine the grounds upon which the truth-values of local knowledge may be validated. The application of the framework involves the following steps in line with the described elements of the framework:

- Step one: specific characteristic features of a given IK practice are to be identified from IK practitioners' narratives
- Step two: the identified characteristic features are analysed to find out how the knowledge is produced and validated. To establish the epistemology of the IK practice analysis is done using the theories of truth in the framework. For example, the question to be asked is: what allows a local practice or knowledge to be classified as coinciding with correspondence theory of truth, pragmatic theory of truth, coherence theory of truth or possibly any other with specific reference to its production and validation?
- Step three: suitable teaching methods are established taking into consideration the identified epistemology of the IK practice.

2.8 Assumptions of the study

In using epistemology as a conceptual framework, several assumptions were made, notably:

1. That the community based IK practices on health, agriculture and technology themes, (science-related practices) commonly practiced in a particular community in Zimbabwe could be documented through observations and interviews of key informants living in the community.
2. That with the use of appropriate methods for gaining entry into the field and appropriate techniques for collecting IK practices such as ethnography, IK practices could be documented successfully.
3. That some of the characteristic features that underpin the scientific way of thinking manifest themselves or are embedded in IK practices and that these could facilitate the incorporation of this body of knowledge into school science teaching.

4. That with the use of an appropriate framework modelled on the theories of truth, epistemologies of IK practices could be identified, i.e. that theories of truth represent an epistemological approach to constructing and validating IK.
5. That suitable teaching methods for incorporating IK practices into school science teaching may be established on the basis of the identified epistemologies of IK practices.

2.9 Chapter summary

Chapter 2 presented a review of the literature on IK and school science integration with particular reference to the possibility of integrating IK into the school science curriculum as a way of enhancing students' performance in science. The review of stances on the nature of science and of IK sought to explore how both scientific knowledge and indigenous knowledge are produced and validated.

The review explored the differences and similarities between scientific knowledge and indigenous knowledge in order to map the possibility of integration of these two bodies of knowledge. Thereafter, the review focused on research on the integration of indigenous and scientific knowledge and ended with a presentation of the conceptual framework of the study. The conceptual framework is shown to lead to a tool (when included with argumentation) which is able to assist teachers to judge IK practices for inclusion in science curricula. The next chapter (three) presents the research methodology that was used in this study.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Chapter 3 is about the research methodology and other procedures used to collect and analyse data. It describes the research method and design, followed by the sampling procedure, the development and validation of data collection instruments, ethical considerations and the pilot study.

3.2 Research method and design

The research used a qualitative research approach involving ethnography and the case study method within an interpretive paradigm (Marton, 1986; Creswell, 2009; Merriam, 2009) to address the research questions. A qualitative research approach was considered appropriate for the study because the interest is with providing in-depth information and rich descriptions of IK practices of the local community in the designated fields of health, agriculture, and technology (Mason, 2006) and to examine through focus group discussions how selected science teachers might incorporate them into school science curricula in practice. Merriam (2009) contends that the reason of research from an interpretive viewpoint is to describe, comprehend and interpret the observable fact under investigation. In this paradigm reality is manifold, context bound and as seen by participants in the study (Creswell, 2007; Merriam 2009). Creswell (2007) argues that investigators conduct their studies in the field where participants live and work in order to have greater insight into what the participants are saying and doing. Towards this end, data collection, which invariably is personal and interactive, using qualitative research methods and/or multiple sources of qualitative and quantitative data such as observations, interviews and artefact analysis, is predominant in this worldview (Mthethwa-Kunene, 2014; Mertens, 2010).

The context of this study is the traditional community where IK is practised and the exploration of the integration of indigenous and scientific knowledge in school science teaching environment. The cases investigated in this study were six IK practices within the three fields as described by 24 practitioners of a specific community. These practices were then presented to two groups of science teachers and studied were their efforts to use an epistemological framework to classify these practices. This was done with a view to establishing the efficacy of the truth classification scheme and its usefulness for their practice.

The study adopted a descriptive research design (McMillan & Schumacher, 2010), using ethnography as the research method in which the researcher sought to describe and interpret the shared culture of a group of people in a particular field setting (Creswell, 2007). With the aim to understand the IK practices of a culture-sharing group, ethnography was used mutually with the case study method. As pointed out by Cohen, Manion, & Morrison (2011 p. 289) “case studies are important sources of data, either own or to supplement other kinds of data”. A culture-sharing group is typically large, but sometimes this group may be small (at times just a few IK experts in a given community), as in this study. A descriptive study is concerned with the ‘how?’; ‘what is’ and what was? and in turn seeks to describe the current or past status of something or an event or a practice (McMillan & Schumacher, 2010). It was assumed that the identified IK practitioners were knowledgeable and the interest was with identifying health, agriculture and technology-related practices that could be incorporated into science teaching.

IK is stored in people's memories and activities. It is expressed for example in stories, songs, agricultural practices, technology, symbolic representations, and animal breeds (Grenier, 1998; Ogunniyi, 2013). Emeagwali (2003) points out that in research, rich data about IK come from those people who are immersed in IK traditions. The researcher had therefore to identify and understand the specialised knowledge held by IK practitioners as a human enterprise in order to tap the resources. In this study, an ethnographic case study approach was used on a one-on-one interview basis to investigate indigenous practices of 24 practitioners in the community. With the aim to understand the shared culture, certain community-based IK practices in health, agriculture and technology that are commonly practised in Chikwanda community in Zimbabwe were carefully documented through interviews and observations of key informants in the community (Creswell, 2009; Hewson, 2013). Four practitioners were interviewed on each IK practice. Adopting a non-holistic perspective in this study was helpful because the investigation could focus on just one aspect or facet of the culture, consistent with the interest of the research, which was manageable and practical rather than on its entirety (Bodner & Orgill, 2007).

In this study the case study method was used concurrently with ethnography. The case study method allowed the study to be carried out in a natural context and within a particular time and boundaries (Cohen, Manion, & Morrison, 2000, 2011; Hamilton & Corbett-Whittier, 2013). "Case studies are a design of inquiry found in many fields … in which the researcher develops an in-depth analysis of a case, often a program, event, activity, process, or one or more individuals. Cases are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (Creswell, 2014 p.14) It also provided an opportunity for the identified individual traditional IK practitioners to be investigated over a sustained period of time using various methods of data gathering (Stake, 1995; Yin, 2009, 2012; Creswell, 2013, 2014) and to subsequently find patterns in the data

(Hamilton & Corbett-Whittier, 2013). After the IK practitioners had given their narratives, the researcher subsequently looked for patterns such as how the knowledge was produced and validated. Further, the researcher looked for patterns in science teachers' views on how the IK practices can be integrated into the school science curriculum. In short, in this study the case was 'a particular group of IK practitioners' in 'six cases' narrating their practices for purposes of allowing science teachers to give their views on how the IK practices could be integrated into the school science curriculum.

The use of the case study research method in science education research has had some criticisms. Critics such as Yin (1984, 2009, 2012) are of the view that a small number of cases cannot suggest sufficient justification for establishing reliability or generality of findings. Although there are certain methodological limitations with the use of the case study method, there are several advantages and science education researchers (Appleton, 2008; Brown et al., 2013; Mthethwa, 2014; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008) continue to employ the case study technique productively in most studies on the knowledge base of teachers. For instance, a case study is useful in providing a rich and detailed account or description of the case in its natural setting (Merriam 2009). The validity and soundness of the argument by Soy (2006) for the continued use of case study methods is derived from the reason that it has been successfully used in carefully planned practical studies of real-life scenarios (Bodner & Orgill, 2007). For these reasons, an ethnographic case study method was considered suitable for this study to obtain IK practices from a community in Zimbabwe where they are practised.

3.2.1 Research Phases

This study was carried out in three phases. Phase 1 was about the development of a framework for analysing and identifying epistemologies for IK. Phase 2 was based on an ethnographic case study of practitioners of indigenous knowledge in the Chikwanda community. Finally, Phase 3 was about testing the possibility of incorporating or integrating the documented IK practices into school science teaching using the epistemological framework established in Phase 1. The research instruments were piloted prior to their use in the study to determine the reliability and validity of the research instruments, as well as aspects of practicability of administering the instrument (ref. 3.5).

In Phase 2, the intermittent interaction with the community in which contact was established for one year gave rise to mutual trust and ease of access to the IK practitioners. One-on-one interviews were used to obtain IK-related narratives from 24 IK practitioners as would be expatiated on later in the section on research instruments (ref. 3.4.1.).

In the final phase, Phase 3, school science teachers were workshopped in the use of the truth-based epistemological framework in order to obtain their views about the appropriate pedagogy for such incorporation in a suitable, perhaps legitimate and logical way. Focus-group discussions were used with 12 participating teachers to obtain their opinions on the integration of the two bodies of knowledge.

3.3 Population and sample

3.3.1 Study population

The population of this study in phase two comprised about 2250 elderly people who reside in Chikwanda communal area as presented in the Zimbabwe census national document 2012 (ZNSA, 2012) and 42 school science teachers from the seven schools in the Chikwanda communal area that offer science subjects at secondary school level (ref. Phase 3). In this study, the elderly people were regarded as those who are 65 and above as defined in the Zimbabwe census national document 2012 (ZNSA, 2012).

3.3.2 Study sample for phase 2

This phase of the study took place in Chief Chikwanda's communal area in Zimbabwe. This area was chosen because it is rich in indigenous practices and beliefs (Zimbabwe National Traditional Medicine Policy [ZNTMP], 2007). Chief Chikwanda has five headmen in his area of jurisdiction. Each headperson has on average ten village heads under his or her authority, with each village on average having fifteen households. This translates to 50 villages with a total of 750 households and about 2250 elderly people on average.

A purposive sampling procedure (Patton, 2002) was used to select twenty-four (24) people who are immersed in IK tradition to participate in this study. The IK practitioners were selected according to pre-selected criteria pertinent to the study research questions (Nieuwenhuis, 2007). As explained by Merriam (1988), in purposive sampling, the researcher has to find a sample that matches his or her established criteria, as demonstrated below.

The following criteria were used in selecting the sample of the study. First, key informants, including village heads and stakeholders in the community, were consulted to assist in identifying individuals or groups steeped in IK tradition in agriculture, health and technology. The 36 people who were identified were called to a meeting by the researcher with the assistance of the village heads to explain to them the purpose of the study, their expected role, the way in which confidentiality would be assured, and of their right to participate or withdraw voluntarily (Appendix B) and to obtain formal consent from them. Participants were assured that permission to use quotations and pictures in the thesis statements must be obtained from them. Volunteers were requested to participate in the interviews. The 24 volunteers who were finally selected were considered to reflect most closely the interests of the research in terms of knowledge and expertise and who were also willing to assist as key informants. The distribution of the IK practitioners according to their areas of expertise is displayed in Table 3.1 below.

Table 3.1

Distribution of IK practitioners according to area of expertise

Area of practice	**Number of practitioners**
Agriculture	8
Health	8
Technology	8

3.3.3 Study sample for Phase 3

For Phase 3 of the study, two high schools were randomly selected from seven schools in the Chikwanda area that offer biology, integrated science, chemistry and agricultural science, mathematics, and technology subjects from Form 1 up to Form 4 (Grades 9 to 12). A number of 12 science teachers from these schools were requested by the researcher to participate in the two-day workshop and afterwards in the focus group discussions. Each of the schools has six science teachers. All 12 teachers were qualified teachers, eight with a degree in science education, and the other four with a diploma in science education. The distribution of the science teachers according to area of teaching, qualification and teaching experience is presented in Table 3.2 below.

Table 3.2 Distribution and teaching experience of participating teachers

Teacher and type of school	Sex	Area of teaching	Years of teaching experience	Qualification
T1-Mission school	Female	Integrated science & Biology	17	Diploma in science education
T2-Mission school	Female	Agriculture	4	Degree in science education
T3-Mission school	Male	Chemistry & integrated science	7	Degree in science education
T4-Mission school	Male	Integrated science	2	Degree in science education
T5-Mission school	Male	Biology & human and social biology	6	Degree in science education
T6-Mission school	Male	Physical science	8	Degree in science education
T7-Rural school	Female	Integrated science	5	Diploma in science education
T8-Rural day school	Male	Agriculture	7	Degree in science education
T9-Rural day school	Female	Integrated science	4	Diploma in science education
T10-Rural day school	Male	Agriculture	9	Diploma in science education
T11-Rural day school	Female	Agriculture	11	Degree in science education
T12-Rural day school	Male	Integrated science	9	Degree in science education

Key: T1 to T12=Teacher 1 to Teacher 12

3.4 Development and validation of research instruments

The study was conducted from April 2011 to February 2012 to collect IK practices from the Chikwanda community, and from February 2012 to March 2012 to conduct focus-group discussions with teachers. Two instruments were developed for collecting data in this study. One-on-one semi-structured interviews with IK practitioners formed an important part of the data collection process. Observations and artefacts were also used as data sources during the collection of IK practices and technologies. The second instrument was a focus-group interview guide for the science teachers. Focus-group discussions were conducted with teachers using the epistemological framework based on truth theories (ref. 2.7: fig 2.1) to explore ways in which the selected practices in IK could be integrated into the school science curriculum to establish appropriate pedagogies.

3.4.1 Semi-structured one-on-one interviews with IK practitioners

A semi-structured interview schedule for a one-on-one interview format was developed to collect in-depth information on indigenous knowledge practices and technologies from 24 IK practitioners. The guide was developed in the form of an information gathering sheet (ref. Table 3.3) The main questions used in the interviews were derived from one of the study's research questions, that is, *What indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture in Chikwanda district in Zimbabwe can be identified and documented?* The questions were as follows:

- What is it the practitioners do?
- How do the IK practitioners do what they do?
- Why do the IK practitioners do what they do?

Table 3.3 Indigenous knowledge information sheet in the areas of health, agriculture and technology

Indigenous practice or belief: The practitioners were requested to focus on a specific practice or technology in a chosen area for example agriculture	Question 1: What is it the practitioners do and how do they do it? Practitioners were then requested: Could you please give a detailed description of what you do and how you do it. Practitioners were asked to articulate and show artefacts where possible	Question 2: Why do the IK practitioners do what they do? Practitioners were requested to explain their reasons for carrying out their practices

3.4.2 Semi-structured focus-group interview guide for science teachers

Focus-group interviews are "carefully planned discussions designed to obtain perceptions in a defined area of interest in a permissive, non-threatening environment" (Morgan, 1997, p. 18). A semi-structured focus-group interview guide was developed for conducting discussions with science teachers using a truth conceptual framework (ref. 2.7: Figure 2.1) to analyse and identify IK epistemologies and to establish their views on appropriate pedagogies for incorporating IK into the school science curriculum in a valid and legitimate way. Focus-group interviews provided information within a short period, and a diversified range of responses (Hamilton & Corbett-Whittier, 2013).

The main questions used in the interviews were derived from the study's first and third research questions: ii) *How can, from a theoretical perspective, epistemologies of indigenous knowledge be identified for integrating IK into school science teaching curriculum in a valid and legitimate way?* iii) *How should the identified indigenous knowledge and practices be integrated into school science teaching?* The focus-group discussions were guided by three major questions presented below:

- Question 1: What makes a local practice or knowledge able to be classified as coinciding with correspondence theory of truth, pragmatic theory of truth, coherence theory of truth or possibly any other?
- Question 2: Given the epistemologies of the IK practices you have identified above, what appropriate methodologies can you establish for incorporating IK into the school science curriculum in a valid and legitimate way?
- Question 3: Have your views about IK integration into the science curriculum changed or remained the same? If they have changed or not changed, what are your reasons?

3.4.3 Validation of research instruments

Content validity refers to the extent to which a measure covers a variety of meanings built-in a concept (Babbie, 2011, 2013). For Creswell (2009), content validity has to do with the question; do the items measure the content they were intended to weigh up? Validation of the epistemological framework, the interview schedule for IK practitioners and the interview schedule for the science teachers is explained in Sections 3.4.3.1 to 3.4.3.3 below.

3.4.3.1 Validation of the epistemological conceptual framework

To determine the content validity of the epistemological framework (ref. 2.7: figure 2.1), three university lecturers in philosophy reviewed the framework to assess whether:

- The three theories of truth (correspondence, pragmatic and coherence) often frame the basis upon which knowledge claims are produced and are accepted in many contexts.
- The definitions of these theories of truth cover the range of truth meanings sufficiently for the framework to be used to analyse and identify epistemologies for IK.

The reviewers were two lecturers from the University of Zimbabwe and one from a teachers' college in Zimbabwe. One of the lecturers holds a PhD in philosophy and has been teaching epistemology for more than ten years. The other two lecturers hold master's degrees in philosophy and have more than fifteen years' teaching experience at tertiary level.

All three lecturers agreed that the framework consisted of the traditional and substantive theories of truth that form a sufficient basis upon which knowledge claims in the area of IK could be analysed and accepted in many contexts.

3.4.3.2 Validation of the interview schedules for IK practitioners

To determine the reliability of the one-on-one interview schedule, it was tested with four IK practitioners in the areas of health and agriculture who did not form part of the main study. The process is discussed in detail in the pilot study (ref. 3.5.3.1). The testing was done to determine the extent to which the interview schedule was likely to yield consistent responses from IK practitioners (Cohen, Manion & Morrison, 2007) in terms of describing what they do and how they do it. The responses of the IK practitioners were found to be consistent and similar in the selected areas of health and agriculture. The reliability of the interview schedule was thus generally established on this outcome (Morse, Barrett, Mayan, Olson & Spiers, 2002).

3.4.3.3 Validation of the interview schedule for the science teachers

To determine the content validity of the focus-group interview schedule for science teachers, the instrument was given to science education lecturers involved in instrument validation for research at Bindura University of Science Education. They were requested to judge the suitability of the questions to elicit appropriate responses in line with the research questions:
How can, from a theoretical perspective, epistemologies of indigenous knowledge be identified for integrating IK into school science teaching curriculum in a valid and legitimate way?, and
How should the identified indigenous knowledge and practices be integrated into school science teaching?

One lecturer is a professor in science education and has more than fifteen years' experience of teaching at university level. One of the lecturers holds a master's degree in science education and mathematics and has more than five years; teaching experience. The other two lecturers, one of whom holds a master's degree in biology and the other a master's degree in chemistry, have more than ten years' teaching experience. The four lecturers agreed that the focus-group interview schedule was suitable for eliciting appropriate responses to the research question focused on in Phase 3.

3.5 Pilot study

A pilot study was conducted to determine the reliability and validity of the research instruments, as well as aspects of practicability of administering the instrument (Cohen et al., 2007). Trying out the interviewing methods with a small number of participants helped to come to grips with realistic aspects of the methodology of the study.

3.5.1 Pilot study purpose

The purposes of pilot study were as follows:

- To determine whether the one-on-one interview schedule for IK practitioners was likely to yield consistent responses from the practitioners in terms of what they do and how they do what they do
- To test key entry protocols for gaining entry and trust within the community
- To establish the suitability of the interview guide questions for eliciting appropriate responses from the science teachers
- To determine appropriate duration to administer the instruments, as well as to test comprehensibility of items and clarity of instructions in the instruments
- To obtain feedback regarding any necessary modifications on methods for administering the main study.

3.5.2 Participants in the pilot study

Four willing IK practitioners in the areas of health and agriculture, who were not part of the main study, participated in the pilot study. Five willing ordinary-level science teachers in various science subjects, who did not form part of the main study, participated in the pilot study. All the teachers hold a degree in science education and have a minimum of six years' teaching experience.

3.5.3 Administration of the pilot study

Permission to conduct the study was obtained from the Chief (Appendix R), the Ministry of Education (Appendix P and Q), and school principals (Appendix C). The participating IK practitioners were asked to participate voluntarily and were informed about the purpose of the study, their expected role, the way in which confidentiality would be assured, and their right to participate or withdraw (Appendix B). The teachers then signed letters of consent (Appendix A), which informed them of these factors.

3.5.3.1 Pilot study with the indigenous knowledge practitioners

With the aid of the IK information sheet (ref. 3.4.1: Table 3.3), the researcher requested the practitioners to describe how they carried out certain practices or technologies and to give reasons for doing so. As the participants related the knowledge, the researcher wrote notes in the spaces provided in the sheets under each question. Concurrently, the researcher, with the help of a research assistant, recorded the participants' voices. The IK practitioners were interviewed using the one-on-one approach. Interviews were conducted in Shona. The researcher recorded the time it took to hold a comprehensive interview, and checked the comprehensibility of the interview schedule's items and clarity of instructions. All the interviews were recorded and transcribed. Field notes and transcriptions from video-recordings were translated from Shona to English, and back translation was done from English to Shona. A lecturer in the Language Department at the University of Zimbabwe performed this task.

Certain protocols were utilized during the collection of IK practices to gain entry and trust. Conventions of greetings and introductions, ceremonial rules, protocols of identity revelation and acknowledgement of the importance of a person's customs, and of systems of the Shona people were used to gain entry and trust. For instance, when the elders were addressed, greeted or introduced with their totems, they felt honoured (Malcolm, Gopal, Keane, & Kyle, 2009) especially if the person were a headman or village head. Shona totems include *Shumba* (symbol of a lion), *Moyo* or *Gono* (symbol of a heart and bull) and *Zhou* (symbol of an elephant). The totems show the significance of the clan, and their capabilities and obligations in life. To illustrate, when the researcher arrived at one of the participants' home, he courteously requested entry: '*Tisvikewo pamusha wenyu Gono*' ('I request to enter and be received at your homestead, Bull.'). The old man reciprocated, '*Svika zvako ndinokugamuchira norudo mwanangu.*' ('Come in. I welcome you with love, my child.) In all cases, the participants showed that they were respected.

3.5.3.2 Pilot study with the science teachers

The translations of two IK practices were taken to the science teachers. To enhance the teachers' ability to use the epistemological framework to analyse and identify IK epistemologies of the two practices, five teachers participating in the pilot study were introduced to reasoning skills based on logic. After the five teachers had been introduced to argumentation skills (ref. Appendix F1**)**, semi-structured focus-group interviews were conducted with them. Using the epistemological framework (developed in Phase 1 (ref. 2.7: figure 2.1), the teachers were asked to identify and analyse the IK epistemologies of the two practices and how they could be integrated. They were requested to answer the following questions:

i) What makes a local practice or knowledge to be classified as coinciding with correspondence theory of truth, pragmatic theory of truth, coherence theory of truth or possibly any other?

ii) Given the epistemologies of the IK practices you have identified above, what appropriate methodologies can you establish?

iii) Have your views about IK incorporation into the science curriculum changed or remained the same? If they have changed or not, what are the reasons?

Data collected from the focus-group discussions were later analysed.

3.5.4 Results of the pilot study

- The results obtained from the pilot study were used to improve the instruments. The approximate duration for administering each of the interview schedules was also established.

- The methods for gaining entry into the community yielded positive results and could be assumed to be appropriate for the main study.

- There was coherence, similarity and consistency in the descriptions given by the IK practitioners on each of the practices in the fields of health and agriculture. Based on this outcome, the reliability of the interview schedule and its suitability to elicit appropriate responses to the research question were generally assumed.

- The teachers were able to use the epistemological framework convincingly and their views on appropriate pedagogy for integration based on focus-group discussions were established.

3.6 Administration of main study

The main study was administered using the same procedures as the pilot study. The 24 selected IK practitioners and the 12 science teachers participated in the main study.

3.6.1 Administration of the interviews with IK practitioners

The same protocols that were utilized in the pilot study (ref. 3.5.3.1) were used in collecting IK practices in the main study. The IK practitioners were interviewed individually. Transcription protocols of these interviews were later analysed.

3.6.2 Conducting focus group discussion with science teachers

To equip the 12 teachers with the necessary information and skills to participate meaningfully in the focus-group discussions, a two-day workshop was organized prior to the focus-group discussion. The workshop was aimed at equipping them with the skills of logic that would enable them to analyse arguments, and form and present valid and sound arguments. The workshop also provided participants with an opportunity to peruse the IK practitioners' protocols. The workshop documents included the following guidelines:

i) Guidelines on how to use tools of logic to perform analysis of arguments to check the validity and soundness of arguments

ii) Practitioners' protocols on how to undertake certain traditional practices in health, agriculture and technology (ref. 4.3.1.1 to 4.3.3.2)

iii) The developed epistemological framework for identifying and analysing IK epistemologies (see Figure 2.4 ref. 2.7).

A content test on logical reasoning was administered at the end of the workshop to assess the achievement level of the teachers. The outcomes of the test are presented in Appendix M.

After the teachers had been trained, focus-group discussions led by the researcher were conducted using the questions in the pilot study (ref. 3.5.3.2).

The teachers were requested to use the framework (fig. 2.4 ref. 2.7) to analyse and identify IK epistemologies in relation to science classroom teaching for the described IK practices and/or technologies. In these focus-group discussions the teachers were asked to establish teaching methods for each of the local practices that would be most appropriate for incorporating the IK practices into science classroom teaching. Each session lasted from 50 minutes to an hour, and the sessions were recorded. The researcher was the moderator whose role was to guide the discussions. Data collected from the focus-group discussions were later analysed (ref. 3.7.2).

3.7 Procedure for analysing data

The data from Phases 2 and 3 were analysed. Below, 3.7.1 focuses on data analysis which was done on interviews which were conducted with IK practitioners and 3.7.2 is a presentation of data analysis on focus-group discussions which were conducted with science teachers.

3.7.1 One-on-one interviews on IK practice data analysis

A collection of community-based IK practices in health, agriculture and technology that were commonly practised in a particular locality in Zimbabwe were carefully documented through observation and interview of informants in the community. The data were analysed, utilizing a set of themes and codes that had been pre-determined from the interview schedule questions:

- What is it the practitioners do?
- How do the IK practitioners do what they do?
- Why do the IK practitioners do what they do?

The following steps were carried out:

- Pseudonyms were used to identify practitioners, and data were organized according to the IK practitioners for easy access during analysis and writing up of the findings.
- First, field notes and transcriptions from video-recordings were translated from Shona to English.
- Second, back translation was done from English to Shona on all the 24 interviews to check for consistency. A lecturer in the Languages Department at the University of Zimbabwe performed this task. The lecturer agreed that there was consistency.
- The individual narratives from the 24 IK practitioners on each practice in health, agriculture and technology were compared. The purpose was to identify consistency and divergence, if any, in order to provide a common structure for the data.
- Several artefacts (ref. Appendixes N1 to N6) were observed and analysed to check for consistency and divergence, if any, among practitioners' narratives, observed facts and demonstrations and these artefacts.
- Finally, the transcriptions for each IK practice were collapsed into one narrative form to provide a summary description of the practice. The same three probing questions (What do they do? How do they do it? Why do they do it?) were used to group the emerging evidence of their practices.
- The researcher revisited the participants periodically and follow up questions were asked.

- To ensure reliability, crosschecking for mistakes on transcriptions and on the consistent use of codes was done several times at all stages.

Finally, a truth-functional knowledge framework for identifying epistemology(ies) of indigenous knowledge was used by the researcher to analyse the IK practitioners' protocols. The guiding question was: What makes a local practice or knowledge classifiable as coinciding with correspondence theory of truth, pragmatic theory of truth, coherence theory of truth or possibly any other? The identified epistemologies were then used to crosscheck the outcome of the application of the framework by teachers in Phase 3 of the research.

For example, the epistemology for the cereal seed preservation method in Table 3.4 is used to illustrate the teachers' reasoning from the truth base on which the constructed reality of the cereal seed preservation method to suggestions of methods that can be used to teach the practice. In summary, the correspondence theory of truth adheres to the view that knowledge claim or belief is true provided there is a fact (empirical base) corresponding to the claim. The pragmatic theory views truth in terms of what would solve a problem. The coherence theory takes a belief as true when it fits well with accepted systems of beliefs.

Table 3.4 Application of framework for identifying epistemologies for IK practices and beliefs based on three theories of truth

IK practices/beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Cereal seed preservation method: a variety of seed crops are stored and preserved by hanging the stocks on the inside surface of the thatched roof of the round kitchen, people in Chikwanda having realized that pests do not attack seeds with carbon soot	The reality of this practice is constructed with reference to the correspondence theory because of the empirical base to what is being practised. Because the processes in this practice are observable and there is empirical evidence, experiments and practicals can be done in the laboratory by learners to investigate the causes	The reality of this practice is based on the pragmatic theory because what is being practised solves a problem	Reference to the coherence theory has not been found necessary with respect to reasons for constructing the reality of this practice

3.7.2 Focus-group discussion data analysis

The data from the focus-group discussions with the science teachers were analysed. The following steps were carried out:

- Pseudonyms were used to identify teachers, and data were organized according to the participating teachers for easy access during analysis and writing up of findings.
- The video-recorded discussions were transcribed verbatim by the researcher to obtain accurate and comprehensive records of the conversations.
- The researcher typed all notes taken during the focus-group discussions.
- Video-recordings were listened to repeatedly, and the notes were read several times to obtain a clear and accurate sense of what the participants had said.
- The teachers' identified epistemologies of the six IK practices were described.
- Similarities, coherence and consistency were checked by comparing the identified epistemologies in the teachers' arguments.

- The emerging epistemologies were used to guide the focus-group discussions to establish the teachers' views of appropriate pedagogies for incorporating IK into school science.

3.8 Validity and reliability of the study

This research included various techniques in order to meet the principles of trustworthiness, and validity for naturalistic inquiry (Creswell, 2008). The validity and reliability were guaranteed chiefly through triangulation. The research instruments were validated by philosophy experts (ref. 3.4.3.1), IK practitioners (ref. 3.4.3.2), and science education experts (ref. 3.4.3.3) and piloted (ref. 3.5) prior to their use in the major study. The procedure of validation and piloting added and enhanced the validity and reliability of the study.

Dissimilar methods of data gathering, including interviews, observation and artefacts were used to strengthen the credibility of the results and consistency of the findings with the data (Rude & John, 2011). Additionally, observation, member checking and video-recordings were done to obtain accurate and relatively complete records and to describe in detail how data were collected and analysed, producing thick description, and spending prolonged time in the field which enhanced the trustworthiness of the findings (Rude & John, 2011). Video-recordings were listened to repeatedly, and the notes were read several times to obtain a clear and accurate sense of what the participants had said. Field notes and transcriptions from video-recordings on all the interviews were translated from Shona to English, and back translation was done from English to Shona to check for consistency (ref. 3.7.1). The researcher took the IK practitioners' protocols back to the participants to confirm the credibility of the information and the narrative accounts. The aim was to determine the accuracy credibility, fairness and reliability.

3.9 Ethical considerations

The researcher applied for ethical permission from the Ethics Committee of the University of Pretoria before data collection commenced. Permission to carry out the study was obtained, and once the study was completed, a clearance certificate was issued (Appendix O) as confirmation that the study was conducted in line with the expectations stated in the application for ethical clearance.

In Phase 2 of the study, to gain access into the community in order to conduct the study, written permission was obtained from Chief Chikwanda (Appendix R). The 24 IK practitioners who had volunteered for the project were informed of the purpose of the study, their expected role, the way in which confidentiality would be assured, and of their right to participate or withdraw voluntarily (Appendix B). Formal consent was obtained from elderly people, practitioners and IK experts. Participants were assured that permission to use quotations and pictures in the thesis statements must be obtained from them. To maintain anonymity IK practitioners were labelled from practitioner I (P1) to practitioner 24 (P24). Permission for observing their artefacts and video-recording the interviews was obtained from the practitioners.

In Phase 3 of the study, to gain access to the schools permission was obtained from the Ministry of Education (Appendices P and Q), and from the school principals (Appendix C). The teachers signed letters of consent (Appendix A), which informed them about the purpose of the study, their expected role, the way in which confidentiality would be assured, and their right to participate or withdraw voluntarily. Permission to video-record the focus-group discussions was obtained from the teachers.

The privacy of participants was protected, and all participants were assured of confidentiality of results from the study, as well as anonymity. Practical steps that were taken to ensure confidentiality and anonymity in the sample selection phase and data collection phase are detailed below.

In Phase 3 of the study, a list of schools was obtained from the Provincial Department of Education. The researcher randomly selected two schools: schools were about 20 km apart while the district had a diameter of around 70 km. Each was assigned a code by which it was identified throughout the study. The two schools are labelled School 1 and School 2. Participating teachers were also assigned codes and synonyms. These codes were used whenever reference was made to them, so that the identities of the teachers were not revealed. Teachers were labelled T1 to T6 for the first school and T7 to T12 for the second school to maintain anonymity. The researcher explained to the participants that the information supplied by them and their identities would be treated confidentially and would not be disclosed to the public. The names, addresses, and locations of participating schools, teachers, and those steeped in IK tradition were not revealed in the study report. Only the name of the educational district where the data were collected was revealed in the study report.

3.10 Chapter summary

In this chapter, the research methodology and other procedures used to collect and analyse data was discussed in detail. First, the research method and design was described and the sampling procedure explained. Second, the function of the pilot study and its results were used to lay down the stages for administering the main study. Third, methods of data collection, analysis and trustworthiness procedures were discussed. Finally, ethical considerations were explained. The next chapter presents the results of the study.

CHAPTER 4

STUDY RESULTS

4.1 Introduction

Chapter 4 presents the results of this study in line with the study's research questions. Section 4.2 is about the developed epistemological framework and section 4.3 is about the indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture that were identified and documented. Finally, Section 4.4 is a presentation of results from focus-group discussions which were conducted with science teachers exploring ways in which the selected IK practices could be integrated into the school science curriculum.

4.2 Framework for identifying and analysing IK epistemologies

The first research question was concerned with the development of a conceptual framework for identifying IK epistemologies for the purpose of integration with school science education.

Research question 1

How can, from a theoretical perspective, epistemologies of indigenous knowledge be identified for integrating IK into school science teaching curriculum in a valid and legitimate way?

In an attempt to answer this research question, an epistemological framework was developed in order to help the teachers to identify epistemologies of indigenous practices and technologies (ref. 2.7). The epistemological framework (ref. 2.7: Figure 2.1) was intended to assist the users (teachers) to determine the grounds on which the truth-values of local knowledge and practices may be validated. Teachers were asked: What makes a local practice or knowledge classifiable as coinciding with the correspondence theory of truth, pragmatic theory of truth, coherence theory of truth or possibly any other? For example, the epistemology for the cereal seed preservation method in Table 4.1 (below) ought to be described as reality or knowledge that has been constructed based on the correspondence and pragmatic theories of truth as explained in Table 4.1 below.

The correspondence theory of truth adheres to the view that a knowledge claim or belief is true provided there is a fact (empirical base) that corresponds to it. The pragmatic theory views truth in terms of what would solve a problem. The coherence theory accepts a belief as true when it fits well with accepted systems of beliefs.

Table 4.1 Example of interpretation using the epistemological framework (Figure 2.1)

IK practices or beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Cereal seed preservation method for a variety of seed crops such as maize, millet and sorghum, using soot	The practitioners demonstrated the empirical base to this practice, therefore the reality of this practice is constructed with reference to the correspondence theory of truth	The practitioners have used it for a long period, confirming each time that it works. Therefore the reality of this practice has been constructed with reference to the pragmatic theory of truth	The practitioners have not found that this practice conflicts with any of their beliefs.

4.3 Indigenous knowledge community-based practices of agriculture, technology and health

The second phase of the study focused on research question 2 presented below:

What indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture in Chikwanda district in Zimbabwe can be identified and documented?

In an attempt to answer this question, interviews, observations, and artefacts were used as data sources in collecting IK practices and technologies.

4.3.1 IK practitioners narratives on agricultural practices

Practitioners' narratives on agricultural practices are presented below in sections 4.3.1.1 and 4.3.1.2. The practices are the cereal seed preservation method and the use of waste products from animals, specifically cow dung, to fertilize crops.

4.3.1.1 Topic: Cereal seed preservation method

Indigenous Knowledge Practitioners 1 to 4 (involving 4 key (P1, P2 P3 P4) informants) gave their description of the cereal seed preservation method. P2's description is representative of the practice:

> "*During harvest time, which is usually in April and May, we select a variety of seed crops such as millet, maize, and sorghum. We exchange crop seeds with our relatives and neighbours to get better and higher yields. We have observed that using the seed produced from the same crop over many seasons makes the crops weak. We select and store in our traditional kitchen sufficient and suitable crop seeds for planting in the next season. We do not shell the maize, millet and sorghum seed from the stalk to make it easy for us to hang them inside the thatched kitchen. A variety of seeds are stored and preserved by hanging the stalks on the inside surface of the thatched roof of the round kitchen. As we make fire every day for cooking, the smoke gets to the seeds and black soot covers them over time. The kitchen temperature is generally high and sufficient for hardening the hanging seeds.*

We have observed over time and have realized that pests do not attack seeds with soot. This method of seed preservation has been used by our people over many generations. It is our method for preserving seeds from being attacked by pests, which we refer to as kudzivirira zvipfuto*, which is translated as 'preserving the seed crops from being attacked by weevils'* ".

"*We keep the seeds in the kitchen until the next planting season, which is usually in November and December. This practice is called Kuchengetedza mbeu muchiutsi mumba yokubikira in our Shona language".* Which means preserving the seed crops using carbon soot from firewood smoke.

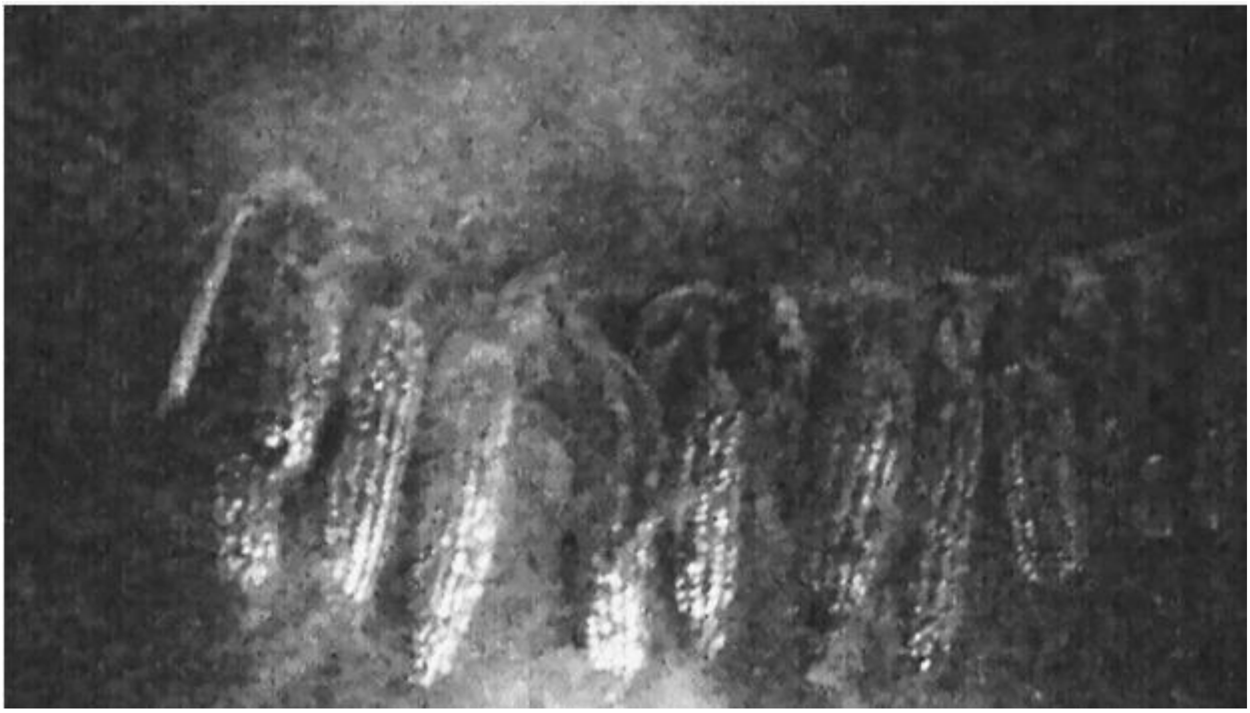

Figure 4.1 Picture of maize stalks tied inside a round kitchen's roof in the Chikwanda district

Table 4.2 Researcher's' epistemology for cereal seed preservation method

IK practices/technologies	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
The people in Chikwanda used observation and inference to produce the IK on cereal seed preservation method for a variety of seed crops such as maize, millet and sorghum, using soot	Every aspect of the practice has empirical evidence	Knowledge developed through careful observation of trial-and-error experiments leading to creativity and has worked for the people	Not in conflict with any aspect of their worldviews

4.3.1.2 Local fertilizer

The other practice that was described on the subject of agriculture is the use of cow dung as local fertilizer. The informants provided this description of the use of waste products from animals, specifically cow dung, to fertilize crops.

> "*We use* mupfudze *(cow dung) from our cattle kraals to fertilize crops such as maize. Over time our ancestors observed the healthy growth of grass around the cattle kraals and attributed it to cow dung. It was through keen observation of their surroundings that they came to associate cow dung with healthy plant or grass growth, especially in the rainy season. Almost everyone in this community uses cow dung from the cattle kraal as fertilizer for growing their crops. Before planting our crops, we spread* mupfudze *evenly all over the field and when the rains come, we then plant our crops.*"

Figure 4.2a Picture of cow dung from Chikwanda district

Figure 4.2b Picture of cow dung from cattle kraal ready for dispatch to the fields (from Chikwanda district)

Table 4.3 Researcher's epistemology for indigenous method for fertilizing crops such as maize using cow dung

IK practices/ beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
The people have observed the healthy growth of grass around the cattle kraals, became curious, and made certain inferences which lead to the use of cow dung as an Indigenous method for fertilizing crops such as maize	Every aspect of this practice has empirical evidence therefore the correspondence theory of truth best describes the epistemology of this practice	The method works and the pragmatic theory of truth also described the epistemology of this practice	Not in conflict with the people's practices and beliefs

4.3.2 IK practitioners' narratives on health practices

Practitioners' narratives on health practices are presented below in sections 4.3.2.1 and 4.3.2.2. The practices are the treatment of abdominal diseases using the munhunguru tree and the method for treating coughs and abdominal pains using the *chimuwatonzvi* herb.

4.3.2.1 Treatment of abdominal diseases using the munhunguru tree (Flacourtia indica)

Within the community in the Chikwanda district in Zimbabwe, there are various practices that used plants and herbs for dealing with ailments. One of the two examples that were investigated has an unusual practice attached to it.

Indigenous knowledge practitioners 17 to 20 described an abdominal disease treatment method using the *munhunguru* tree *(Flacourtia indica).* In the community, various practices use plants and herbs to deal with ailments. The practice that is presented in this report is unusual. P20's description (below) is representative of the practice.

"In this community, if a person is suffering from abdominal pain, tummy ache or diarrhoea and he or she is unable to walk on his or her own, other helpers generally carry the patient to the bush. The patient is lifted up and assisted to pluck two to three leaves of the munhunguru tree with his or her mouth, like a giraffe say, without touching the leaves of the tree. The medicine is supposed to work only when the patient takes the prescribed number of leaves with the mouth without touching the leaves. I think that our elders might have included this aspect or requirement after realizing that the resource of the munhunguru tree might be depleted if nothing is done. The poor health of people in the rural community caused mainly by waterborne diseases and communicable diseases could easily lead to environmental degradation-with many people wanting to use the munhunguru tree for treating the ailments. So plucking the leaves with the mouth is a deliberate strategy, I think, designed to ensure that the tree is not overly used as you can see there are very few trees of this kind in our area."

The participant continued:

"The patient chews about three leaves of the munhunguru tree and swallows the juice and he or she gets healed. It has been experienced over time that the quantity of leaves has to do with the amount of juice that comes out of them. Three leaves produce juice just sufficient for treatment without causing harm to patients. Our ancestors observed the animals getting relief from this tree and started to use it by trial and error until they realized that the dosage of three leaves is sufficient for a human being. If the patient takes too much, the ailment gets complicated. We also use 'munhunguru*' to cure problems associated with breathing. We also boil leaves of* munhunguru plant together with leaves of zumbani plant (Lippia juvanica) and use the decoction to cure malaria. Commonly we make tea by boiling zumbani leaves in water. The tea tastes good, you know."

In the scientific community, the munhunguru plant (Flacourtia indica) has demonstrated several pharmacological attributes including antimalarial, antioxidant, antimicrobial and antiasthmatic properties as revealed by laboratory research (Kota, Kannan & Rajasekar, 2012). According to the literature, traditional medical practitioners in Tanzania have used this medicinal plant over the years for curing diseases such as malaria and diarrhoea (FAO Corporate Document Repository, 1993).

Figure 4.3a Part of *Flacourtia indica* tree, picture from Chikwanda district

Figure 4.3b Small branch of *Flacourtia indica* tree (Wikipedia, 2013)

Table 4.4 Researcher's epistemology for abdominal pain and diarrhoea treatment method using the *munhunguru* tree

IK practices/ beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Abdominal pains and diarrhoea treatment (AP&DT) using a certain amount of leaves from the 'munhunguru' tree *(Flacourtia indica)*	Some aspects of the practice are observable, and it is not clear whether those that are not observable have any effect. This is a IK practice which is both empirically based and socially and culturally embedded, which also involves imagination	While the metaphysical element makes it difficult to know why the medicine works, the truth-value of this practice needs to be checked	The claims are consistent with the people's supernatural beliefs

4.3.2.2 Treatment of cough using chimuwatonzvi

A similar use of plants in the sphere of health involves the treatment of coughs. The same plant is used to treat abdominal pain. Indigenous knowledge practitioners 21 to 24 described a method for treating coughs and abdominal pains using *chimuwatonzvi (Dicoma anomala).* IK practitioner 24's description (below) is representative of the practice:

> "*We use* chimuwatonzvi *to treat coughs and abdominal pains.* Chimuwatonzvi *is a shrub with a tuberous root that normally grows to the size of a chicken egg. To treat abdominal pain, we crush one to two tubers of the* chimuwatonzvi *and mix it with a cup of water. Half a cup of the mixture is then given to the patient to drink three to four times a day. Normally a person is healed within three days of starting treatment. For treating something like coughs and the chest pain caused by coughing, we prepare a more concentrated mixture by doubling the number of tubers in the cup of water, as cough mixture. In some cases with severe coughing the patient may be asked to chew the tubers directly and swallow only the juice.*"

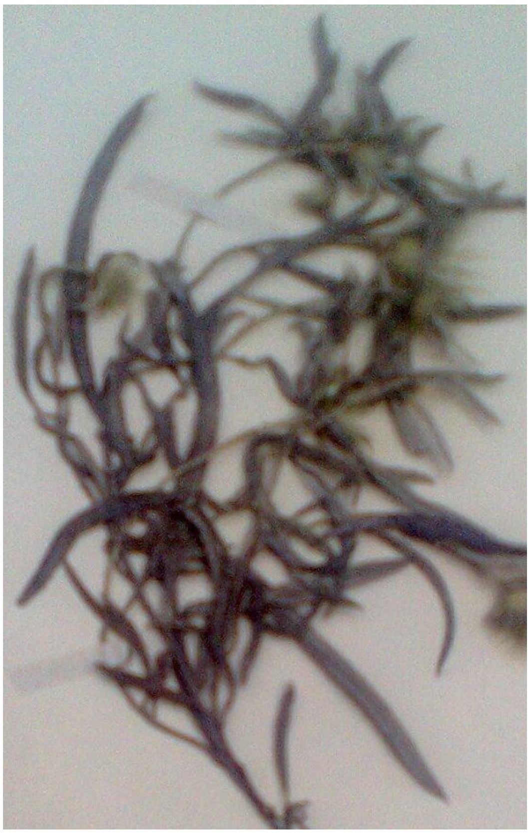

Figure 4.4 Picture of *Chimuwatonzvi* or *Dicoma anomala*

Table 4.5 Researcher's epistemology for cough and abdominal pain treatment method using *Dicoma anomala*

IK practices/ beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Cough and abdominal pain treatment method using *Dicoma anomala*	Every aspect of the practice has empirical evidence	Reality of this practice is constructed with reference to the pragmatic theory of truth	Not conflicting with other beliefs

4.3.3 IK practitioners' narratives on technological practices

Practitioners' narratives on technological practices are presented below in sections 4.3.3.1 and 4.3.3.2. The practices are the traditional fire-making technology and the traditional roof-making technology.

4.3.3.1 Making a fire

The next paragraph describes the techniques used traditionally by the community to start a fire. Indigenous knowledge practitioners 9 to 12 described the primitive technology that was used successfully for starting or making a fire for cooking and other purposes in their homes. The narrative of the fire-making technology is presented below.

> "*Long ago before the white settlers brought in and introduced to our people matches as a quick way of making fire, our elders used to start fire using the* mukubvu *tree* (Vitex payos). *We no longer use this method, but we believe it is essential that everyone in our society should possess such knowledge and skills. This is why this knowledge has been passed on over generations."*

> *"Our forefathers used to start fire from the friction of two bone-dry pieces of* mukubvu *tree. First, they would make a hole halfway into a thick piece (log) of dried* mukubvu *tree. The thick piece of the very dry* mukubvu *tree should be about 15 cm in diameter [using the fingers of his palms to demonstrate the inferred diameter of the tree]. They would then make a metre-long spindle cut from a dry piece of* mukubvu *tree. The spindle would be of a diameter around 2 cm. One end of the spindle was sharpened with a stone, rock or a sharp object of metal such as a knife. The sharp end of the spindle was then placed into the prepared hole of the* mukubvu *log. Several people in turn would roll the spindle by running it very fast between their palms to produce a temperature hot enough to have an ember to start glowing.*"

Figure 4.5 Picture of *Vitex payos* tree from Chikwanda district

Table 4.6 Researcher's epistemology for primitive technology for starting or making a fire

IK practices/ beliefs	**Correspondence theory of truth**	**Pragmatic theory of truth**	**Coherence theory of truth**
Primitive technology using the 'mukubvu' tree *(Vitex payos*) in English to make a fire a practice based on imagination and creativity	All aspects of this practice are observable	Knowledge developed in order to solve a problem they had encountered and to enhance their lives	Not in conflict with any of the people's beliefs

4.3.3.2 Roof thatching

The other practice that was described under the area of technology is traditional roof thatching. Indigenous knowledge practitioners 13 to 16 described traditional roof-making technology, which is used by many people in their community today.

> "*We use dry grass, dry poles and ropes obtained from the inner side of the barks of trees such as the* mutondo *tree* (Julbernardia globiflora) *to roof our huts and houses. Skilled artisans like me first fix the poles, about four or five wooden poles, in such a way that they all meet at one point (i.e. the apex of the roof under construction) in the middle of the hut. We do not use poles from any tree, but only trees that traditionally we know such as murwiti are strong and durable. After fixing the apex of the roof, we then position several wooden poles cut to the required length on which the dry grass [thatch] will be attached using the sisal ropes. The lower part of all the poles rest on top of the wall of the hut, extending about one metre downwards (in slanting form) from the wall to form an open shade round the hut.*
>
> *We then sew the thatch on the poles layer by layer working from the bottom to the top of the roof using dry grass and ropes obtained from the inner side of the bark of trees such as mutondo tree because they are strong and long lasting.*"

Several concepts such as shapes, force, materials, angles (trigonometry) and measurement that are embedded in this local technology can be integrated in science, mathematics and technology topics.

Figure 4.6 Picture of thatched roof of round hut from Chikwanda district

Table 4.7 Researcher's epistemology for traditional roof-making technology

IK practices/ beliefs	**Correspondence theory of truth**	**Pragmatic theory of truth**	**Coherence theory of truth**
Traditional roof-making technology	All aspects of this practice are observable	Pragmatic	Not conflicting with other beliefs

4.4 Exploring IK integration with teachers

The third phase of the study focused on the following research question:

Research question 3

How should the identified indigenous knowledge and practices be integrated into school science teaching?

In Phase 3 of the study, the documented IK practices and technologies were made available to two groups of science teachers. Focus-group discussions were conducted using the epistemological framework (ref. 2.7: Figure 2.1) and argumentation to analyse and identify epistemologies for IK practices exploring ways in which the selected IK practices could be integrated into the school science curriculum. The teachers were requested to use the three theories of truth and supply reasons (argumentation) that a local practice or knowledge could be classified as coinciding with any of the three theories of truth in the epistemological framework.

Several facts emerged with respect to the epistemologies of the six IK practices and technologies. These are presented in the teachers' voices below. The group's responses were categorized deductively using the three theories of truth (ref. 4.4.1 to 4.4.6). Several facts emerged with respect to the epistemologies of the six IK practices and technologies. These are presented in the next sections.

4.4.1 Epistemologies of the method of cereal seed preservation

The focus group discussions started with the analysis of the method of cereal seed preservation. The views of the teachers about the epistemology of this practice are presented in italics below:

> T12 *"To my mind, one thing that is very clear is that there is empirical testability and rationality in this practice. Every stage or the whole process in the practice can be*

observed enabling us to argue that the correspondence theory of truth best describes the epistemological basis of this practice if we are to go by the framework we are using"

T10 *"The creativity and resourcefulness of these people in their historical context for tackling their socio-economic problems is seen in such practices. The cereal seed preservation method has been used by these people over many generations and is practiced because it solves a problem. The pragmatic theory of truth therefore describes the epistemological basis of this practice.*"

T8 *"In my view, this practice demonstrates that these people are intellectually capable as is demonstrated by their creativeness and resourcefulness. To add to what T10 and T12 have just said, my view is that both the correspondence theory of truth and the pragmatic theory of truth best describe the epistemological base of the cereal seed preservation method."*

T2 *"Two things are clear from the above description. First, there is empirical evidence and the outcome is evident, second they really do it, they have been doing it over years, have observed the process and have realized that it works... pragmatic theory also explains why it is a reality."*

T4 *"Since all the processes in the cereal seed preservation method can be observed and in actual fact can be practically done, reality is grounded on empirical evidence. The people in Chikwanda have constructed the reality of this practice on the basis of the correspondence theory of truth."*

Table 4.8 Summary of the teachers' views on the epistemology for cereal seed preservation method

IK practices/technologies	**Correspondence theory of truth**	**Pragmatic theory of truth**	**Coherence theory of truth**
Cereal seed preservation method for a variety of seed crops such as maize, millet and sorghum, using soot	*'Since every stage in the practice can be observed and done practically and the outcome is evident, reality is grounded on empirical evidence. The reality of this practice is constructed with reference to the correspondence theory of truth'*	*'Cereal seed preservation method has been used by these people over many generations and is practiced because it solves a problem. The reality of this practice is constructed with reference to the pragmatic theory of truth too'*	None of the teachers referred to the coherence theory. The reality of this practice is not constructed with any reference to the coherence theory of truth

4.4.2 Epistemologies of the indigenous method for fertilizing crops

The IK method for fertilizing crops was the next IK practice that the teachers analysed.

Teachers' voices about its epistemology are presented below:

T10 *"From the description we have just read, these people like scientists have used their senses of sight, reflected on the data, came up with a hypotheses, made several observations and finally confirmed their theory which is a generalisation in their community today. This is so considering what the practitioners have said- 'our ancestors observed over time the healthy growth of grass located around the cattle kraals and attributed it to cow dung. It was through the keen observation of their surroundings that they came to associate cow dung with healthy plant or grass growth especially during rainy season.' It is obvious then that the reality of this practice is best described with reference to the correspondence theory of truth. The whole process can be observed and we can logically then argue that this practice is base on empirical evidence."*

T11 *"It is also logical from the truth theories in our framework that the reality of this practice should also be described with reference to the pragmatic theory of truth."*

Table 4.9 Summary of the teachers' views on the epistemology for the indigenous method for fertilizing crops

IK practices/ beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Indigenous method for fertilizing crops such as maize	*'The reality of this practice is constructed with reference to the correspondence theory of truth.*	*'Reality of this practice is constructed with reference to the pragmatic theory of truth'*	None of the teachers referred to the coherence theory of truth

4.4.3 Epistemologies of the abdominal pain and diarrhoea treatment method using the *munhunguru* tree

The abdominal pain and diarrhoea treatment method was the third IK practice that was analysed. By the teachers. Teachers' views about its epistemology are presented below:

T7 "*Since the medicine only works when the patient takes the leaves without touching the leaves, the metaphysical element makes it difficult to know why the medicine works from a scientific point of view. But, I am of the view that because it is said to work it is useful. Considering our framework, reality of this practice is only constructed with reference to the pragmatic theory of truth.*"

T9 *"I don't think so because the process can be observed and the outcome can be observed. For our purposes I believe what is important is that there is empirical evidence despite the fact that there is a metaphysical element attached to this practice, allowing us to say that the correspondence theory of truth partially describes the epistemology of this practice."*

T8 "*There is need for us to understand the imaginativeness and interpretive experience of these people in this practice, a particular way of thinking and knowing is evident form how* *they deal with their environment. There is the existing reality that the conservation status of Flacourtia indica –the 'munhunguru' tree is threatened, and that is the reason why the elders or practitioners have attached that requirement as was described in the transcription, which for us may be an example of indigenous environmental knowledge. Therefore it is clear that the treatment works, the metaphysical element though not scientific was just attached to the practice simply for purposes of preserving the tree."*

T7 *"What we should do then is to subject the practice to experiments but I fear if we find out that the treatment works without observing the metaphysical element this will be the end to the metaphysical/spiritual aspect which is not scientific of this practice."*

T9 *"The fact remains that the practice is based on both the correspondence theory of truth and the pragmatic theory of truth."*

T12 *"Yes, that cannot be denied if we are to go by our framework."*

Table 4.10 Summary of the teachers' views on the epistemology for abdominal pains and diarrhoea treatment method using the *munhunguru* tree

IK practices/ beliefs	**Correspondence theory of truth**	**Pragmatic theory of truth**	**Coherence theory of truth**
Abdominal pains and diarrhoea treatment using a certain amount of leaves from the *munhunguru* tree *(Flacourtia indica)*	*'empirical evidence despite of the fact that there is a metaphysical element attached to this practice, allowing us to say that the correspondence theory of truth describes the epistemology of this practice'*	*'Since the medicine only works when the patient takes the leaves without touching the leaves, the spiritual element makes it difficult to know why the medicine works' The teachers think that 'because it is said to work it is useful. Reality of this practice is constructed with reference to the pragmatic theory of truth'*	None of the teachers directly referred to the coherence theory of truth.

4.4.4 Epistemologies of the cough and abdominal pain treatment method using *Dicoma anomala*

Teachers' voices about the epistemology of the cough and abdominal pain treatment method using *Dicoma anomala* are presented below:

> T7 *"Here it is obvious that the best theory of truth to describe this practice is the correspondence theory of truth since the reality of this practice is constructed with the reference to the correspondence theory of truth."*

> T10 *"Like in most of the practices we have discussed, the reality of this practice has been constructed with reference to the pragmatic theory of truth and if we are to go by our framework the pragmatic theory of truth also describes the epistemology of the cough and abdominal pain treatment method using Dicoma anomala ."*

Table 4.11 Summary of the teachers' views on the epistemology for the cough and abdominal pain treatment method using *Dicoma anomala*

IK practices/ beliefs	**Correspondence theory of truth**	**Pragmatic theory of truth**	**Coherence theory of truth**
Cough/ abdominal pain treatment method using *Dicoma anomala*	*'The reality of this practice is constructed with reference to the correspondence theory of truth'*	*'Reality of this practice is constructed with reference to the pragmatic theory of truth'*	None of the teachers referred to the coherence theory of truth

4.4.5 Epistemology of technology for making a fire

Teachers' voices about the epistemology of the technology for making a fire are presented below:

> T9 *"empirical evidence shows how the technology works, everything about it can be observed … the method works." T6 "The correspondence* theory is its epistemology*"*.

Table 4.12 Summary of the teachers' views on the epistemology for the primitive technology for making a fire

IK practices/ beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Primitive technology using the *mukubvu* tree *(Vitex payos)* to make a fire.	'*Empirical evidence shows how the technology works, everything about it can be observed*' The action of causing friction brings about the reality of this practice, which is constructed with reference to the correspondence theory of truth. The evidence of the produced fire corresponds with the reality they have in their minds	'*The method works*' Reality of this practice is constructed with reference to the pragmatic theory of truth	None of the teachers referred to the coherence theory of truth

4.4.6 Epistemologies of traditional roof-making technology

The last IK practice that was analysed by the teachers was the traditional roof-making technology. The views of the teachers about the epistemology of this practice are presented below.

> T12 *"The reality of this practice is constructed with reference to the correspondence theory of truth."*
>
> T11 *"Reality of this practice is constructed with reference to the pragmatic theory of truth."*

Table 4.13 Summary of the teachers' views on the epistemology for traditional roof-making technology

IK practices/ beliefs	Correspondence theory of truth	Pragmatic theory of truth	Coherence theory of truth
Traditional roof-making technology	*'The reality of this practice is constructed with reference to the correspondence theory of truth.*	*'Reality of this practice is constructed with reference to the pragmatic theory of truth'*	None of the teachers referred to the coherence theory of truth

4.4.7 Summary of the themes that emerged from the teachers' views about epistemologies of the six IK practices.

By deductively categorizing the group's responses using the three theories of truth as given in the Tables 4.8 to 4.13 the following three themes emerged with respect to the epistemologies of the six studied IK practices and technologies:

First, five of the six listed practices – cereal seed preservation method, primitive technology for making a fire, traditional roof-making technology, cough and abdominal pain treatment using *Dicoma anomala,* and the use of cow dung for fertilizing crops such as maize – have empirical evidence as their predominant epistemological base. According to the teachers' responses, the explanatory scientific principles that underpin these practices are that they are done practically, all their procedures can be observed, and they are repeatable, producing similar or identical results. These reasons should allow for their incorporation into their science teaching.

Second, what was observed about one IK practice, namely treating abdominal diseases with the *munhunguru* tree, is that the unusual element of plucking the leaves with the mouth was attached to this practice to foster certain kinds of behaviour. On the whole, in the context of science classroom teaching the need to know how, why and if something works could present its challenges in determining appropriate methods for teaching or investigating this IK practice in science lessons. On the other hand, evidence exists that a particular tree or plant contains active ingredients (antimicrobial agents) that are found scientifically to be effective in treating a wide range of infectious diseases (Kota, Kannan & Rajasekar, 2012). With this information, the teachers could undertake investigation or research of the literature.

Finally, having identified the epistemologies for the IK practices, the third theme was about teachers' views about the suitability and justification for integrating IK into school science. They claim it would allow local issues and practices to be incorporated into the science curriculum in line with Holbrook's (2009) discourse on science education in the context of sustainable development.

4.4.8 Teachers' perceptions of indigenous and scientific knowledge integration in school science

Three themes emerged from their views about the integration of IK into school science. First, about 25% of the teachers expressed cognitive shifts from an initial mindset of total exclusion of IK practices to a willingness to include or at least introduce in their science lessons where appropriate those aspects of IK which have a scientific base. They moved from thinking that all IK is 'primitive' and 'superstition ridden' to realizing there are IK customs that are practised on the basis of acceptable, sound and valid reasons. This is the stance taken by T3 (T = Teacher) and T6 as expressed by T6:

> *"I used to think that all IK is primitive and superstition dominated and not to be included in science ... I now hold the view that there are many IK practices that are based on reasons that can be identified using this framework, and when this is done it helps us to have a clear understanding of its identity ... most of the practices we have studied here have empirical evidence ... the correspondence theory explains these practices. I now believe that it is a beneficial effort to teach science integrating IK into it because when the two are combined one realises that not all IK is based on spiritual beliefs ... the cereal seed preservation is a practice that could be grounded on empirical evidence."*

Similarly, T3 testifies that:

> *"I used to look at IK practices and treating them all as based on spiritual beliefs and not worthy of entertaining and including in science ... I now see that some IK practices are practiced based on empirical evidence ... The correspondence theory explains the epistemologies for those IK practises with empirical evidence such as cereal seed preservation method."*

This emerging theme is evidence of teachers' cognitive shifts as noted by Ogunniyi (2011).

ii) Other teachers (17%) argued for the total exclusion of IK practices with no empirical evidence or basis. These teachers believe that some IK practices and beliefs, including the supernatural, contain components that are inadmissible in science. T1 for example, insists that:

> *"I don't think science should entertain and I strongly argue that science should not entertain those IK practices and beliefs that have no good grounds for supporting their reality; I mean those IK practises that have no empirical evidence and those with spiritual elements. ... They have no room in science because science is about facts, laws and theories that require empirical evidence."*

T12 also agrees that:

> *"The truth-value of those IK practises that have spiritual elements cannot be established and these must be totally excluded from science, in fact they do not exist. ... This framework is good because it will help us to battle and throw away the IK practices and beliefs that should not be part of science. ... Only practices like cereal seed preservation which have empirical evidence should be entertained in science."*

(iii) The remainder (58%) support the idea of including most aspects of IK in science classroom practice but at the same time carefully indicating the nature of the knowledge and being clear on the purpose of its inclusion. These teachers felt that the exclusion of some components of IK would somehow diminish its holistic features (Emeagwali, 2003). They argue that it would afford learners an opportunity to engage in a holistic way in science teaching and learning process, notably in argumentation, experimentation and decision making; emphasizing the point that accessing IK for practical purposes is inherently a complex process.

T11's view as follows is representative of this majority third theme:

> *"Total exclusion of some components of IK practices when integrating it with science is likely to diminish the holistic picture of IK we are aiming to preserve. By that I mean the opportunity to harness the holistic value of IK in the teaching and learning process. I believe it is necessary for such IK to benefit from both laboratory testing and from investigations that try to find out reasons why they are practised. We should include in the teaching and learning of science aspects of IK used by the people to help explain their scientific activities or the science embedded in them if any, inclusive of those with spiritual components. Some aspects may have no place in the school science curriculum as scientific knowledge, but for purposes of deliberation they should be included at the same time showing the rationale. Although there may be no empirical evidence for the spiritual components perhaps with some of these practices learners could benefit from laboratory testing research, indigenous ways of doing research, learner argument and contribution. Especially to reinforce the idea that science may not always have all the answers, it is tentative. After all, it is a human activity with obvious limitations and boundaries. Things can change."*

This view is in synchronization with what others have argued, namely that inclusion of local knowledge in the science classroom could provide opportunities for various knowledge systems to develop synergies that would respect and value indigenous knowledge systems (Onwu & Mosimege, 2004; Ogunniyi & Hewson, 2008).

4.4.9 Teachers' perceptions of suitable teaching methods and possible outcomes

Based on the epistemologies they described, the teachers suggested methods for teaching the six IK practices that were used in this study, and gave their views on methods that are suitable for integrating these practices into the science classroom. They also expressed the view that indigenous and scientific knowledge integration has potential for enhancing learners' performance.

> T3: *"Experiments, observations, practical lessons, argumentation and discussions can be used to teach those practices with empirical evidence such as cereal seed preservation. For example, seeds can be placed in different places, some in a place where there is supply of smoke every day and some in a place where there is no smoke supply. Having subjected seeds to these two different conditions, observation can be done over five or more months to see what happens. This implies experiments and practicals. Cereal seed preservation IK practice should be taught in agriculture, under the topic 'Pests and disease control' with specific focus on requirement for germination and optimum growth. I believe, if learners' alternative conceptions are explored this could improve conceptual understanding in the teaching of science. Argumentation and discussions are very useful for exploring learners' alternative conception."*

T1: *"Cereal seed preservation practice should also be taught in integrated science, under the topic science and agriculture, again focusing on seeds and seeds germination, because once we talk of a seed which does not germinate, maybe the weevils will have damaged the embryo of the seed. So under germination we discuss seed and seed germination and possible causes of germination failure. I have observed in my teaching that exploration of contexts each time at the beginning of my science lessons helps to arouse my learners' interest in concepts being taught. I am sure based on my personal experience; the use of IK context-based will go a long way towards enhancing learners' performance as this approach to teaching science has motivational value to learners."*

T6: *"Chemistry could also have experiments under the topic chemical properties useful for agricultural practices. They may want to check on the effects of carbon monoxide and carbon dioxide on pests. These experiments on content that is familiar and relatable to learners provide them with great opportunities to explore applicable socio-scientific issues and to critically examine their prior conceptions and misconceptions regarding a given scientific phenomenon. For example, learners are likely to understand that there are alternative effective methods of cereal seed preservation. Argumentation and discussions together with experiments are most likely to produce this desired outcome."*

T4: *"Cereal seed preservation practice can also come under seed dressing as a topic in agriculture. Seed dressing, because when the seed is being dressed, there is need to harden the seed before application of chemicals for pest control. This procedure is in fact similar to the one used in the seed dressing method in Western science. In the first place, the recommended moisture content is taken into consideration as the seed is hardened, and* *thereafter the seed is treated with chemicals. This IK practice is similar to Western science because in the kitchen there is heat plus the shade to cater for reduction of moisture content as well as hardening of the seed which gradually takes place as the seed is kept under kitchen temperatures and continuously gets covered by the smoke (soot). The soot preserves the seed from being attacked by the weevils. I agree the empirical evidence of this practice as well as for all those with empirical evidence makes experiments, observations and practicals suitable teaching methods for them."*

T12: *"Cereal seed preservation is a practice that has a practical component to it, which may be carried out at home. This practical is too evolving, let students observe the process at home and let the teacher just have a theory lesson to teach this practice. It takes more than six months to get the results. It is a challenge because this observation has to be done over a long period."*

T11: **"***If we take practices such as cereal seed preservation into the classroom it might be time consuming. I agree, with such practices, teachers should organize outdoor visits to homes where it is being practised. The project method is one appropriate teaching and learning method. Teachers can start with the theory lesson and then have an outdoor visit with their learners to go and observe what the practitioners do."*

Some teachers expressed their views in comparison with other practices and beliefs. A representative statement of T2, 7, 8 and 9 was presented by T8:

"We do have serious challenges if not an impossibility to describe teaching methods for IK practices with spiritual aspects, but with respect to practices with pragmatic value their epistemological grounds could be shown ... based on scientific technological or

mathematical principles. These could then serve as useful indicators for appropriate teaching methods."

T6: *"Experiments, observations, practical lessons, argumentation and discussions can be used to teach those practices such as abdominal pains and diarrhoea treatment using the* munhunguru *tree and cough/ abdominal pain treatment method using* Dicoma anomala*."*

T2: *"Several concepts such as medicinal compounds and nutritional content, extraction and duration, chemical compositions, separation of substances, formation of solutions, temperatures and extraction, and stoichiometry [mathematical concepts in chemistry especially considering the dosage of the medicines] can be integrated in science mathematics and technology topics."*

T10: *"Considering the traditional roof-thatching practice, several concepts such as shapes, force, materials, angles [trigonometry] and measurement embedded in this local technology can be integrated in science mathematics and technology topics using experiments and practical lessons."*

T9: *"Many science concepts can be taught in physics and chemistry using the described techniques used traditionally by the community to start a fire for example friction, temperatures and fuels."*

The findings of the study showed that a conceptual framework based on truth theories of knowledge for interpreting epistemologies of IK practices and beliefs greatly assisted science teachers at two sample schools in Chikwanda District in Zimbabwe to identify epistemology(ies) of some selected indigenous knowledge practices. Second, the epistemologies helped the teachers to identify methods and approaches that could be used to integrate this knowledge into school science in a valid and legitimate way. Finally, teachers support the views that:

- If learners' alternative conceptions are explored, this could improve conceptual understanding in the teaching of science.
- The use of IK that is context based will go a long way towards enhancing learners' performance as this approach to teaching science has motivational value to learners.
- Experiments on content that is familiar and relatable to learners provide them with great opportunities to explore applicable socio-scientific issues and to critically examine their prior conceptions and misconceptions regarding a given scientific phenomenon.
- To sum up observation, experiments, projects, practicals, argumentations and discussions are suitable methods that can be used in the integration of IK practices in school science teaching.

4.5 Chapter summary

In this chapter, the results of the study were presented. The most important results are, first, that indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture that were identified and documented. Second, that focus-group discussions which were conducted with science teachers exploring ways in which the selected IK practices could be integrated into the school science curriculum produced significant data. In the next chapter, discussion is needed to establish some generalisable findings in line with the research questions. The next chapter presents a discussion of the results.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 Introduction

This chapter presents a discussion of the results, focusing on the epistemological basis for the integration of indigenous knowledge into science education. Specifically the discussion focuses first on data of community-based IK practices in health, agriculture and technology to find out to what extent some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that allows for their incorporation in school science teaching. Second the discussion pays attention to data from the focus-group discussions with science teachers concerning the epistemologies of IK practices and the integration of IK into science teaching.

5.2 Organization of the findings of the study

The presentation of the findings is guided by the research questions. Each of the questions is presented under the phase to which it is related in Sections 5.3 to 5.5 below.

5.3 Phase 1: Developing a framework for analysing IK epistemologies

Research question 1:

How can, from a theoretical perspective, epistemologies of indigenous knowledge be identified for integrating IK into school science teaching curriculum in a valid and legitimate way?

In this study, the development of an epistemological framework to integrate IK into the school science curriculum has been regarded as one way of helping to improve learners' performance in school science. Understanding of epistemological similarities and differences between IK and school science is a prerequisite to indigenous and scientific knowledge integration (Kibirige & Van Rooyen, 2007; Bohensky & Maru, 2011).

Against this backdrop it became necessary to develop a conceptual framework for characterising IK epistemologies if any mainly with the aim of using the framework to analyse the following three aspects:

- Whether or not IK practices can be located within philosophical considerations of epistemology
- To identify epistemological features of IK particularly those which have to do with how it is produced and validated (Bernecker & Pritchard, 2012) and how this knowledge system could be reconcilable within the framework of science curricula (Webb, 2013)
- Whether those characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that helps to facilitate integration of IK practices into school science teaching.

The truth based framework for characterising IK epistemologies was used by science teachers to identify and analyse the epistemologies of the chosen six IK practices (ref. 4.4.1 to 4.4.6).

The findings revealed two aspects. First, that, IK practices can be located within philosophical considerations of epistemology. Second, that some characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that helps to facilitate integration of IK practices into school science teaching. It is also interesting to note that though only one out of the six practices used in this study contained an aspect of mysticism, the teachers managed to demarcate that aspect of IK as not science. Some aspects would require African argumentation. The findings allow it to be argued that the three theories of truth are appropriate for analyzing and identifying epistemologies of IK practices.

5.4 Phase 2: Community-based practices of agriculture, technology and health

5.4.1 Introduction

Research question 2 *What indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture in Chikwanda district in Zimbabwe can be identified and documented?*

Discussion of findings from IK practitioners' narratives on community-based practices focuses on the question: given that NOS demarcates science from other ways of knowing, to what extent do some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices? The discussion is done here also considering the epistemologies identified by the researcher (ref. 4.3.1: Table 4.2 to 4.7). Importantly, to find out the possibility of establishing some common elements between IK and school science (Kibirige & Van Rooyen, 2007). In a way if some of the characteristic features that underpin the scientific way of thinking are found in IK practices that would help to facilitate the integration of these practices into school science teaching. The characteristic features of the six studied IK practices identified by the researcher in the areas of agriculture, health and technology are discussed below, in sections 5.4.1 to 5.4.6.

5.4.2 Six studied IK practices and their characteristic features

The first practice that was described is the cereal seed preservation method (ref. 4.3.1.1). This is one case of evidence that, like scientists, indigenous people use observation and inference in processes of knowledge production (Lederman, Lederman & Antink, 2013). Several scientific principles are embedded in the various stages of the seed preservation method, such as the use of heat from the kitchen to harden the seed, and the use of soot as a chemical substance for the treatment of seed. In reality the teachers (T3 ref. 4.4.9 and T6 ref. 4.4.9) gave examples of topics in agriculture, chemistry, and integrated science in which the practice could be integrated, for instance.

The second practice that was described is the use of cow dung as a local fertilizer (ref. 4.3.1.2). Evidence shows that this practice has been produced by observing the natural world, and involves curiosity and human inference, allowing it to be argued that the process of this knowledge production is similar to the one scientists use (McDonald, 2013; Lederman, 2007). Here the community members have used what scientists regard as the process skill of observation to observe their environment and have made inferences about what causes the grass around the cattle kraals to grow healthy.

- Learners start by observing the healthy growth of grass located around the cattle kraals at home
- learners seek for explanations establishing similarities, differences, or relationships between school science and the IK practice used in the community
- Engaging in experiments, learners investigate the substances that cause healthy growth of grass located around the cattle kraals.

The third practice that was investigated is the abdominal pains and diarrhoea treatment with a certain amount of leaves from the *munhunguru* tree *(Flacourtia indica)* (ref. 4.3.2.1*).* The practitioners claim that the medicine works only when the patient takes the leaves by mouth without touching them with the hands. The practice carries a purely environmental degradation message, for sustainability, with the realization that indiscriminate use of the tree could lead to depletion. There is the existing reality that the conservation status of *Flacourtia indica* – the *munhunguru* tree – is threatened, and that is possibly why the elders or practitioners have attached that requirement so as to reduce the amount of leaves to be plucked as well as to discourage the cutting of the branches of the tree. As related by indigenous knowledge practitioner 20 (ref. 4.2.2.1), this degradation message may be an example of indigenous environmental knowledge.

In scientific research, the *munhunguru* plant *(Flacourtia indica)* has revealed several pharmacological properties, including antimalarial, antioxidant, antimicrobial and anti-asthmatic ones (Kota, Kannan & Rajasekar, 2012). According to the literature, traditional medical practitioners in Tanzania have used this medicinal plant over the years for curing diseases such as malaria and diarrhoea (FAO Corporate Document Repository, 1993).

The fourth practice that was investigated the use of *chimuwatonzvi (Dicoma anomala)* to treat cough and abdominal pain (ref. 4.3.2.2). The feature of empirical evidence that shows itself in this IK practice, allows for it's incorporation into school science teaching.

Mnengwane & Koekemoer (2007) have documented various diseases such as intestinal worms, colic, diarrhoea and dysentery that traditional medical practitioners in South Africa treat with root concoctions of *Dicoma anomala*, the *chimuwatonzvi* plant. Becker, Van der Merwe, Van

Brummelen, Pillay, Crampton, Maharj (2011) used standard phytochemical analysis techniques to investigate the active ingredient of *Dicoma anomala subsp. Gerrardii.* It was secluded and recognized as dehydrobrachylaenolide, and this amalgam confirmed *in vitro* anti-malarial activity against a chloroquine-sensitive strain of P. falciparum. Given the results of these scientific investigations, science teachers have the opportunity to investigate and build on the claims that the *chimuwatonzvi* plant can treat various diseases.

The fifth practice that was presented is the primitive technology that uses the *mukubvu* tree *(Vitex payos*) to make a fire (ref. 4.3.3.1). The empirically based stages of fire making, which involves concepts of friction and temperature, are indeed amenable to scientific principles, facts or experiments.

The sixth practice in the area of technology is traditional roof thatching (ref. 4.3.3.2). Several concepts such as shapes, force, materials, angles in terms of support and balance (trigonometry) and measurement embedded in this local technology (ref. 4.3.3.2) make this practice to be amenable to scientific principles, facts or experiments.

5.4.2 Summary

In summary, the findings have revealed that all the six IK practices have some characteristic features that underpin the scientific way of thinking (Lederman et al., 2013; McDonald, 2013). Although indigenous knowledge and scientific knowledge at times differ profoundly in terms of their ways of thinking, the six studied practices demonstrate that some IK practices are based on empirical evidence. The scientific characteristic features that show themselves in the production of some of these methods such as observation and inference help to facilitate the integration of such practices into school science teaching. The common elements between these IK practices and school science could provide opportunities for active learning in classroom science (Kibirige & van Rooyen, 2007). These features allow for the incorporation of these practices into school science teaching.

An example of how the incorporation can be done is to consider crossing the boundary into ‘theoretical’ knowledge with respect to the use of cow dung practice (ref. 4.3.1.2). Through naive experience of nature (observations by the community over time) a problem is observed (for example that crops do not grow optimally). This creates a community based problem statement. Later, further experience shows that the grass grows better in vicinity of cow dung. The community starts to apply this ‘pre-theoretical’ knowledge practically and to their advantage for many years. Now, to cross the boundary into ‘theoretical’ knowledge, this community practice gets formulated as a formal hypothesis: does cow dung make the grass grow better by acting as a natural fertilizer? This hypothesis is studied by abstracting only the physical and chemical aspects of the soil and the dung, and as a future perspective, perhaps the physiological aspects of plants in the typical formal scientific manner (laboratories, white coat wearing scientists and publications in accredited journals).

But the process doesn't stop here (i.e. on the "theoretical" level). The abstracted knowledge always has to be re-integrated into the fullness of holistic human experience. Scientific results are not produced to be kept in isolation and again find its way back to the community in the form of improved practical methods of fertilization. In turn, this can be integrated into the "pre-theoretical" system again, by for instance, developing new community rules for cattle management. Through this example, we can see that there is always a natural movement/links between the "pre-theoretical" and "theoretical" types of knowledge and that these two types of knowledge are not polar opposites, but rather alternating complements.

By understanding the epistemological nature of both science and indigenous knowledge correctly, it can be seen that these two types of knowledge complement each other. They are both (in their own way) inherently valid and necessary for human knowledge production. They should both be valued for their own sakes but considering demarcation. Demarcation is not meant for "condemning" parts of other knowledge systems which are not science, but rather for determining suitable methods for integrating aspects that are considered worthy teaching in the science curriculum.

5.5 Phase 3: Exploring IK integration with teachers

Research question 3

How should the identified indigenous knowledge and practices be integrated into school science teaching?

The literature review revealed that NOS demarcates science from IK (Good & Shymansky, 2001; Webb, 2013) (ref. 2.2.3). Further, although there are some similarities between science and IK there are some sharp differences which pose a serious challenge to integration of the two bodies of knowledge. Against this backdrop, suitable frameworks for demarcating science from IK and for characterising IK practices for purposes of determining appropriate teaching methods for this type of knowledge were found essential. In this study, using the epistemological framework, the groups of teachers were able to consistently identify and state the epistemological underpinnings of IK practices, demarcating aspects which do not fit to be considered as knowledge in science. The teachers described the epistemologies for each IK practice or technology (ref. 4.4.1 to 4.4.6). The findings support the view that the theories of truth used to develop the framework cover the range of truth meanings sufficient for identifying epistemologies of IK.

However, the same results reveal that it is not possible to categorise IK practices and technologies under one epistemological description. The problem, as was observed, is that IK epistemologies could not be categorized under one universal epistemology as is done when describing the epistemology of school science. The question then is: Is there an acceptable level of generality regarding understanding the nature of IK that is accessible to teachers and learners and relevant to their everyday lives in comparability to the "acceptable level of generality regarding understanding the nature of science that is accessible to learners" and teachers and relevant to their everyday lives? (Lederman, Lederman & Antink, 2013 pp. 40).

What has resulted from the study is that with the use of the framework, the teachers managed to ascribe specific epistemologies to each IK practice. Thus, it can be argued there appears to be an acceptable level of generality of understanding of IK that is accessible to science teachers.

Each IK practice or technology has an epistemological base that is specific to it, as demonstrated by the teachers in this study (ref. 4.4.1 to 4.4.6). This would appear to confirm the argument that there is epistemological particularity in IK (Ogunniyi, 2013; Semali & Kincheloe, 1999). Therefore, when integrating IK practices, beliefs or values into school science curriculum, teachers have to analyse each practice to identify epistemologies for the IK practice in question.

5.5.1 Teachers' views on the epistemologies of six IK practices

Discussed in sections 5.5.1.1 to 5.5.1.6 below are teachers' views on the epistemologies of the six studied IK practices. The discussion pays attention to findings from the focus-group discussions with the teachers.

5.5.1.1 Epistemologies of the method of cereal seed preservation

The explanatory scientific principles that underpin the method of cereal seed preservation as a practice are that it is done practically, and all its procedures can be observed and are repeatable, producing similar results, which allows for its incorporation into the science curriculum. These procedures are more in tune with science processes, which are activities related to observing, inferring, collecting and analysing data and drawing conclusions.

5.5.1.2 Epistemologies of the abdominal pain and diarrhoea treatment method using the munhunguru tree

The findings based on the teachers' perceptions on the theories of truth that could account for the epistemological base of the abdominal pains and diarrhoea treatment method using the *munhunguru* tree contain two aspects. First, the reality of the abdominal pains and diarrhoea treatment method using the *munhunguru* tree is constructed with reference to both the correspondence theory of truth and the pragmatic theory of truth. Second, as viewed by T7 and T8 (ref. 4.4.3), the metaphysical/mystical aspect of the abdominal pains and diarrhoea treatment method using the munhunguru tree is not scientific. The epistemological framework assisted the teachers to demarcate an aspect of the abdominal pains and diarrhoea treatment method using the *munhunguru* tree which does not fits to be considered as knowledge in science (ref. 4.4.3). As argued by Vhurumuku & Mokeleche (2009 p. 98) this aspect therefore, has no place in the "school [science] curriculum as knowledge, but may have a place as an area for debate".

However, the traditional beliefs may not be necessarily true, but the reason for attaching them could be to foster certain kinds of behaviour most likely to preserve the tree from extinction' as argued by T8 (ref. 4.4.3).

5.5.1.3 Epistemology of technology for making a fire

The findings from the teachers' perceptions on the theories of truth that could account for the epistemological base of the primitive technology for making a fire reveal two aspects. First, like one of the characteristics of the scientific enterprise corresponding to the general understanding about NOS (Lederman et al., 2013) this practice is empirically based. This implies that the reality of the primitive technology for making a fire is constructed with reference to the correspondence theory of truth as argued by T6 (ref. 4.4.5). Second, 'the method works', implying that the reality of the primitive technology for making a fire should also be described with reference to the pragmatic theory of truth. The explanatory scientific principles that underpin this practice are that the primitive technology for making a fire is done practically, all its procedures can be observed, and are repeatable, producing similar results, which allows for its incorporation into the science curriculum.

5.5.1.4 Epistemologies of traditional roof-making technology

The findings from the teachers' perceptions on the theories of truth that could account for the epistemological base of traditional roof-making technology reveal the following aspect. Because the traditional roof-making technology is empirically based, the correspondence theory of truth was used by the teachers to best describe its epistemology. The pragmatic theory of truth was also used to describe the epistemology of this practice. None of the teachers referred to the coherence theory of truth. The explanatory scientific and mathematical principles that underpin traditional roof-making technology are similar to those of the cereal seed preservation method and the primitive technology for making a fire, which allows for its incorporation into the science curriculum. It is done practically; all its procedures can be observed and are repeatable, producing similar results.

5.5.1.5 Epistemologies of the cough and abdominal pain treatment method using Dicoma anomala

The results from the teachers' perceptions on the theories of truth that could account for the epistemological base of the cough and abdominal pain treatment method using *Dicoma anomala* reveal the following aspects. The reality of this practice is constructed with reference to the correspondence theory of truth as well as the pragmatic theory of truth. None of the teachers referred to the coherence theory of truth.

The explanatory scientific principles that underpin the cough and abdominal pain treatment method using *Dicoma anomala* are similar to those of the cereal seed preservation method, the primitive technology for making a fire and traditional roof-making technology, which allows for its incorporation into the science curriculum. It is done practically, all its procedures can be observed and are repeatable, producing similar results.

5.5.1.6 Epistemologies of the indigenous method for fertilizing crops

Observation and inference has been used to produce this IK practice as reflected in the informants' narratives (ref. 4.3.1.2). The whole process of the indigenous method for fertilizing crops can be observed and therefore it can be logically argued that this practice is based on the correspondence theory of truth and with reference to the pragmatic theory of truth, as argued by the teachers (ref. 4.4.2).

5.5.1.7 Summary

The epistemological framework based on truth theories is one tool teachers can use to demarcate aspects of IK practices which are not scientific knowledge. Because the five practices and technologies clearly have empirical evidence as their predominant epistemological base, it may be argued (as done in Chapter 2 ref. 2.4) that there are many points at which IKS and Western science intersect (Ogunniyi, 2013). A complementarity of IKS and Western science can lead to a better appreciation of the various schemes of knowledge, particularly their truth claims.

What was observed about one of the six IK practices; the abdominal pains and diarrhoea treatment using the *munhunguru* tree, is that the medicine is administered with the emphasis on the spiritual element to be observed for it to work. This is an example of a more pressing metaphysical question about spiritual phenomena and explanations postulated by IKS, but rejected by Western science because they are empirically unobservable.

Clearly five of the practices and technologies have empirical evidence as their predominant epistemological base. The explanatory scientific principles that underpin these practices are that they are done practically, all their procedures can be observed and are repeatable, producing similar results, which allows for incorporation into the science curriculum.

5.5.2 Teachers' use of the epistemological framework

The teachers' ability to use the epistemological framework to identify the IK epistemologies made the significance of its assistance to them more explicit. All 12 teachers involved in this study were of the view that the framework was useful for identifying IK epistemologies, thereby enabling them to suggest suitable methods for integrating indigenous and scientific knowledge in the school curriculum. None of the teachers indicated difficulties in using the framework.

5.5.3 Teachers' post activity views about the integration of IK in the school science curriculum

The epistemological framework was particularly useful in addressing teachers' concerns (ref. 4.4.8), for example the frequently expressed view that IK is inherently based on superstition and irrationality. The use of the epistemological framework produced a change in view.

The study created opportunities for teachers to discuss the integration of IK into school science prior to suggesting suitable teaching methods for IK. Probably the teachers' ability to use argumentation when applying the framework could account for the cognitive shifts. Previous studies cited argumentation tools as useful for science teachers when integrating science and IK (Glasson, Mhango, Phiri & Lanier, 2010; Dube & Lubben, 2011; Ogunniyi, 2011). Interestingly, this study used argumentation tools as auxiliary to the application of a framework for identifying IK epistemologies, which made its significance more pronounced.

Some teachers favoured the total exclusion of IK with no empirical evidence, as well as all IK practices and beliefs that they believe are inadmissible in science, such as those with spiritual components. These teachers believe that some IK practices and beliefs contain components that are inadmissible in science. Comments from teachers who support the total exclusion of IK that lacks empirical evidence suggest that a considerable number of teachers will not appreciate the value of integrating the IK with no empirical evidence into the science curriculum.

Most of those teachers (ref. 4.4.8) who supported the idea of including most aspects of IK which are not scientific for various purposes view demarcation as necessary. They further pointed out that the purpose of the inclusion of knowledge which is not scientific in the teaching of science must be clearly stated.

5.5.4 Teachers' perceptions on suitable methods for teaching IK

The teachers suggested methods for teaching the six IK practices that were considered in this study. For example in T3's words *'Experiments, observations and practicals can be used to teach those practices with empirical evidence such as cereal seed preservation'* (ref. 4.4.9). T6, T4, and T9 also named these topics/concepts to be considered when carrying out the practicals and experiments (ref. 4.4.9).

Some teachers also expressed their views in relation to other practices and beliefs. A representative statement of T2, 7, 8 and 9 was presented by T8 when she stated:

> *"We do have serious challenges if not an impossibility to describe teaching methods for IK practices with spiritual aspects, but with respect to practices with pragmatic value their epistemological grounds could be shown ... based on scientific technological or mathematical principles. These could then serve as useful indicators for appropriate teaching methods" (ref. 4.4.9).*

To sum up, observation, experiments, projects, practicals, and theory lessons are suitable methods that can be used in teaching IK practices with empirical evidence and pragmatic value.

5.6 Evaluation of the conceptual framework

This section presents an evaluation of the conceptual framework used in the study. The evaluation was done to determine to what extent the conceptual framework has enabled the researcher to answer the research questions.

One of the major aims of this study was to find out whether or not some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that helps to facilitate integration of IK practices into school science teaching. With this aim, documenting some IK practices was found necessary in order to analyse and identify epistemologies of IK. IK is said to be tacit, and that it may not be easily codified (Kibirige, & Van Rooyen 2007). Secrecy among some of the indigenous people could have been another major obstacle for the researcher in this study (Onwu & Mosimege, 2004), necessitating the use of appropriate methods for gaining entry into the field and appropriate techniques for collecting IK practices. Gaining the trust of key informants in the community was a major solution to this limitation. What could be gathered from the results of the study is that the use of confidence building techniques, such as methods for gaining entry, enabled the researcher to successfully interview 24 participating IK practitioners on what they practise in science related areas of health, technology, and agriculture. The use of individual interviews with IK practitioners was effective in obtaining crucial information because the practitioners were comfortable to share their knowledge of IK practices. The individual interactions of the researcher for a year with those immersed in these practices accorded him the opportunity to listen to their explanations and observe what they do. Subsequently, observations, interviews and artefacts were used to enable the researcher to capture data on how IK is produced and validated in a given community.

Another major challenge raised in the literature review (ref. 2.2.) was the nature of school science is based on the logical positivist-empiricist (positivism) epistemology (Abrams, Taylor & Guo, 2013; McErlean, 2000; Rosenberg, 2012), which rejects the validity of other forms of knowledge in science that are not produced and validated within positivism. This aspect of the nature of science has been used as a guiding standard for the choice of methods of teaching and learning in science and has been used as a 'gate-keeping' mechanism for determining aspects to be included or excluded as science (Onwu & Mosimege, 2004). Regrettably, as noted by Kibirige, & Van Rooyen (2007 p. 236), "there is often a tendency to place IK in contestation to science or so-called 'Western knowledge systems' – as if there were an absence of science in IK". An analysis of IK epistemologies became necessary in this study to find out whether or not some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices and 'ways of knowing'. To identify epistemologies of IK necessitated the development of a conceptual framework based on the philosophical considerations of theories of truth that could possibly be used to evaluate IK practices.

The framework was found useful in analysing and identifying epistemologies of six IK practices (ref. tables 4.2 to 4.7). The sampled science teachers used it in focus group discussions to successfully identify and analyse the epistemologies of the same six IK practices (ref. 4.4.1 to 4.4.6) as the researcher's. These results revealed two aspects. First, that, there are aspects of IK practices that can be justified within philosophical considerations of epistemology. Second, that some characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that could help to facilitate integration of IK practices into school science teaching. The epistemological framework was particularly useful and efficacious in addressing teachers' philosophical concerns about the inclusion of IK in the science curriculum. For instance, about 25% of the teachers expressed cognitive shifts from an initial mindset of total exclusion of IK practices and beliefs to a willingness to include or at least introduce them in science lessons where appropriate (ref. 4.4.8). The epistemological framework was also useful in helping the teachers to successfully establish effective teaching approaches for integrating indigenous knowledge into science education for improved learner performance (ref. 4.4.9).

It should be noted that in this study the framework was tried out with six IK practices. Although the findings supported the view of the reviewers (who validated the epistemological framework-ref. 3.4.3.1) that the theories of truth used to develop the framework cover the range of truth meanings sufficient for analysing and identifying epistemologies of IK, the framework should be tried on a larger scale with more than six IK practices used in this study.

Finally, though the epistemological framework was tested with some science teachers to establish its effectiveness for equipping them with a way of identifying IK epistemologies for establishing suitable teaching methods, and the results revealed its value in the views of participating science teachers, it is important to try this approach in the classroom to find out its relative value to science learning.

5.7 Chapter Summary

Chapter 5 presented a discussion of the results, focusing on the epistemological basis of indigenous knowledge in science education. Specifically the discussion focused first on findings about community-based IK practices in health, agriculture and technology to find out to what extent some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices. Second the discussion paid attention to findings from the focus-group discussions with science teachers concerning their views on epistemologies of IK practices and the integration of IK into science teaching. Findings revealed that IK practices can be justified within philosophical considerations of epistemology and that some of the characteristic features that underpin the scientific way of thinking manifest themselves in IK practices. The findings allowed it to be argued that the similarities allow for the incorporation of IK in school science teaching.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Introduction

In Chapter 6 the summary, major findings, recommendations and conclusions of the study are presented. The contribution of the study to the field of education is discussed, and suggestions for further research are given.

6.2 Summary of the study

Literature revealed that (ref. 2.4) some sharp differences between IK and school science pose serious challenges to integration of the two bodies of knowledge. Against this background, an epistemological framework for characterising IK practices for purposes of integrating with school science was developed. The study was carried out in three phases: i) Phase 1 was about the development of an epistemological framework for characterising IK practices. ii) Phase 2 was based on an ethnographic case study method during which examples of indigenous knowledge and explanations were obtained from practitioners of indigenous knowledge, after a period of contact during which trust and access were established; and iii) Phase 3: the epistemological framework established in the first phase was tested with teachers of physical, life and agricultural sciences, and views on appropriate pedagogies were established.

6.2.1 Phase 1: Developing a framework for IK epistemologies

A desk top philosophical analysis of theories of truth was undertaken with the aim of developing a conceptual framework for analysing and identifying epistemologies of IK practices. An epistemological framework for identifying IK epistemologies was developed to allow the identification of aspects of IK that might fruitfully be included in science curricula. In order to achieve this inclusion, the epistemologies of IK need to be understood to determine differences and similarities (Bohensky & Maru, 2011) and to establish which aspects are compatible with science and which are not (Dube & Lubben, 2012; Kibirige & Van Rooyen, 2007; Ogunniyi (2011). Three traditional and substantive theories of truth were used to develop the conceptual framework through which IK practices were mapped against the various components of the designated theories of truth.

The framework was later presented to teachers to assist them to determine the epistemologies of indigenous knowledge themselves, and to propose appropriate points and mechanisms of inclusion of suitable IK aspects.

6.2.2 Phase 2: Community-based practices of agriculture, technology and health

The second phase of the study consisted in identifying and documenting a selection of community-based practices as part of a coherent theme or knowledge area. Community-based IK practices on health, agriculture and technology themes, commonly practised in a particular community in Zimbabwe, were carefully documented through observations and interviews of key informants living in the community. The criteria for the selection of these practices were based on the assumptions that aspects of local knowledge that describe, explain, predict and try to negotiate nature (Emeagwali, 2003), that have to do with socio-scientific issues (Onwu &

Kyle, 2011; Sadler, 2009) and that are compatible with science (Ogunniyi, 2011) would be most appropriate for this study.

These selected examples of IK were analysed according to the epistemological framework, and were presented to teachers for their own placement within the framework in Phase 3.

6.2.3 Phase 3: Exploring IK integration with teachers

In the third phase of the study, the documented IK practices and technologies were made available to a group of science teachers. Focus-group discussions were conducted using the epistemological framework to explore ways in which the selected IK practices could be integrated into school science curricula.

The views of participating teachers were explored on the usefulness and efficacy of the epistemological framework to guide integration of indigenous and scientific knowledge in the school curriculum. Teachers reported that IK integration into the school science curriculum provides contexts that are useful, familiar and relatable to learners, which may enhance learners' performance in science learning.

6.3 Major findings according to the research questions

6.3.1 Question 1: Utility and design of IK epistemologies

Question 1: How can epistemologies for indigenous knowledge be identified for integrating IK into school science curriculum in a valid and legitimate way?

In this study, an epistemological framework based on truth theories was developed for interpreting epistemologies of IK. Previous studies have cited the lack of a specifically stated epistemology for IK.

The groups of teachers that participated were able to consistently identify and state epistemologies of IK practices using the epistemological framework proposed in this study. Correspondingly, it can be concluded that epistemologies for indigenous knowledge and practices can indeed be identified with the use of an appropriate framework.

As revealed in this study, each IK practice has an epistemological base that is specific to it, which confirms the argument in previous studies that there is epistemological particularity to IK (Ogunniyi; 2013; Semali & Kincheloe, 1999). However, the same results reveal that it is not possible to categorise IK practices and technologies under one epistemological description. This means that when integrating IK into the school science curriculum, teachers have to analyse each practice.

The teachers' ability to use the epistemological framework to identify IK epistemologies made the significance of its assistance to them more explicit. The 12 teachers involved in this study were all of the view that the framework is useful for identifying IK epistemologies, thereby enabling them to suggest or agree on suitable methods for integrating indigenous and scientific knowledge into the school curriculum. None of the teachers indicated difficulties in using the epistemological framework.

The ability to use the framework fruitfully was enhanced in that the teachers applied the framework after they had been introduced to reasoning skills based on logic, which were introduced to them before the focus-group discussions were conducted.

The epistemological framework was particularly useful in addressing teachers' concerns, for example a frequently expressed view that IK is inherently based on superstition and irrationality, for which the use of the epistemological framework produced a change in view.

The epistemological framework also proved useful for developing teaching approaches to integrate indigenous knowledge into the school science curriculum appropriately.

6.3.2 Identification of some indigenous knowledge practices

Question 2: What are some of the indigenous knowledge practices and technologies in the areas of health, technology, and agriculture in Chikwanda district in Zimbabwe?

In this study, six IK practices were documented in the areas of health, agriculture and technology. This study has revealed that with the use of appropriate methods for gaining entry into the field and appropriate techniques for collecting IK practices such as ethnography, teachers could successfully gather indigenous knowledge in the communities surrounding their schools.

6.3.3 Integration of the identified knowledge and practices with school science

Question 3: Given the identified epistemologies for indigenous knowledge practices and technologies, how should indigenous knowledge be integrated into the school science?

The identified epistemologies helped the participating teachers to identify methods and approaches that could be used to integrate this knowledge into school science in a valid and legitimate way. All teachers who participated in the study showed willingness to include IK in science teaching, although 17% showed continued to express reservations about the inclusion of aspects of IK with no empirical basis.

6.3.4 Synthesis

The research findings together provide a conclusion that indigenous knowledge can be accessed by teachers of sciences themselves, that aspects of indigenous knowledge can be analysed regarding their epistemological bases, and that teachers are thereby enabled to identify appropriate points at which aspects of indigenous knowledge can be included into the science curriculum, and develop appropriate pedagogical approaches, in particular the aspects that had an empirical foundation. Teachers expressed scepticism about integrating practices or knowledge for which the epistemology was based on pragmatism only and lacked empirical evidence. The enabling basis of this potential for integration was shown to be an epistemological framework, together with disciplines of logic, which thereby has demonstrated the usefulness of such a framework founded in the philosophical considerations of epistemology

6.4 Evaluation of the methodology of the study

It is necessary to highlight two components of the methodology applied in this study with respect to usefulness and successes of instruments.

6.4.1 The instruments

The use of individual interviews with IK practitioners was effective in obtaining crucial information because the practitioners were comfortable to share their knowledge of IK practices. The individual interactions of the researcher for a year with those immersed in these practices accorded him the opportunity to listen to their explanations and observe what they do. The protocols incorporated in the study allowed the participants to accept the researcher. The participants realized that they and their customs were respected and honoured and were keen to participate and share their knowledge. This was made possible through the researcher being able to establish and understand their customs and symbols (totems) and approach them in a manner that was respectful to their cultural practices.

The focus-group discussions with the teachers using the epistemological framework to explore ways in which the selected IK practices and knowledge could be integrated into the school science curriculum proved effective in obtaining information. Teachers seemed relaxed and willing to share their views. The teachers from both groups seemed eager to voice their opinions and views on all aspects of the discussions. Although the teachers were of the view that the epistemological framework was useful for identifying IK epistemologies, they held different views about the integration of IK into school science. For example, two teachers (17%) argued for the total exclusion of IK practices that do not have an empirical basis or evidence.

6.5 Possible contribution of the study to science education

This study provides practical ways of integrating IK into the school science curriculum in a legitimate way specifically taking into consideration the epistemological differences between indigenous knowledge and scientific knowledge. It is believed this study makes a number of contributions to existing skills and knowledge in the teaching of science. No such study is known to have been carried out.

First, an epistemological framework has not been tried in previous studies in the development of methodologies for indigenous and scientific knowledge integration. Previous studies have raised the epistemological problem as the major challenge to indigenous and scientific knowledge integration without providing possible solutions to this problem. It is hoped that the epistemological framework that was considered useful and important by participating science teachers can be used by teachers and teacher training institutions. Second, the study has provided an example of how teachers may gain access to practitioners of traditional knowledge through respectful approaches within the customary context of these custodians. Third, previous researchers (Ogunniyi, 2011) have acknowledged the motivational effect of use of argumentation in teaching science. The results of this study suggest that argumentation alone is not useful for implementing an IK-science curriculum, but that it becomes useful when used to reason out IK epistemologies in order to determine suitable teaching methods. Fourth, as revealed from the teachers' arguments, IK integration into the school science curriculum is likely to provide contexts that are useful and familiar to learners and that may enhance learners' performance in science.

6.6 Recommendations

Based on the findings of this study, the following recommendations are made:

- An epistemological framework can provide participating science teachers with a practical way of exploring authentic methods for integrating indigenous and scientific knowledge. Such methods may help improve learners' performance, expose alternative conceptions held by learners, expose misconceptions in the learners' minds, improve conceptual understanding, and enhance higher-order thinking skills in the form of argumentation. It is therefore recommended that science teachers should use this methodology in their teaching of science.

- The use of an epistemological framework may be particularly useful in addressing teachers' concerns and in developing teaching approaches for integrating indigenous knowledge into the school science curriculum. Given the usefulness of the approach, it is recommended that teacher-training institutions incorporate the epistemological framework, logic, reflective thinking and reasoning skills in the development of teachers' knowledge and skills for integrating IK into the school science curriculum.

6.7 Suggestions for further research

Further, the following research opportunities could emanate from this study:

- In this study the framework was tried out with six IK practices. Although the findings supported the view of the reviewers (who validated the epistemological framework-section 3.4.3.1) that the theories of truth used to develop the framework cover the range of truth meanings sufficient for analysing and identifying epistemologies of IK, the framework should be tried on a larger scale involving other knowledge themes or knowledge forms, including science and non-science disciplines.
- Though the epistemological framework developed in this study revealed its value in the views of participating science teachers, it is important to try this approach in the classroom
- From the perspective of the school-community interface, it is possible that IK can serve as a useful link between home/community and school based experiences. Will valuing IK

therefore boost the morale, and enhance the sense of self-worth and scientific literacy of the local indigenous community? Further research is needed to answer this question.

- Though the epistemological framework was found useful for demarcation purposes, with respect to spiritually based examples of IK practices teachers were provided with minimum assessment opportunity to test the usefulness (or validity) of the framework to determine their truth base, further research on this aspect is therefore suggested.

6.8 Conclusion

The aim of this study was to i) develop a framework for epistemologies appropriate to indigenous knowledge founded in the philosophical considerations of epistemology; ii) collect and document some science-related IK practices; and iii) have a group of school science teachers use the framework to engage in focus-group discussions on how the selected practices and local knowledge may be integrated into the school science curriculum in a valid and legitimate way. The following three research questions were addressed:

1. *How can, from a theoretical perspective, epistemologies of indigenous knowledge be identified for integrating IK into school science teaching curriculum in a valid and legitimate way?*
2. *What indigenous knowledge practices and technologies in science related areas of health, technology, and agriculture in Chikwanda district in Zimbabwe can be identified and documented?*
3. *How should the identified indigenous knowledge and practices be integrated into school science teaching?*

Answers to the three research questions provided a refined understanding of how teachers can begin to integrate IK into the school science curriculum in a valid and legitimate way in order to improve learners' performance. An epistemological framework based on truth theories was developed. Some science related IK practices were collected and the framework was tested with some science teachers to establish its effectiveness for equipping them with a way of identifying IK epistemologies for establishing suitable teaching methods. The research findings together provided a conclusion that indigenous knowledge can be accessed by teachers of sciences themselves, that aspects of indigenous knowledge can be analysed regarding their epistemological bases, and that teachers are thereby enabled to identify appropriate points at which aspects of indigenous knowledge can be included into the science curriculum, and develop appropriate pedagogical approaches, in particular the aspects that had an empirical foundation. The views of the participating teachers on the usefulness and efficacy of the approach were explored. The successful application of the framework revealed two aspects. First, that, IK practices can be justified within philosophical considerations of epistemology. Second, that some characteristic features that underpin the scientific way of thinking manifest themselves in IK practices in a way that helps to facilitate integration of IK practices into school science teaching. The findings allow it to be argued that the three theories of truth were appropriate for analyzing IK practices for the purpose of this study. The framework was particularly useful and efficacious in addressing teachers' philosophical concerns about the inclusion of IK in the science curriculum, and in developing effective teaching approaches for integrating indigenous knowledge into science education for improved learner performance.

This study adds value to the field of science education through providing practical ways that can be used by teachers to gain access to practitioners of IK, analyse epistemologies of IK and establish suitable teaching methods for integrating IK into school science teaching

The benefits of using such authentic methods for integrating indigenous and scientific knowledge are that it may help improve learners' performance, expose alternative conceptions held by learners, expose misconceptions in the learners' minds, improve conceptual understanding, and enhance higher-order thinking skills. IK-science curriculum integration, it is argued, provides contexts that are familiar and relatable to learners, and those features are likely to enhance interest and improve performance and in turn increase the socio-cultural relevance of science and science education.

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APPENDICES

Appendix A: Letter of Informed Consent for Teachers

Appendix B: Letter of Informed Consent for the IK practitioners

Appendix C: Letter to the school Principals

Appendix D: Letter to the Ministry/Provincial Offices

Appendix E: Letter to Chief Chikwanda

Appendix F1: Details on the workshop with the teachers before the focus-group discussions

Appendix F2: Questions that teachers deliberated on during focus-group discussions Appendix G *Kuchengetedzwa kwembeu*: Seed preservation method

Appendix H: *Mufudze wedu wechivanhu*: Local Fertilizer

Appendix I: *Kurapwa kwezvirwere zvemudumbu kuchishandiswa muti wemunhunguru* : Treatment of abdominal diseases using the '*munhunguru*' tree (botanical name: *Flacourtia indica*)

Appendix J: *Kurapwa kwechikosoro ne chimuwatonzvi*: Treatment of cough using '*chimuwatonzvi*' (the vernacular shona language, for *Dicoma anomala*)

Appendix K: *Kuvesa moto tichishandisa mukubvu:* (Making a fire using *Vitex payos* tree*)*

Appendix L: *Kupfurira imba*: Roof thatching

Appendix M: Outcome of the test: Table 7.1 Percentage levels of gained skills and knowledge among the teachers after the test

Appendix N1: Picture of maize stocks tied inside a round kitchen roof from Chikwanda district

Appendix N2: Picture of cow dung from Chikwanda district

Appendix N3: Picture of *Flacourtia indica* from Chikwanda district

Appendix N4: Picture of *Chimuwatonzvi (Dicoma anomala)*

Appendix N5: Picture of 'Mukubvu tree' *(Vitex payos)* from Chikwanda district

Appendix N6: Picture of thatched roof of a round kitchen from Chikwanda

Appendix O: Permission from the University of Pretoria to conduct research (Ethical clearance certificate)

Appendix P: Letter of permission from Ministry of Education and Culture Head Office

Appendix Q: Letter of permission from Ministry of Education and culture provincial offices

Appendix R: Letter of permission from Chief Chikwanda

Appendix A Letter of Informed Consent for Teachers

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics &
Technology Education

Dear Teacher

RE: Request to Participate in a Research Project

Research Project Title: 'The epistemological basis of indigenous knowledge systems in science education'.

Please read this consent document carefully before you decide to participate in this study.

Purpose of the research study

You are kindly invited to participate in a research project aimed at gaining some insight about integration of indigenous and scientific knowledge into the school science curriculum in order to improving learners' performance in science.

What you will be asked to do

Training issues

Time required:

At most one hour and at most three sessions will be used for the interviews each session lasting for 30 minutes to hour duration as sessions will be recorded.

Risks and Benefits

Risks: There is no envisaged potential risk or harm to you. However you may feel a bit uneasy to participate in the focus-group discussions, but you will soon get used to the group and to me, hopefully. I want you to understand that information to be obtained from you is just for the purpose of my study and nothing else. Feel very comfortable to discuss all aspects your beliefs and practices.

Benefits

Schools in Zimbabwe might realise the necessity to include these valuable IK practices in the science curriculum and ultimately include this knowledge.

Voluntary Participation and Confidentiality

Your participation in this study is completely voluntary and there is no penalty for not participating. Should you declare yourself willing to participate in this study, confidentiality is guaranteed. The researcher will satisfy and adhere to the highest ethical standards as required for research projects of this nature, and as prescribed by University of Pretoria, which include as far as possible anonymity and confidentiality of participants. You will be assigned codes and synonyms. These codes will be used whenever reference is made to you, so that your true identity will not be revealed. The researcher will treat all information you supply including video-recordings confidentially and will not disclose any information to the public. Your name, address, and place, will not be revealed in the study report. When the study is completed and the data have been analyzed, all information supplied will be kept safe and confidentially. Your name will not be used in any report.

Right to withdraw from the study:

You have the right to withdraw from the study at anytime without consequence.

Agreement:

I have read, understood and considered above which explains your intent, mission, and request for my participation in your research. I voluntarily agree to participate in the research and I have received a copy of this description. I show my willingness to participate by signing in the space provided bellow.

Teacher's signature_______________________________ Date: ________________

Video Recording

The researcher wishes to audio-record the focus-group discussions to be contacted which involve your participation and hereby seek your permission to do this.

Agreement: I understand that there will be video-recoding of the group during discussions, which will only be used in order to the research project without my name and picture appearing anywhere in the research report. I understand that when the study is completed and the data have been analyzed, these will be destroyed and will not be revealed in the study report.

I agree to video-recording: **Teacher's signature**…………………………Date…………………..

Should you need any clarification or have questions about the research project, be free to contact me or my supervisor.

Professor Gilbert O.M. Onwu
Supervisor
University of Pretoria
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Thanking you in advance for your anticipated cooperation in this regard.

Yours Sincerely

Gracious Zinyeka

Researcher's signature……………………………Date……………………..

Supervisor's signature…………………………...Date………………………

Appendix B Letter of Informed Consent for the IK practitioners

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics & Technology Education

Date

Dear IK practitioner

RE: Request to Participate in a Research Project

Research Project Title: 'The epistemological basis of indigenous knowledge systems in science education'.

Please read this consent document carefully before you decide to participate in this study. NB: For these participants everything will be explained to them in their mother tongue which is Shona. No interpreter will be required since the researcher's mother tongue is Shona.

Purpose of the research study

You are kindly invited to participate in a research project aimed at gaining some insight about your IK practices in the area of health/agriculture/technology.

What you will be asked to do

I will be around for a period of a year. In the first few months I will make some friendly visits, and have casual discussions with you in order to making an effort to acquaint myself with you, hoping to win your confidence and trust; especially to ensure that you understand that information to be obtained from you is just for the purpose of study and nothing else. Following these visits you will be asked to volunteer to participate in face-to-face discussions and interviews with me. I will interview you individually to find out what you do, how you do it, and why you do it. Face-to-face semi- structured interview guides will be used in gathering information on indigenous knowledge practices and beliefs from you in the area you are steeped in IK tradition. These will be used to guide our discussions and interviews. I propose to use observations, interviews, and artefacts as data sources.

Time required:

At most one hour and at most three sessions will be used for the interviews each session lasting for 30 minutes to hour duration as sessions will be recorded.

Risks and Benefits

Risks: There is no anticipated risk or harm to you. However you may feel a bit uneasy to have me observing your practices, but you will hopefully soon get used to me.

Benefits

Schools in Zimbabwe might realise the necessity to include these valuable IK practices in the science curriculum and ultimately include this knowledge. It is hoped that the integration of IK practices will help improve the performance of the learners in science in this community.

Voluntary Participation and Confidentiality

Your participation in this study is completely voluntary and there is no penalty for not participating. Should you declare yourself willing to participate in this study, confidentiality is guaranteed. The researcher will satisfy and adhere to the highest ethical standards as required for research projects of this nature, and as prescribed by University of Pretoria, which include as far as possible anonymity and confidentiality of participants. You will be assigned codes and synonyms. These codes will be used whenever reference is made to you, so that your true identity will not be revealed. The researcher will treat all information you supply including video-recordings confidentially and will not disclose any information to the public. Your name, address, and place, will not be revealed in the study report. When the study is completed and the data have been analyzed, all information supplied will be kept safe and confidentially. Your name will not be used in any report.

Right to withdraw from the study:

You have the right to withdraw from the study at anytime without consequence.

Agreement:

I have read, understood and considered above which explains your intent, mission, and request for my participation in your research. I voluntarily agree to participate in the research and I have received a copy of this description. I show my willingness to participate by signing in the space provided bellow.

Practitioner's signature (or of Child or relative) ___________________ Date: ________

Video Recording

The researcher wishes to audio-record the one-on-one interviews with you and hereby seeks your permission to do this.

Agreement: I understand that there will be video-recoding of the interviews, which will only be used for purposes of the research project without my name and picture appearing anywhere in the research report. I understand that when the study is completed and the data have been analyzed, these will be destroyed and will not be revealed in the study report.

I agree to video-recording: **Practitioner's signature (or Child or relative**………..Date……….

Should you need any clarification or have questions about the research project, be free to contact me or my supervisor.

Professor Gilbert O.M. Onwu
Supervisor
University of Pretoria
Faculty of Education
Science, Mathematics and Technology Education
South Africa
Gilbert.onwu@up.ac.za

Gracious Zinyeka
Researcher
Bindura University of Science Education
Bag 1020
Bindura
Zimbabwe
gzinyeka@gmail.com
00263772379079

Thanking you in advance for your anticipated cooperation in this regard.

Yours Sincerely

Gracious Zinyeka

Researcher's signature………………………………Date……………………..

Supervisor's signature…………………………...Date………………………

Appendix C Letter to the school Principals

Faculty of Education
Department Science, Mathematics & Technology Education

Date

The School Principal

Chikwanda: Gutu District

Zimbabwe

Dear Sir/Madam

Re: Permission to Conduct a Research Project in your School.

Research Project Title: 'The epistemological basis of indigenous knowledge systems in science education'.

I am a lecturer at Bindura University of Science Education. Currently, I have enrolled for a Doctoral degree in Science, Mathematics, and Technology Education with the University of Pretoria in South Africa. As part of the programme, I am to carry out research.

I hereby request permission to conduct research in your school, specifically to conduct focus-group discussions with science teachers. The focus-group discussions are on the possibility of integrating indigenous and scientific knowledge in the school science curriculum with the aim to establish teachers' views about appropriate pedagogy for this integration. The aim is to explore ways in which integration of IK into the school science curriculum can be used to improve learners' performance in science. Participation of teachers in the research project will be voluntary. The good thing is that participating teachers will get an opportunity to reflect on their classroom practice based on the epistemological framework used. The findings of the study will hopefully be useful in improving learners' performance in science.

The study is carried out under the Supervision of Professor G. O. M. Onwu at the University of Pretoria (Department of science, Mathematics and Technology Education).

Should you need any clarification or have questions about the research project, be free to contact me or my supervisor.

Professor Gilbert O.M. Onwu
Supervisor
University of Pretoria
Faculty of Education
Science, Mathematics and Technology Education
South Africa
Gilbert.onwu@up.ac.za

Gracious Zinyeka
Researcher
Bindura University of Science Education
Bag 1020
Bindura
Zimbabwe
gzinyeka@gmail.com
00263772379079

Thanking you in advance for your anticipated cooperation in this regard.

Yours Sincerely

Gracious Zinyeka

Researcher's signature……………………………….Date……………………..

Supervisor's signature……………………………...Date………………………

Appendix D Letter to the Ministry/Provincial Offices

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics &
Technology Education

Date

The Officer for Research Activities

Ministry of Education and Culture

Head Office/Masvingo Provincial

Zimbabwe

Dear Sir/Madam

Re: Permission to Conduct a Research Project in your School.

Research Project Title: 'The epistemological basis of indigenous knowledge systems in science education'.

I am a lecturer at Bindura University of Science Education. Currently, I have enrolled for a Doctoral degree in Science, Mathematics, and Technology Education with the University of Pretoria in South Africa. As part of the programme, I am to carry out research.

I hereby request permission to conduct research in your schools in Chikwanda-Gutu District in Masvingo Province. Specifically to conduct focus-group discussions with science teachers at two schools. The focus-group discussions are on the possibility of integrating indigenous and scientific knowledge in the school science curriculum with the aim to establish teachers' views about appropriate pedagogy for this integration. The aim is to explore ways in which integration of IK into the school science curriculum can be used to improve learners' performance in science. Participation of teachers in the research project will be voluntary. The good thing is that participating teachers will get an opportunity to reflect on their classroom practice based on the epistemological framework used. The findings of the study will hopefully be useful in improving learners' performance in science.

The study is carried out under the Supervision of Professor G. O. M. Onwu at the University of Pretoria (Department of science, Mathematics and Technology Education).

Should you need any clarification or have questions about the research project, be free to contact me or my supervisor.

Professor Gilbert O.M. Onwu
Supervisor
University of Pretoria
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Gracious Zinyeka
Researcher
Bindura University of Science Education
Bag 1020
Bindura
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gzinyeka@gmail.com
00263772379079

Thanking you in advance for your anticipated cooperation in this regard.

Yours Sincerely

Gracious Zinyeka

Researcher's signature……………………………….Date……………………..

Supervisor's signature……………………………...Date………………………

Appendix E Letter to Chief Chikwanda

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education
Department Science, Mathematics &
Technology Education

Date

Dear Chief Chikwanda
Gutu
Masvingo Province
Zimbabwe

Dear Sir/Madam

Re: Permission to Conduct a Research Project in Chikwanda district.

Research Project Title: 'The epistemological basis of indigenous knowledge systems in science education'.

I am a lecturer at Bindura University of Science Education. Currently, I have enrolled for a Doctoral degree in Science, Mathematics, and Technology Education with the University of Pretoria in South Africa. As part of the programme, I am to carry out research.

I hereby request permission to conduct research in your area (Chikwanda). Specifically to conduct interviews with some indigenous knowledge practitioners in the areas of health agriculture and technology with the aim to document these practices. The IK practices will be later taken to science teachers who will discuss in focus-group discussions the possibility of their integration into the school science curriculum with the aim to establish teachers' views about appropriate pedagogy for this integration. Participation of IK practitioners in the research project will be voluntary. The findings of the study will hopefully be useful in improving learners' performance in science in this community.

The study is carried out under the Supervision of Professor G. O. M. Onwu at the University of Pretoria (Department of science, Mathematics and Technology Education).

Should you need any clarification or have questions about the research project, be free to contact me or my supervisor.

Professor Gilbert O.M. Onwu
Supervisor
University of Pretoria
Faculty of Education
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Gracious Zinyeka
Researcher
Bindura University of Science Education
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Bindura
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00263772379079

Thanking you in advance for your anticipated cooperation in this regard.

Yours Sincerely

Gracious Zinyeka

Researcher's signature……………………………Date……………………..

Supervisor's signature…………………………...Date………………………

Appendix F1 Details on the workshop with the teachers before the focus-group discussions

To equip the teachers with the necessary information and skills to participate meaningfully in the focus-group discussions, a two day workshop was organized for all the 12 teachers prior to the focus-group discussion. The workshop was aimed at equipping them with the skills of logic that would enable them to analyse arguments, and equally have the ability to form and present valid and sound arguments. The workshop also provided participants with the opportunity to peruse the IK practitioners' protocols (Section 4.3). The workshop documents included the following guidelines:

(i) Guidelines on how to use tools of logic to perform analysis of arguments specifically checking on the validity and soundness of arguments. For instance the content included various terms used in logical argument: Validity means that the conclusion(s) must follow from the premises or given reasons; Soundness meaning that the argument must be valid first, and secondly the premises used to draw the conclusion must be true. For example Premise 1: All men die and Premise 2: given John is a man, leads to Premise 3 (conclusion) that John dies. This argument is a good one because the reasons provided are true plus the conclusion follows from the given reasons. The IK practitioners' protocols on how they undertake certain traditional practices in the areas of health, agriculture and technology.

(ii) The developed epistemological framework for analysing and identifying IK epistemologies (see Figure. 2.4).

A content test on logical reasoning was administered at the end of the workshop to assess achievement level of the participating teachers. Three out of twelve teachers (25%) answered all the questions correctly, and the remaining 75% obtained a mark above 70%. The outcome was considered adequate to enable all of them to participate meaningfully in the focus-group discussions. The outcomes of the test are presented in appendix N.

After the teachers were trained, focus-group discussions led by the researcher were conducted using the questions in the pilot study (Appendix F2)

Appendix F2 Questions that teachers deliberated on during focus-group discussions

- What makes a local practice or knowledge to be classified as coinciding with correspondence theory of truth, pragmatic theory of truth, coherence theory of truth or possibly any other?
- Given the identified epistemologies of the specific IK practices what teaching methods could be suggested as suitable for integrating the examined practices into school science?
- Have your views about IK incorporation into the science curriculum changed? If they have changed what are the reasons for the change?

Appendix G Kuchengetedzwa kwembeu: Seed preservation method

Panguva yekukohwa mumwedzi waKubvumbi newa Chivabvu, tinosarudza mbeu dzemhando yepamusoro dzechibage, zviyo, nemhunga (maize, millet and sorghum). Tinopota tichipanana mbeu nevavakidzani kuti tiwane goho repamusoro. Takaona kuti kuramba toshandisa mbeu irikubva pazvirimwa zvimwechete makore achitevedzana kuoita kuti zvirimwa zvive zvemhando yepasi. Tinosarudza mbeu yakakwana uye yakafanira/yakakodzera toyichengetera muimba yekubikira tichigadzirira kurima mwaka unotevera.

Hatichokonyori chibage, mhunga kubva pamaguri kuitira kuti zvive nyore kwatiri kana toda kuomesa takarembedza muimba yokubikira. Mhando dzakasiyana dzembeu dzinochengetedzwa nekurembedzwa mukati member yekubikira yemauswa. Pega pega patinovesa moto utsi hunoenda pa mbeu uye matsito anokomberedza mbeu dzose nekufamba kwenguva. Muimba yekubikira munopisa zvekuti mbeu dzinooma. Takaona zve kuti zvipuka nezvipfukuto hazviwanikwe pambeu inematsito. Iyi nzira yekuchengetedza mbeu ndo yagara ichishandiswa nedzinza redu kubva kare kare.
Iyi ndiyo nzira yedu yekudzivirira mbeu dzedu kubva kuzvipfukuto.

Mbeu dzinochengetwa muimba yekubikira kusvika panguva yekurima mumwedzi wa Mbudzi kana Zvita.

Appendix H Mufudze wedu wechivanhu: Local Fertilizer

Tinoshandisa mufudze wemombe pazvirimwa zvakaita sechibage. Madzitateguru edu akaita nguva achiona makuriro akanaka aita mauswa pamatanga emombe akaziva kuti zvaikonzerwa nemufudze wemombe. Vakaongorora vakaona kuti kukura kwakanaka kwemauswa nembeu, kunyanya panguva yekunaya kwemvura kwaisakiswa nemufudze uyu.

Potse monhu wese munzvimbo iyi anoshandisa mufudze wemombe kubva kumatanga pakukurisa zvirimwa zvovo. Tisati tasima mbeu tinoisa nekuparadzira mufudze mumunda wose tozosima kana mvara yonaya.

Appendix I Kurapwa kwezvirwere zvemudumbu kuchishandiswa muti wemunhunguru: Treatment of abdominal diseases using the 'munhunguru' tree (botanical name: Flacourtia indica)

Munharaunda iyi kana paine munhu anorwara kana kumhanyiswa nemudumbu uye asingachagoni kufamba oga anotakurwa oendwa naye musango.

Anosimudzirwa mudenga kuti agone kutora mashizha maviri kana matatu e munhunguru achishandisa muromo semhuka asina kubata nemaoko.

Mushonga uyu unoshanda chete kana anorwara akagona kutora mashizha atarwa nemuromo asina kumabata nemaoko.

Ndofunga vakuru vakaita kuti zvidaro nekuti vakatya kuti muti uyu ungapera.

Nekurwararwara kwevandu vekumaruwa nezvirwere zvinobva mumvura zvaigona kuti muti uyu ushandisiwe zvakanyanya kurapa zvirwere izvi, zvichizvokonzera kuparadzwa kwemasango vanhu vachitora mashizha emunhunguru.

Naizvozvo kuti mashizha anotorwa nemuromo chete kunoita kuti muti uyu usanyanyisa kuparadzwa nevanoushandiswa.

Appendix J Kurapwa kwechikosoro ne chimuwatonzvi: Treatment of cough using ‘chimuwatonzvi’ (the vernacular shona language, for Dicoma anomala)

Tinoshandisa chimuwatonzvi kurapa chikosoro kana marwadzo emudumbu.

Chimuwatonzvi kamuti kanemudzi unowanzo kura kuinzana nezai rehuku.

Pakurapa marwadzo emudumbu tinotswanya midzi miviri kana umwe ye chimuwatonzvi tosanganisa nemvura yakazara komichi. Chikamu chemushonga uyu chinopiwa kumurwere kuti anwe katatu chero kana pazuva.

Kazhinji munhu anopora musure memazuva matatu atanga kunwa mushonga uyu.

Pakurapa chikosoro kana chipfuva tinosanganisa mushonga okora. Izvi zvinoitwa nekuwedzera midzi pakomichi imwechete iya kuti mushonga uwedzere simba.

Kana chikosoro chacho chichinyanyisa murwere anogona kutsenga midzi yakadaro omedza muto wacho.

Appendix K Kuvesa moto tichishandisa mukubvu: (Making a fire using Vitex payos tree)

Kare varungu vasati vauya nemachisi vakatiratidza nzira inokurumidza kuvesa nayo moto, vakuru vedu vaivesa moto vachishandisa mukubvu.
Hatichashandisa nzira iyi kuvesa moto but munhu wese anofanirwa kuva neruzivo rwakadai. Izvi ndizvo zvakakonzera kuti ruzivo urwu rwuchengetedzwe uye rupiwe kubva kumadzitateguru karekare kusvika iyezvino.
Madzitateguru edu vaivesa moto nekukwizanisa zvidimbu zvemukubvu zvakaoma kuti gwa. Vaitanga nekuboora buri pachidimbu chemukubvu asi buri racho risingabudi kuseri.
Chidimbu chemukubvu ichi chaive chakakora masendimita gumi nemashanu.

Vaizogadzira chimuti chakaraba mita rimwe kubva pachimuti chhemukubvu chakaoma. Chimuti ichi change chakareba masendimita maviri uye chiazorodzwa nedombo kana simbi inopinza sebanga. Kunopinza kwe chimuti ichi kwaizobairwa muburi redanda remukubvu. Vanhu vakawanda vaizouya vobatsirana kusika moto vachishandisa chitanda chemukubvu ichi.

Appendix L Kupfurira imba: Roof thatching

Tinoshandisa uswa, matanda akaoma nemakavi anobva pamiti yakaita semitondo kupfurira dzimba dzedu.

Vanezvipo zvemaoko seni vanotanga vaisa matanda mana kana mashanu vachitenderedza muduri kuti asangane ose pamusoro asi panganangana nepakati nepakati peimba.

Hatishandise matanda anobva pamiti yose yose asi miti yakaita somurwiti waingozivikanwa kubva kare kuti wakasimba uye unogara.

Kana matanda aya asangana pamusoro pachiruvi tinobva tazoisa mamwe matanda panozvoiswa uswa huchisungwa nemakavia

Matanda ese anenge akagara pamusoro pemuduri asi achidarikira pasi zvishoma kuitira kuti kana mauswa aiswa poita kamuvuri kanotenderedza imba.

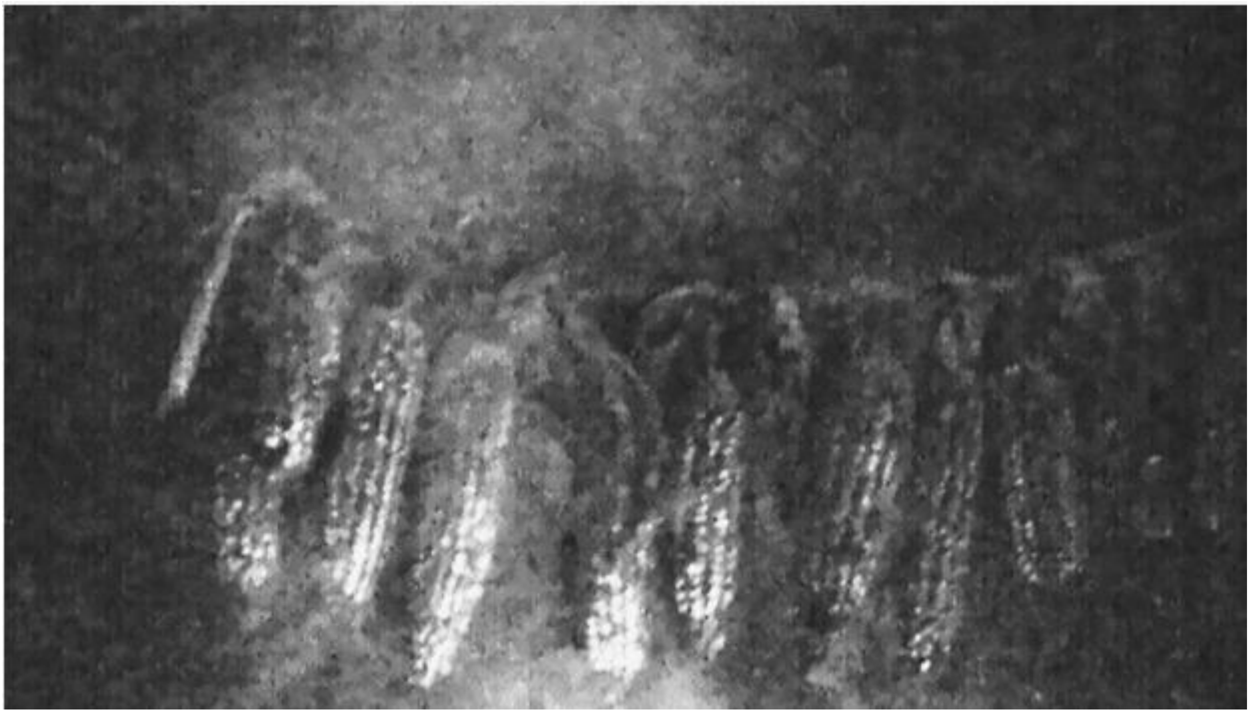
Tinobva tachirukira mauswa akaoma pamatanda zvidimbu zvidimbu tichishandisa makavi uye tichibva nepasi kuenda kumusoro. Makavi emiti yakaita somutondo akasimba uye anogara kwemakore mazhinji.

Appendix M Outcome of the test

Table 7.1 Percentage levels of gained skills and knowledge among the teachers after the test

Question	**Expected answer**	**Number of teacher who managed to provide the correct answer**
1 Define logic as it is used in argumentation	Logic is the study of methods and principles used to distinguish good (correct) from bad (incorrect) reasoning	All teachers provide the correct answer
2 Define an argument	An argument is a defended statement based on reasons	All teachers provide the correct answer
3 Explain what makes an argument to be valid	An argument is valid when its conclusion follows from given premises	All teachers provide the correct answer
4 Present the features of a sound argument	Sound when its conclusion follow from given premises plus the reasons must be true	Three teachers gave full answers, two failed to answer the question
5 An argument is never described as --- or ---, but as --- and --- only statements/premises are described as --- and ---	Arguments are never described as true or false, but as valid and sound, only statements/premises are described as true or false	Three teachers gave full answers and nine gave half answers
6 Explain why an argument may be valid and yet not sound	This is so because the conclusion may follow from the given reasons yet the reasons are false	Two teachers failed to explain
7 The conclusions drawn in a deductive form of argument which is valid and sound follow by ----	Follows by necessity	One teacher gave a wrong answer
8 The conclusions drawn in an inductive form of argument which is valid and sound follow by ----.Give the reason that that is so	Follow by probability. This is so because of the problem of induction	All teachers got the first answer, five teachers did not give reasons
9 Define the correspondence theory of truth	The correspondence theory of truth adheres to the view that a knowledge claim or belief is true provided there exists a fact (empirical base) corresponding to this theory	All teachers provide the correct answer
10 Define the pragmatic theory of truth	The pragmatic theory views truth in terms of what would solve a problem	All teachers provide the correct answer
11 Define the coherence theory of truth	The coherence theory takes a belief as true when it fits well with already accepted systems of beliefs	All teachers provide the correct answer
12 Explain the relationship between theories of truth and arguments	Sound arguments are based on true premises; the truth-value of their premises is assessed upon some acceptable theory of truth	Eight teachers explained correctly

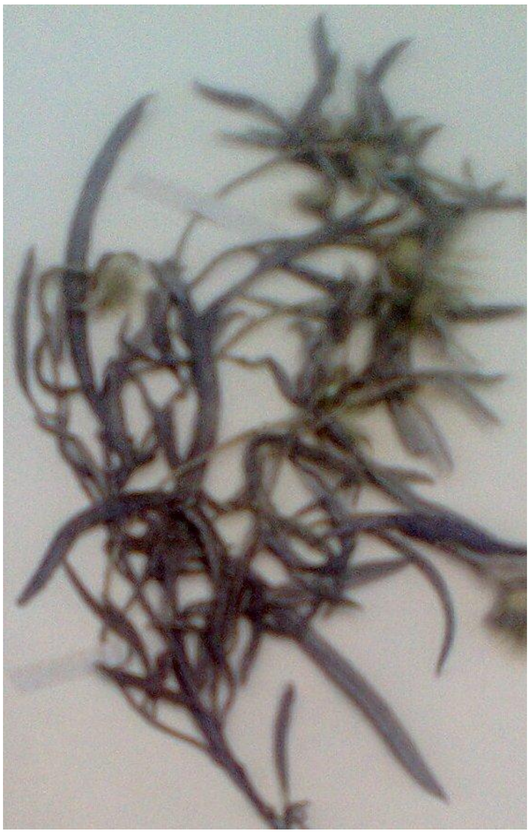
Appendix N1 Picture of maize stocks tied inside a round kitchen roof from Chikwanda district



Appendix N2 Picture of cow dung from Chikwanda district

Appendix N3 Picture of *Flacourtia indica* from Chikwanda district

Appendix N4 Picture of Chimuwatonzvi (Dicoma anomala)



Appendix N5 Picture of 'Mukubvu tree' (Vitex payos) from Chikwanda district

Appendix N6 Picture of thatched roof of a round kitchen from Chikwanda

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix O Permission from the University of Pretoria to conduct research

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	**CLEARANCE NUMBER :** SM 10/11/02
DEGREE AND PROJECT	PhD The epistemological basis of indigenous knowledge systems in science education
INVESTIGATOR(S)	Gracious Zinyeka
DEPARTMENT	Science, Mathematics and Technology Education
DATE CONSIDERED	6 October 2014
DECISION OF THE COMMITTEE	APPROVED

Please note:
For Masters applications, ethical clearance is valid for 2 years
For PhD applications, ethical clearance is valid for 3 years.

CHAIRPERSON OF ETHICS COMMITTEE	Prof Liesel Ebersöhn
DATE	6 October 2014
CC	Jeannie Beukes Liesel Ebersöhn Prof GOM Onwu Prof MWH Braun

This ethical clearance certificate is issued subject to the following condition:

1. It remains the students' responsibility to ensure that all the necessary forms for informed consent are kept for future queries.

Please quote the clearance number in all enquiries.

Appendix P Letter of permission from Ministry of Education and Culture Head Office

Ref: C/426/3

All communications should be addressed to
"The Secretary for Education Sport and Culture"
Telephone: 734051/59 and 734071
Telegraphic address : "EDUCATION"
Fax: 794505

ZIMBABWE

Ministry of Education Sport, Arts and Culture
P.O Box CY 121
Causeway
Zimbabwe

- **Gracious Zinyeka**
- **Bindura University of Science Education**
- **Science Education**
- **P Bag 1020**
- **Bindura**

Re: PERMISSION TO CARRY OUT RESEARCH

Reference is made to you application to carry out research in the Ministry of Education, Sport, Arts and Culture institutions on:

-Inquiry Into Epistemological Basis of Indigenous Knowledge Systems in Scince Education ---

Permission is hereby granted. However you are required to liaise with the Provincial Education Director responsible for the schools from which you want to research.

You are also required to provide the Ministry of Education, Sport and Culture with the final copy of your research since it is instrumental in the development of Education in Zimbabwe.

MINISTRY OF EDUCATION SPORT AND CULTURE
23 SEP 2010
P.O. BOX CY 121, CAUSEWAY
ZIMBABWE

C. Mazonde
For: SECRETARY FOR EDUCATION, SPORT, ARTS AND CULTURE

Appendix Q Letter of permission from Ministry of Education and culture provincial offices

ALL communications should be addressed to
"The Provincial Education Director for Education Sport and Culture"
Telephone: 263585/264331
Fax: 039-263261

ZIMBABWE

Reference: C/A121

Ministry of Education Sport and Culture
P.O Box 89
MASVINGO

15 November 2010

TO ALL DEOS

RE: PERMISSION TO CARRY OUT RESEARCH MR GRACIOUS ZINYEKA BINDURA UNIVERSITY OF SCIENCE EDUCATION

Reference is made to Approval of Permission to carry out research in the Ministry of Education, Sport, Arts and Culture.

Permission is hereby granted.

P. MUBAU
FOR PROVINCIAL EDUCATION DIRECTOR: MASVINGO

Appendix R Letter of permission from Chief Chikwanda

Chief Chikwanda's Address

DROMORE FARM
PLOT Nº 15
CHIDZA ROAD
CHIKWANDA
MASVINGO

Mr. Gracious Zinyeka
Bindura University of Science Education
Bag 1020
Bindura

RE: PERMISSION TO CARRY OUT RESEARCH

Reference is made to your application to carry out research involving some societal members in the Chikwanda area on the topic:

Inquiry into Epistemological Basis of Indigenous Knowledge Systems in Science Education.

Having been fully informed about the aims and purposes of your research, permission is hereby granted. However there is need for you to liase with the participants to get their consent.

CHIKWANDA KADIWA		04/10/2010
Chief's Full Name	**Signed**	**Date**

CERTIFIED TRUE COPY OF ORIGINAL
Signature
Date 04-10-2010
CHIEF K. CHIKWANDA
COMMISSIONER OF OATHS