Relating Indigenous Knowledge Practices and Science Concepts:

An exploratory case study in a secondary school teacher-training programme

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ABSTRACT

This study reports research on how student teachers in Science at Mutare Teachers' College in Zimbabwe worked with indigenous knowledge practices in relation to science concepts in the secondary school syllabus. The study was conducted among first-year science students and involved them in developing science learning activities for a peer-teaching process that was part of their course. The research was undertaken during a review of the college syllabus and as a study to inform the Secondary Teacher Training Environmental Education Programme (ST^2EEP).

The research design involved the researcher in participant observations and interviews with rural people to document indigenous knowledge practices and to develop materials for the students to work with in the lessons design part of the study. The student teachers used the documented practices to generate learning activities and lesson plans to teach the science concepts they had identified. A peer review session and focus group interviews followed the lesson presentations.

Findings from the research point to the rural community being a repository of diverse indigenous knowledge practices. Student teachers showed that they had prior knowledge of both indigenous knowledge practices and science concepts when they come to class. Student teachers were able to relate indigenous knowledge practices and science concepts in ways that have the potential to enhance the learning of science in rural school contexts that lack laboratories and science equipment.

The scope of the study does not allow for anything beyond tentative conclusions that point to the need for further work to be undertaken with student teachers and for the research to be extended to teaching and learning interactions in schools. Recommendations are also made for further resource-based work to be undertaken within the forthcoming St^2eep implementation phase in 2007.

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LIST OF ACRONYMS AND ABBREVIATIONS

[C]	Denoting the ChiShona mother tongue
DESD	Decade of Education for Sustainable Development
DG	Data generation
DLPR	Detailed lesson plan review
DTE	Department of Teacher Education for the University of Zimbabwe
EE	Environmental education
EEASA	Environmental Education Association of Southern Africa
FGD	Focus group discussion on lesson
GoZ	Government of Zimbabwe
IK	Indigenous knowledge
LO	Lesson observations
LSM	Learning support material
MoET	Ministry of Environment and Tourism
MTC	Mutare Teachers' College
'O Level	Ordinary level
[S]	Denoting the Shiwambo mother tongue
St^2eep	Secondary teacher training environmental education programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
ZJC	Zimbabwe Junior Certificate

CHAPTER 1

INTRODUCTION

"...in the process of restructuring education, we should place increasing value on the diversity of educational realities, and thereby on the multiplicity of learning situations and the realisation of different types of formalisation" (Hountondji, 1997: 9)

1.1 Introduction

This chapter introduces the research by presenting the context of the study. It also presents the nature of the science syllabus at Mutare Teachers' College in order to show the research orientation. The chapter outlines the focus of the research as it highlights the research interest, question and the goals of the study. An overview of the research is presented through a brief summary of each of the chapters.

1.2 Background

The birth of the research focus on indigenous knowledge was prompted by visits that the researcher made to his wife's family who reside in Manesa Village, Chipinge, in rural Zimbabwe. He observed how proficient the rural people were in their day-to-day practices related to the preparation and storage of grain as well as treatment and storage of milk. They knew how to do these things in sensible ways and he found himself as a science teacher understanding how and why their patterns of indigenous knowledge practice were so effective. He identified some environmental practices that could be explained using scientific knowledge. He also noted that the people had understandings that did not need these explanations for them to be effective in what they were doing.

At the time of this visit home, the Mutare Teachers' College science syllabus was being reviewed to integrate environmental education (EE) into teacher training. The researcher is part of the Secondary Teacher Training Environmental Education Programme (ST^2EEP) team and took up this research focus as a contribution to the development of a more relevant programme at the college.

As a result of his experience in the rural area and his work on the ST^2EEP syllabus review, the researcher decided to investigate how he could use some experiences of this local community as a source of indigenous knowledge practices and knowledge that he could incorporate into teaching activities with student teachers at Mutare Teachers' College. The aim was to explore how indigenous knowledge practices could be used in the teaching of science. Student teachers would eventually work in poorly equipped classrooms with learners in communal areas.

1.3 Context of Study

This case study was conducted in the Science subject area, at Mutare Teacher's College (MTC), which is located in the city of Mutare, in eastern Zimbabwe. The MTC trains secondary school teachers. Case stories of indigenous knowledge practices were observed and documented in a communal area, the Manesa Village.

The research involved first-year teacher trainees in science. The College enrols Zimbabwean and Namibian students with Ordinary level (O level) qualifications for a three-year secondary school teacher-training course. Student teachers are trained in science for three years. During their first and third years, students are based in the college and cover theoretical components of the course. The students spend the second year doing teaching practice in the schools. The schools used for teaching practice are mostly in rural areas.

The class has 45 students from Namibia and 15 students from Zimbabwe. Of these, 35 are females and 25 are males. This college was ideal for the study because it has African students, mostly from rural or communal areas. The assumption was that most of the student teachers would easily be able to relate to the documented indigenous knowledge practices because the practices are still common in communal areas across southern Africa.

1.4 The science syllabus at Mutare Teachers' College

The science curriculum of MTC is manifest in the science syllabus and the teaching (topics and teaching methods) that is guided by this syllabus. Consequently, this research report will primarily use the terms 'science curriculum' with reference to the national curriculum for schools and 'science syllabus' when it refers to the MTC science syllabus. The MTC science syllabus has four units, namely, biology, chemistry, physics and science education. The biology, chemistry and physics sections are similar in structure and content to the national

Zimbabwe Junior Certificate (ZJC) and Ordinary (O) level secondary school science curriculum. Student teachers are expected to be able to teach a ZJC science class during their teaching practice year. The college syllabus provides depth of content to enrich the student teachers' content. Further, the syllabi are similar in that they constitute conceptual content in the form of a prescribed list of aims, objectives, content topics and experiments. These experiments are found in textbooks and the teachers use conventional equipment and laboratories. Secondary schools generally have a shortage of textbooks. In addition many do not have conventional laboratories and rural schools usually lack equipment that is too expensive.

Therefore at college, student teachers learn science and how to teach science in a conventional laboratory. Yet most of the schools providing access to teaching practice and those they join when qualified are under-resourced and are mostly found in the rural areas. These teachers have to struggle to prepare for and to teach science in conventional ways yet there are no laboratory resources to use. They also grapple with teaching this conventional science in ways that are relevant to the learners and to the learners' community. Student science teachers have shown during teaching practice this inability to adapt their teaching to the challenges of their school environments.

The researcher also observed that during teaching practice student teachers were unable to embed practical work in their teaching. It is notable that students tended to isolate practical work from theory lessons. Lessons at college are divided into theory and practical sessions in such a way that some days are set aside for theory and some are set aside for practical work that covers the theory. Student teachers fail to realise how these two components should complement each other in order to enhance understanding of concepts. When they teach they generally tend to lecture to learners during science lessons without performing any experiments and then do the practical work component at a different time. This performance may be a result of the poor fit in pedagogy between the science they learnt in college and the reality of classrooms in the schools in communal areas. A few of these students visit college in order to ask for conventional materials such as iron filings and sulphur that they may use to illustrate "mixing and separating" in the Zimbabwe Junior Certificate (ZJC) syllabus. Unfortunately, the college is also running short of teaching and learning materials and is not always in a position to loan out equipment and to supply the necessary materials for experiments.

The way student teachers are supposed to teach in the schools is a methodological challenge for the science syllabus at the college. The nature of science education at Mutare Teachers' College has to change so that students are prepared for the realities of Zimbabwean secondary schools (Mandikonza, 2004). Based on this context, the research sought to establish how student teachers' experiences with indigenous knowledge practices might be used in order to make teaching of science more relevant and meaningful to the secondary school learners they teach. In so doing the research sought to explore how student teachers could relate local knowledge and experience to the body of theory and practice in science learning.

Science lecturers are specialised for any one or more of the content units of the college syllabus that are respectively, biology, chemistry and physics. The Science Education component that focuses on classroom practice is shared among eight lecturers in the department.

The Department of Teacher Education (DTE) for the University of Zimbabwe, which certifies the MTC graduate teachers, is responsible for controlling the quality of science education for student teachers at the college. The DTE requires that the science syllabus content be reviewed once every three years in view of new developments in teaching and understanding of education. Lecturers in science do the syllabus review. They then present this syllabus to the DTE, who analyse and approve it. The syllabus review process that is part of integrating EE was completed in 2006 and this research was conducted during the period of the syllabus review process. The research subsequently sought to examine how this syllabus with EE, in the form of indigenous knowledge could be applied in the secondary teacher-training classroom during peer teaching activities. Peer teaching involves trainee teachers in order to simulate the secondary school classroom and learners. During peer teaching teachers use the school curriculum to derive lesson plans that they use to teach their peers and the lessons are followed by peer review sessions.

1.5 Rationale for working with indigenous knowledge practices in the teaching of the science syllabus

It has been observed that teachers have inadequacies when adapting to real classroom experiences in rural areas. It therefore becomes pertinent that teacher trainees have to experience an education in which, whilst still at college, they learn to work more directly with learners' knowledge and experience, and simple equipment that is available and accessible in schools they will eventually work in. One way of doing this is to work with the college syllabus in ways that integrate scientific concepts with indigenous knowledge practices (indigenous technologies and the associated indigenous knowledge (IK)) that they are likely to encounter in rural areas From an environmental education point of view, this will allow the propositional knowledge or textbook-based environmental knowledge of the science syllabus (science concepts) to be related to the everyday knowledge of indigenous knowledge practices (environmental knowledge of everyday) and open up spaces for learning scientific ideas. In addition, it may also allow for students to consider sustainable ways of living in their local environments.

1.6 The research focus

This case study focused on how appropriate forms of IK can be brought into lessons in an attempt to enhance the relevance of science teaching and learning, in the context of the college science curriculum. The study therefore examined how these indigenous knowledge practices could be incorporated into classroom discourse particularly covering some of the topics in the Physical Science component of the Zimbabwe Junior Certificate syllabus during peer teaching activities.

1.7 The research question

Based on the discussions in the previous sections the researcher derived two key concerns to focus on in the research:

1. Indigenous knowledge practices and the scientific ideas in the syllabus.
2. How student teachers are able to work with indigenous knowledge practices and scientific ideas.

The following research question was formulated to examine these concerns:

How do student science teachers work with indigenous knowledge practices and scientific ideas in the planning and teaching of science lessons for peer teaching reflections?

The study is thus exploratory in nature to examine how indigenous knowledge practices in the experience of rural learners might be brought into classroom interactions. The scope of the study was restricted to the teacher training interactions with a view to the broader question of classroom practice being more fully taken up by the student teachers as a teaching practice assignment in the second year of their training.

1.8 Research goals

The research aims to:

- Make observations of indigenous knowledge practices in a rural community context and identify science concepts in these. Patterns of actions were observed and recorded by the researcher in the community.
- Review indigenous knowledge practices and the science syllabus with students to establish science concepts for them to develop suitable Learning Support Material (LSM) for trial lessons.
- Undertake and critique peer teaching and peer lesson review activities where students teach back with the lesson plans that they developed.

With a view to

- Explore the possibility of using indigenous technologies and knowledge practices to support the teaching and learning of scientific concepts in the secondary school teacher-training curriculum.
- Develop materials and activities that support the teaching and learning of scientific concepts around relevant and environmentally sustainable indigenous technologies and knowledge practices.
- Encourage lecturers and student teachers to appreciate how indigenous knowledge practices are a rich source of environmental knowledge and sustainable living that are relevant to their lives

The research therefore sought to generate recommendations to the science department at MTC so that, as the syllabus reflects that IK (indigenous knowledge practices) be integrated in the structural context of the curriculum as propounded by Cornbleth (1990) and Doll (1993), the lecturers might have and may begin to think of options on how to handle IK in teaching and learning. Teaching and learning interactions are part of what Cornbleth (ibid.) called the socio-cultural context of the curriculum.

1.9 My position in the Mutare Teachers' College science syllabus

I lecture in Biology and as described in section 1.2, I also lecture in science education. I am the college coordinator for St^{2}eep. As a lecturer, what I teach and how I teach is prescribed by the syllabus. The Head of Science subject area compiles a programme and when it is my turn I prepare schemes of work, and teach guided by the syllabus content and objectives. I also go out into schools to supervise students on Attachment Teaching Practice. Some of my observations during supervision of students on teaching practice have contributed to my thinking on the research problem. Such observations include that student teachers may have failed to teach because of paucity of conventional teaching materials.

I represent the college in issues pertaining to environmental education. In St^{2}eep the representation includes planning and implementing national initiatives for environmental education in the three secondary teacher training colleges (Belvedere Technical Teachers' College, Hillside Teachers' and Mutare Teachers' College). I am in the national training task team for St^{2}eep that is responsible for organising and running capacity enhancement workshops at both college and national levels.

This role prompted me to question what it is that we call syllabus review. I queried how EE in the syllabus could play out in the classroom. I then chose IK as a field of EE in an attempt to address the problem of shortage of teaching and learning materials that I had observed during supervision of science students who were on teaching practice. In my view the issue of relevance of Science content taught in the schools to learners' understanding of the concepts was very strong. During my visits to communal areas I observed that the people can easily and proficiently perform some practices and using experience from my seventeen years of teaching science, I discerned science concepts in the practices.

1.10 General outline of the thesis

This report presents findings arising from my observations of and interviews about patterns of practice in rural Chipinge. These findings were taken to the classroom where student teachers engaged with the practices and syllabus concepts. Student teachers produced lesson plans based on the practices. They worked in groups to critique the lesson plans and then presented lessons to their peers.

A critical review of literature in Chapter Two assisted in guiding the focus of the research. Critical curriculum perspectives provided guidelines for the proposed curriculum innovation. Cornbleth (1990) viewed curriculum as a contextualised social process and proposed that the curriculum is defined in terms of interactions happening between learners and educators and the surrounding environment. Any learning that happens in context helps learners to identify with the knowledge learnt and to understand concepts better. Doll (1993) argued that curriculum changes have not kept up with paradigmatic changes and that learning guided by behaviourist curricula like the one for MTC science is not transformative. He further proposed that it is possible to blend postmodernist and behaviourist perspectives and innovations of curriculum. This research recognises that the science syllabus at MTC was constructed and is being used within a behaviourist framework whilst the integration of indigenous knowledge practices into the curriculum is guided by postmodernist thinking. The research therefore, according to Doll (1993), tries to work with postmodernist views of curriculum within a behaviourist science syllabus context.

It was found that indigenous knowledge practices contribute to the cultural capital that learners have when they come to school. These practices constitute the prior knowledge that learners have in the classroom. It was found appropriate to engage mainly the social constructivist epistemology in order to work with indigenous knowledge practices. In terms of this epistemology learners could identify with the science in these practices and this science was meaningful. Learners commented that the concepts were easy to understand when based on practices that they know.

1.11 Indigenous knowledge practices in this research

For purposes of this research indigenous knowledge practices are seen as those practical ways of knowing and doing things generated in a community over a long period of time and transmitted from one generation to another. The idea thus reflects a community-based common sense that can be unique to a particular context and can reflect characterising features of the local socio-ecological environment. Use of this construct enabled the researcher to avoid the common assumption that indigenous and scientific knowledge are opposing knowledge systems - both refer to the same environment but can involve differing perspectives. This vantage point enabled the knowledge practices of local everyday life to be seen as contextual ways of knowing that constitute prior knowledge for meaning-making interactions with the scientific concepts in the curriculum.

1.12 Overview of the study

The study is introduced in Chapter One where the context of the research is presented. The focus of the research and the goals of the research are outlined. In this chapter, I introduce the nature of the MTC science curriculum. I describe my roles in the department of science and in St^{2}eep and how these roles have influenced this study and the research design decisions.

Chapter Two presents the context of the MTC science syllabus and locates the research within global, regional and national environmental education perspectives. It outlines how the research is located within secondary teacher training curricula. The chapter explores how critical views of the curriculum influence curriculum understanding and processes. It examines the implications of critical curriculum perspectives on social constructivist theories of learning, in the context of the engaging indigenous knowledge practices in the teaching of science.

In Chapter Three, research design decisions for the research are explored. This chapter shows how this research is a case study involving cases of stories and concepts. The processes of generating raw data from the rural community and working with the data with student teachers in the classroom are described. Constant reference was made to the research question and research goals. Details of how the data was analysed are presented in this chapter. The chapter also deals with issues of ethics and validity of the research process and outcomes.

Chapter Four describes the rural community's knowledge of patterns of practice. Student teachers' knowledge of practices is described in this chapter. The chapter explores how to work with IK to make lesson plans and how to use these lesson plans in peer teaching. Critiques of these lesson plans and lessons on various indigenous knowledge practices relevant in science teaching are also presented in this chapter.

Discussions of the findings of the research are made in Chapter Five. The discussions draw on the research question and research goals in Chapter One, literature critical to the research that was reviewed and presented in Chapter Two, and the findings presented in Chapter Four. In so doing, this chapter provides a deeper analysis of the findings in Chapter Four. In this chapter emphasis was made on the need for a 'two-way traffic' of epistemologies in order to facilitate relevance of learning, and particularly of science concepts. Curriculum review that starts from the vantage point of social constructivism and understanding of realism is proposed in order to further the quest for relevance of science learning.

Chapter Six provides a concluding summary to the research. I presented my recommendations on how to engage with integrating IK in the science classroom to the science department of the MTC and to St^2eep. These suggestions that emphasise ''curriculum praxis'' (Grundy, 1987) or curriculum as "a contextualised social process" (Cornbleth, 1990), curriculum integration (Doll, 1993) are important determinants of curricula processes. The MTC science department and St^2eep need to consider these recommendations in implementation of the revised science syllabus.

1.12 Conclusion

This chapter introduced the research by presenting the context in which the research was conducted. A background of the MTC science syllabus was presented and my role in the science department as well as the St^2eep was highlighted. I have also outlined the motivation behind my research in this chapter.

Chapter Two that follows presents the literature that is critical for the research. It discusses orientating perspectives to the research and examines how indigenous knowledge practices contribute to the critical curriculum perspectives and knowledge interests.

CHAPTER 2

INDIGENOUS KNOWLEDGE PRACTICES IN THE CURRICULUM

> "Of course it is not being suggested here that people did not hear, smell or touch natural objects in previous times. What has changed is the meaning of such experiences for modern people. Instead of interpreting these as dirty, obnoxious and uncivilised, many natural objects are now routinely experienced as positive and life-affirming" (Elias 2000, in Sutton 2004: 69)

2.1 Introduction

This chapter examines the literature that is critical to the study. An overview of orientating influences to the study will be drawn from global, regional and national documents and initiatives supporting the development of the environmental education discourse in educational and in particular, science curricula. This section will then look at the notion of the curriculum as well as the context of the science syllabus at Mutare Teachers' College, in order to locate this research in relevant literature. Perspectives on science and technology are examined in order to clarify as well as to locate what is meant by indigenous knowledge practices in the context of the research. A critique of curriculum theory follows in order to locate the research within a guiding curriculum epistemology in an attempt to affirm the premise of the research. A discussion of learning theory will posit constructivist and social constructivist thinking into curriculum understanding, whilst locating IK into the context of this theory. The position and thrust of this research against the background of previous research on IK in education will also be drawn from related literature. The aim is to show how this research seeks to put IK into what Elias in the above quote calls a "positive and life-affirming" position. This is a position in which IK is taken as an alternative way of knowing that can be used to understand science concepts and subsequently contribute to meaningful learning of these science concepts.

2.2 Research context

As already indicated in Chapter One the research was conducted at Mutare Teachers' College, with first-year science students. Teaching and learning of science currently tends to be divorced from the realities of classrooms in the rural areas.

The IK-science relationship can become a pedagogical alternative that makes the two forms of knowing complementary when teachers develop the theoretical (conceptual) and practical (procedural) components of scientific knowledge. The next section illustrates why and how important it can be for learning when teachers engage both IK in context with science concepts in the syllabus.

2.3 Science learning involves conceptual and procedural understanding

Van Wyk (2002) pointed out the notion that knowledge in general, in its social context, exists as either declarative, which is constituted of specific cultural, traditional and community facts or procedural, which encompasses the general processes in knowledge construction. This view of knowledge is similar to that described by Gott and Duggan (1995) who said that science learning involves an interaction of conceptual and procedural understanding. Learners need both conceptual understanding of facts (ways of knowing) and procedural understanding of skills (for example, indigenous knowledge practices) in order to understand science and to be able to solve problems. IK is a body of knowledge that includes what is done and how it is done (hence indigenous knowledge practices) and can be a source of concepts and skills (ways of knowing how to do things). The knowing and the doing are embedded in each other and cannot be conveniently isolated as with other forms of knowledge such as science. In IK there is little or no explanation as to why things happen the way they do. IK therefore focuses on the how and not the why of knowledge, while science focuses on giving propositions (explanations as to why) about how things happen. Development of propositional (scientific) knowledge alongside and in interaction with IK will entail using science concepts to explain indigenous knowledge practices while making understanding of scientific concepts clearer. IK is an epistemology that uses the logic of doing and science is an epistemology that uses the logic of explaining.

Co-engagement of these two forms of knowledge, indigenous knowledge practices and science may provide a space to bridge the two epistemologies that refer to the realities of a given context. In addition, the co-engagement enhances understanding of scientific concepts by relating them to local indigenous practices. According to Elias (in Mennelland and Goudsblom, 1998:232), knowledge is acquired through "a two-way traffic" that is a balance between theoretical forms of knowledge and observed events. In this case theoretical knowledge is the science knowledge of the syllabus and the observed events are the indigenous knowledge practices that the people have used for many years and that their children have learnt. Observed events contribute to the capital of knowing amongst rural school learners. Educators need to recognise and validate the contexts in which the capital of knowledge is produced. New and appropriate knowledge could arise in the process of recognising the value of what the community does and how it contributes to knowledge construction through engaging the learners' local context.

A collection of illustrative case evidence of indigenous processes and case experiences of the use of IK may help in addressing methodological challenges of integrating IK in the curriculum today (O'Donoghue, 2002). The stories exemplify both declarative and procedural knowledge that educators have to pick up and use to clarify concepts. Use of the stories is meant to challenge the naive oppositional assumptions (O'Donoghue, 2002) that characterises much current research on IK in education. This current approach debilitates an open-ended approach to clarifying perspectives on the methodology of integrating IK in science education. The approach used in this research seeks to position the learners at a detached vantage point (reflexive standing back) as they look at the scientific basis of their indigenous knowledge practices during deliberation (engaging, thinking and talking about) (O'Donoghue, 2002).

This research is thus based on and seeks to interrogate ways in which student teachers can work with science-related indigenous practices that constitute a small aspect of the epistemological realm of the African traditional thought and practice systems (Osaki, 1994). From an environmental education point of view, this will allow indigenous knowledge practices in the learners' lived world, to be related to the propositional knowledge of the science syllabus (science concepts) to enable students to consider sustainable ways of doing things within their local environments.

The process of situated meaning-making with intergenerational knowledge processes, IK, is found within communities. O'Donoghue and Neluvhalani (2002) refer to this as the cultural capital of knowing "in and of everyday life" experience. This places IK as that indispensable and diverse capital of sustaining intergenerational knowing in, of and for life in a particular socio-ecological setting (ibid.). Indigenous technologies and ways of knowing associated with IK can be found operating in everyday life. They are alive, functional and are a situated capital of practices and ways of knowing because they can be consciously used, improved and passed on from generation to generation (Emeagwali, 2003). Nel (2005) argued that IK is an embedded and embodied knowledge, therefore community-related and geared towards well-being and healthiness. It is part and parcel of the human being. IK might thus be seen as a form of knowledge capital that can be used to further issues of sustainability.

Neluvhalani (2003) noted that the tendency amongst educators is to put science and IK in opposition, keeping science dominant. This has led teachers to depend solely on textbooks and laboratory experiments to generate understanding, without adequately recognising how scientific ideas have developed in interaction with the realities around us and with what is already known. The challenge in this study was to explore classroom-learning interactions that consciously draw on and relate to local indigenous knowledge practices. The research process explores the use of these approaches as a way of overcoming some of the limitations of conventional laboratory instruction approaches that characterise science lessons today and tend to present scientific concepts as isolated facts disconnected from the realities of local environmental practices and ways of knowing.

The observation by Odora (2000) that indigenous knowledge is referred to in some ecological topics in science, but is not evident in a way that makes the science relevant to everyday life experiences of the learners, is shared by Giest (2004), who noted that one weakness of science education is that it has a predominant orientation towards isolated, non-situated, generalisable facts, which are seldom applied to real life situations. He argued that this leads to difficulties in understanding and a loss of sense and motivation in science in many students. This view was shared by Littledyke, Ross and Lakin (2000) who observed that secondary school science seems to be too academic and remote for the majority. They warned that if it is not brought into the lives of the pupils it will be built up as a knowledge system that is remote from real life and real issues. Absence of connections between what is learnt in school and life experiences may impede meaningful learning.

A science that relates to a learner's contextual experiences is therefore likely to value and use learners' prior knowledge while fostering high confidence, motivation with consequent understanding - not mere recall of the concepts. Shava (2000) recommended that educational approaches be contextual and that they should encourage the learners to bring in and share their experiences in the learning situation. It is hoped that during this interaction of science and indigenous knowledge learners may simultaneously clarify and refine their knowledge of the indigenous knowledge practices and their knowledge of science.

Savage (1998), Shava (2000) and Odora Hoppers (2001) observed that learners are less able to enjoy schooling and to extract meaning from their schooling in ways that can be applied to change to their lives because the schooling is not related to, negates and ignores their indigenous knowledge base. This study aims to explore the use of the existing conceptual capital in local indigenous knowledge practices (patterns of practice) and associated ways of knowing, to make science learning more meaningful and to encourage learners to relate to the indigenous knowledge practices they use to sustain themselves. These patterns are similar between communities and are more appropriately referred to in O'Donoghue (2002) as an orientating capital of sustaining perspectives amongst people. The practices constitute what people know, what they do and what they are able to do, while also influencing how they are able to do it. Elias in Smith (2001) calls this context-specific knowledge a social "habitus. He suggested that initiatives which integrate IK into the curriculum ought to use methods that respect and elicit the minor differences between learners who might differ in their social habitus, in order to effectively make use of the knowledge learners bring to learning activities.

Masuku Van Damme and Neluvhalani (2004:357) challenged people working with IK to "recuperate it" as well as "reconstitute" curriculum in view of this knowledge and its importance in meaning-making interactions. The foundations for the recognition of IK in environmental learning were laid at the Rio Summit of 1992, (Masuku Van Damme and Neluvhalani (2004), O'Donoghue and Neluvhalani (2002)) and the Gaborone Declaration (EEASA, 2002). In Zimbabwe, the Presidential Commission of Enquiry into Education and Training of 1999 recommended that environmental education (EE) be integrated into the curriculum (GoZ, 1999). This document does not directly suggest the use of IK but promotes environmental education as learning interactions that have to be part of the curriculum. The Environmental Management Act (GoZ, 2004a) also promotes environmental education as a response to environmental issues and challenges. This is also an enabling document for integration of EE in educational curricula but does not make direct reference to the use of IK in education. The subsequent EE Policy does, however, recognise the role of IK in responding to environmental risk and the need to have it as part of curricula (GoZ, 2004b).

Grundy (1987) observed that curriculum is praxis and involves action and reflection. It is important that the education context utilises what learners experience in their home environment. Indigenous knowledge practices constitute some of the experience that learners have to bring to school learning contexts as practices to be understood, respected and reflected upon with the conceptual capital of the science syllabus. Cornbleth (1990) argued further that curriculum is a contextualised social process made of the structural context as well as the socio-cultural context. The structural context includes documents and institutions enabling educational endeavours, such as policies and syllabi whilst the socio-cultural context, which this research seeks to address, includes the interactions between learners and the teacher and the environment in the classroom.

The next section reviews key parts of the structural context in order to provide the necessary focus for the research and educational imperative that probes the relationship between IK and the science curriculum.

2.4. Orientating influences

There are several influences that orientate this study. These orientating influences are discussed at three levels: global, regional and national.

2.4.1 Orientating global influences

In the Tblisi Declaration of 1977 and the Rio Summit of 1992 criteria and guidelines for implementation of a transformative education were adopted. One of the guidelines of the Rio Summit encourages education to, among other roles, "...utilise indigenous history and local cultures" in order to "promote cultural, linguistic and ecological diversity" (O'Sullivan, 1999: 255). Guideline 9 promotes the recovery and use of IK in educational settings, while guideline 11 acknowledges the value of diversity of knowledge and the social processes through which this knowledge develops. In so doing environmental education furthers the globalisation agenda that pedagogy be viewed in a context wider than the classroom, in relation to the curriculum and incorporating the identity of learners as well as socio-economic and cultural contexts (Edwards and Usher, 2000).

Here environmental education pedagogy taking up this globalisation agenda should question the way the pedagogy is conducted and then draw relationships between how it is conducted and how best it should be conducted. When working with a multiplicity of cultures in the society and notions of hybridisation of these societies, there is need to adjust pedagogy so that learners can bring together and reconcile the ways of knowing that they already have with the propositions in the formal curriculum.

Principles of environmental education also promote the value of knowledge in its different forms. Every opportunity available must be used to make different forms of knowledge and discourses exist in juxtaposition as each one has its role to play in the lives of the people, and for sustainability of the societies concerned. Using the background of guidelines of EE from the aforementioned Tblisi Declaration and the Rio Summit, the Environmental Education Association of Southern Africa (EEASA) in 2002 recommended EE implementation guidelines to member states and the ensuing document is known as the Gaborone Declaration. EEASA recognises IK as a practical and multifaceted body of knowledge that can be used for knowledge creation and in reflexive environmental education processes.

The United Nations Decade of Education for Sustainable Development (DESD) draft implementation scheme (UNESCO, 2004) notes a strong link between cultural practices, identity and values, and human development. The goals of the DESD are thus strongly rooted in culture. They focus mainly on furthering practices, values and experiences in order to achieve sustainable development. The scheme then recommends the recognition of "the tapestry of human experience in the many physical and socio-cultural contexts of the world" (UNESCO, 2004:13). These socio-cultural contexts include educational processes (see sections 2.7 and 2.8).

2.4.2 Orientating regional influences

In the recommendations of the Gaborone Declaration, EEASA acknowledged that indigenous knowledge is important for stimulating and facilitating transformation, particularly through school curricula and learning. In addition it notes that educators need to consciously recognise learners' prior knowledge whilst drawing on indigenous as well as scientific ways of knowing in order to support environmental learning and foster sustainability in the communities from which the learners come. The assumption is that if IK is valued in classroom learning, learners are likely to revert to it consciously through a deeper understanding of how it works when at home in order to solve local problems and issues.

This EEASA conference (2002) took place after a Presidential Commission of Enquiry into Education and Training in Zimbabwe (GoZ, 1999) that set to establish the cause of high failure rate of learners in public exams and to examine whether the education was still relevant to the country.

2.4.3 National imperatives

The commission found that the education for Zimbabweans was not relevant to their lives, and attributed the high failure rate to the irrelevance of content and accompanying educational experiences. Education and specifically, school curricula, did not adequately consider the context of the Zimbabwean learner. The science curriculum was included amongst these educational curricula. This was so because curricula were not based on and not responding to issues that affect the Zimbabwean learner. The education was found to be very abstracted from the context of the learner. Consequently, the school is seen as an island of western science within an indigenous society, "the very context within which the school is located" (Odora Hoppers, 2001:75).

The commission then recommended that "environmental issues are at the fore of development and it is important to educate people about them" (GoZ, 1999: 376). Environmental education was identified as the key to meaningful and effective educational transformation. The commission recommended that environmental education be integrated into all forms of education in the country. In response to findings of this commission, the

Zimbabwe National Environmental Education Policy was drawn up and was approved in 2004.

The EE Policy, which draws heavily on the Rio Summit, aims at "making sustainable development a national priority" (GoZ, 2004: 7) and to enable national responses to environmental challenges "through education and communication processes". The policy recognises that education in the formal, non-formal and informal sectors is the vehicle for sustainable development. National objective 7 of this policy aims at "protecting and using indigenous knowledge systems". Principle 10 of the same document aims at "recovering, respecting and utilising IK" and principles 13 and 14 advocate for "integrating knowledge, skills and values" into all forms of education. One result of this policy is a Belgian-funded initiative, the Secondary Teacher Training Environmental Education Programme (St^2eep) that seeks to integrate environmental education into secondary teacher training curricula.

2.4.4 Guiding national initiatives

St^2eep aims at "reorienting education towards sustainable development" (St^2eep, 2003: 3). As a product of the Zimbabwe National Environmental Education Policy, St^2eep draws its aims and objectives from this national document. One of its strategies of reorienting education is to recognise IK in curriculum processes. The EE integration process has to include IK in the curriculum. According to Grundy (1987) and Cornbleth (1990) in sections 2.5 and 2.7 that follow, curriculum is more than simply content and a plan - it includes the socio-cultural processes happening between educators and learners. This research examines the socio-cultural processes of indigenous knowledge (indigenous knowledge practices) and the science curriculum in secondary teacher training and probes how ways of knowing and syllabus concepts mutually interact as student teachers seek to address questions of relevance.

St^2eep has sponsored and facilitated syllabus review to integrate environmental education in all college subject syllabi. Syllabus review is only one and the first part of the EE integration process. The next project phase for St^2eep will be to support lecturers in teaching the EE presented in the syllabus in the teaching and learning of science. Objective 7 of the formal education sector in the National EE policy aims "to protect and promote the use of indigenous knowledge systems". The strategies and actions include identifying appropriate aspects of IK and integrating them into the formal education curriculum. The document does not guide users on how these appropriate aspects could be used in the classroom. This research is an attempt to establish how indigenous knowledge practices can be used in the secondary school science classroom activities using the context of secondary teacher training. The research thus goes beyond the scope of the current teacher training syllabus document as it explores how an engagement with IK can pedagogically be used to open up spaces for greater relevance and better learning of science concepts in the secondary school classroom, whilst facilitating better and more sustaining choices in life.

The next section describes the different perspectives on content and structure of knowledge as viewed by Grundy (1987) in an effort to explain the forms of knowledge experienced in the subject while justifying the probable contributions of this research to the knowledge interests in science learning in Mutare Teachers' College. This description will be developed further using Stenhouse (1975), Grundy (1987) and Cornbleth (1990)'s views of curriculum and curriculum theory. Attempts will be also be made to explicate learning theory and constructivist approaches to teaching. The discussion also touches on Doll (1993)'s views on curriculum theory.

2.5 Purposes of knowledge

According to Popkewitz (1988: 80):

> Knowledge is both dispositions toward the world and cognitive elements about the world; influencing how we act, see, feel, and talk about our social conditions. Knowledge is always bound to interests in society.

Knowledge is therefore constituted of dispositions (perceptions and mental constructions) of what happens in the learner's environment. Events in the learner's environment are inclusive of what the learner has seen, done and heard. Knowledge is not value-free, but is dependent on what the society values as knowledge. The discussions that follow illustrate how the different interests in knowledge that a society has, may influence the type of education and educative processes of its people.

Grundy (1987) posited that curriculum is a cultural construction; hence is understood in terms of different purposes of the knowledge and what counts as knowledge. She called these purposes of knowledge "cognitive interests". Grundy (1987) identified three knowledge interests, namely, the technical, practical and emancipatory knowledge interests. An

understanding of these interests (described in this section below) is important in determining an approach to curriculum development as well as for interpretation of curricula:
The **technical (rationality) knowledge interest** is interpreted as the approach to environmental management that relies mainly on hypotheses and deductions made on these hypotheses. This approach to knowledge construction depends mainly on empirical-analytical processes evident in the empirical analytical sciences. Experience, observation and thought that are informed by experimentation are fundamental for knowledge construction. The understanding is that the environment can be controlled through defined empirically developed laws, rules and regulations. In this form, the knowledge has power and control over and dominates other forms of knowledge. Odora (2000) condemned this hegemony of science, which she terms scientism, in that it was a tool used to dominate and control nature. Understanding of environmental problems was limited to conceptual dimensions whilst connections with other concepts, problems and factors were thinly developed. Volmink (1998) found that science and technology today routinely divorce fact from value whilst favouring fact leading to the destructive exercise of knowledge power of science over other forms of knowledge and over nature.

Within a technical knowledge orientation, subject matter must be learned simply because to know is good. This, in turn, affects the way in which environmental problems are responded to. According to Grundy (1987: 13) "... the objectives model of curriculum design is informed by a technical cognitive interest" that aims at only developing content knowledge. As recognised in Mandikonza (2004), the science syllabus at Mutare Teachers' College is objectives-based and it emphasises content knowledge development; hence this syllabus has a technical interest. Its interest is to produce content-rich graduates who know but may not be able to use the knowledge in their own contexts.

The **practical knowledge interest** is concerned with taking the right (practical) action in a particular environment. There is a strong focus on interaction in the environment, interaction that is based on interpretation of meaning and empowerment (Grundy, 1987). The understanding is that curriculum design is not an end but is a process that is dependent upon the meaning-making interaction between educators and learners. In addition, the knowledge gained must lead to the right action, which means that the focus here is on knowledge that can be applied in real life; therefore this knowledge has utilitarian value. The problem with this cognitive interest is the supposition that knowledge leads to action. This kind of knowledge interest can also propagate a top-down and technically oriented approach to teaching and learning.

The **emancipatory knowledge interest** seeks to encourage autonomy and responsibility in its subjects. It recognises the importance of critical insights in discussing issues that constitute human society and acknowledges that curriculum is a social construction. A curriculum with this orientation involves participants in the educational process in an effort to transform the structures in which learning takes place whilst encouraging self-reflection and action. The knowledge interest goes beyond the practical interest described earlier by bringing in the idea of reflection. Volmink (1998) argues that students must pursue knowledge for life and school science must become science for life that is relevant and meaningful, not decontextualised facts or esoteric, abstract and useless knowledge. Proponents of such relevant and meaningful learning include Grundy (1987) and Cornbleth (1990) as described in section 2.7.

While analysing trends in curriculum theory Doll (1993) noted that curriculum changes have lagged behind paradigmatic changes. He asserted that curricula are grounded in behaviourist psychology where learning is defined by the number of concepts covered yet paradigmatic changes advocate for postmodernist approaches to curriculum theory and practice. He noted that it is possible to practise postmodernist curriculum perspectives in modernist or behaviourist curricula. It also means that it is possible for a curriculum to engage with any two or more knowledge interests that were earlier identified by Grundy (1987). The outcome of this interaction of curriculum perspectives and knowledge interests is a transformative process that embodies the four R's.

The four R's are;
Richness which involves curriculum depth, multiple layers of meaning and possibilities of interpretation,
Recursion which involves the reflective interaction with the environment, others, culture and one's knowledge,
Relations that encompass the making of connections and the understanding that our immediate conceptions integrate into a larger cultural, economic and cosmic matrix, and
Rigour which is understood as dialectic between the complexity of indeterminacy and critical interpretation.

Building on Doll's perspective of curriculum theory Belousa (2002), Sterling (2001) and Gurova (2002) suggested that education must be transformed to go beyond merely expressing content matters. It has to promote lifelong learning and should be defined through four parameters:

1. Learning to know, or acquiring a broad general culture and specific skills. This process is linked to the objective of 'learning in order to profit from the opportunities offered by continuing education'.
2. Learning to do, that is, not only acquiring vocational training but also learning about social experience, working as part of a team, and how to cope as an individual.
3. Learning to live with others or acquiring a culture of communication and tolerance in order to benefit from pluralism, to develop joint projects, and to promote peace.
4. Learning to be, that is, forging one's own 'survival' skills in the present context of rapid changes, by assessing each situation and taking personal responsibility in the search for solutions and in decision-making. (Gurova, 2002: 98)

These four pillars are very similar to the knowledge interests proposed by Grundy (1987). One could say learning to know is similar to the technical knowledge interest, learning to do resembles the practical knowledge interest while the last two elements deal with the human in the society as does the emancipatory knowledge interest.

2.6 The Mutare Teachers' College science syllabus

Mandikonza (2004) noted that the college science syllabus is generally similar in structure and content to the secondary school science syllabus except for the depth of content coverage as well as the absence of the unit 'Science in the Community' from the college syllabus. The school syllabus is reminiscent of the objectives-driven Cambridge syllabi from the 1960s, which portrayed the belief that development could be achieved by fostering a high level of science content. This is what would, as discussed in Section 2.5, be qualified as a technical approach to the curriculum. The science is learnt in a conventional laboratory using conventional experiments. This science is abstracted and presented as detached factual knowledge that often has little direct value to the lived world of the learner.

It is important at this stage to look at curriculum theory in order to try and show how knowledge interests manifest in curriculum processes.

2.7 The curriculum

Grundy (1987) views curriculum as systematic frameworks and processes for regularising courses of study. Curriculum can be viewed as a carefully designed guideline for some learning endeavour. This guideline will have been produced in order to pursue any one or more of the knowledge interests discussed in Section 2.5. The curriculum therefore gives order and direction to educational endeavours. The definition thus encompasses all those processes that enable learning activities that are experienced by learners in a course of study. Therefore curriculum includes what learners actually experience in the learning process. In this view, curriculum includes the subject matter, the learning experiences of the learners, the teaching methods used by educators as well as methods of evaluation and assessment. Some of these processes and activities would have been stated in the curriculum documents and they constitute the explicit curriculum. Learners may also learn what is not stated in curriculum documents and this is termed the hidden or implicit curriculum.

Shava (2000) noted that if the concepts and skills constructed in the learners' environment are not made part of their intellectual repertoire by educative processes, this knowledge constitutes what is termed the null curriculum. All three curricula - the hidden, explicit and null curricula - operate in all educational settings and curriculum planners as well as implementers have to be sensitive to them. This sensitivity entails working with these forms of curricula in ways that open up spaces for effective teaching and learning of concepts in the classroom. Odora (2000) challenges curriculum planners to transform the hidden curriculum because, in addition to its overt influence on learning in schools, she sees it as the arena from which future citizens develop values shaping their identities and future practices.

Grundy (1987) views curriculum as a social construction and like Stenhouse (1975) recognises it as a way of organising a set of human educational experiences. The curriculum must therefore take cognisance of the culture of the society by acknowledging the society's historical background and the consequent social interactions that make that society. Hence, each society has cognitive knowledge interests that dominate in its educational processes. She adds that "... curriculum is to think about how a group of people act and interact in certain situations", meaning that curriculum is not found in documents but is found in how people interact in society. In this case, curriculum (implicit, explicit and null) is not seen as a document but as the interactions between people in an educational endeavour. In my experience of teaching science at MTC, syllabus refers to the teacher education document of guidelines for the range of learning interactions engaged by the college students. Thus syllabus can be viewed as the guiding documents and curriculum as all the interactions, including the syllabus that contribute to an educative process.

Cornbleth (1990) grounded her understanding of curriculum in critical theory. She argued that curriculum is a contextualised social process. Accordingly, curriculum is seen as an ongoing construction and reconstruction of knowledge in the learning spaces created by "social interactions between educators, learners, knowledge and the milieu" (ibid.: 5). It may be of note that *milieu* (surroundings) is a word used interchangeably with *environ* (environment) in French. The environment, educators and learners can thus be said to shape the educational experiences that happen among them through a process of action and reflection, actions being indigenous knowledge practices /interaction and reflection, thinking about and making sense of these. She envisioned a curriculum that was constituted of two contexts, namely, the structural context and the socio-cultural context. In the context of this study I have taken these to be propositions in the formal syllabus (syllabus document for the subject) and the indigenous knowledge practices in the contexts of intergenerational cultural and social life. The former reflects the scientific concepts to be taught and the latter the combination of the life experience of the learner and the cultural capital of knowledge in and of everyday life.

In a wider sense, the structural context is composed of the political ideologies, political systems, education systems, institutional structures and documents enabling and guiding educational experiences during learning. In the MTC case, the structural context includes the dominant political ideologies driving the education system, the Ministry of Higher and Tertiary Education, and all its structures down to the college and the syllabi that guide classroom experiences. As stated earlier, the college is revising its syllabi that are part of the structural context to include environmental education.

The socio-cultural context refers to what actually happens between learners and educators, in context. This context describes what happens as educators mediate environmental learning with learners in their environment and with the understandings and doings that the learners bring to these interactions. In responding to the context of learners, educators need to consider how to work with their indigenous knowledge practices (experiences, patterns of meaningful practice and ways of knowing related to these practices) in a responsive and flexible manner around the scientific concepts. This view of curriculum recognises the important role played by socio-cultural factors in informing learning experiences, within a guiding system of ideas and the framework of concepts in the curriculum.

The view that the curriculum should be a process for guiding learning by socially engaging learners in classroom activities in educative processes is also proposed by Stenhouse (1975), Grundy (1987) and Brimfield (1992). If curriculum is a process that is responsive to the context of the learning, then the people who use it produce the curriculum in interaction with its structures and the more formal framework of concepts in the field of science as outlined in the syllabus. In so doing curriculum planners, as users, should be able to compile the documentary component of the curriculum and outline the actions that it recommends. Users, like planners of curriculum documents, can reflect on practice and modify curriculum action in view of experience gained in context. Consequently, curriculum planners might find ways of presenting some of their recommendations for the socio-cultural context into the syllabus document.

According to Doll (1993) (refer to section 2.5) it is possible to integrate the view of curriculum as exemplified by the syllabus document, with the view of curriculum as what actually happens between educators, learners, knowledge and the environment. This co-engagement provides a platform for critique of the paradigm guiding current curriculum theory and practice. This approach to curriculum may enable the MTC science syllabus to build capacity among student teachers to critique the way they are taught against the way they will teach in the schools and ultimately realise their potential as individual teachers in a community of practice.

The science syllabus at MTC has the potential for such flexibility and reflexivity. The Department of Teacher Education (DTE) at the University of Zimbabwe requires the syllabus to be reviewed every three years. St^{2}eep has identified this opportunity for revising the syllabus in order to integrate environmental education. Since science lecturers produce the science syllabus at MTC, it is they who revise the syllabus in order to integrate environmental issues, concepts and processes of sustainability and perspectives as well as processes to ensure relevance of the science learnt in the college. St^{2}eep, as an enabling organisation, aims to promote the use of IK in the syllabus as already described in section 2.4.5. This research probes how the IK in society can be worked with in the classroom so as to fulfil these expectations of curriculum as a process of action and reflection of IK and science as proposed by Grundy (1987). The research also probes the socio-cultural context of curriculum that was envisioned by Cornbleth (1990). The research therefore focuses on how IK can be usefully used by student teachers during teacher training to prepare lesson plans and to teach their peers. In so doing curriculum manifests as action in the classroom as educators interrogate how IK can be used as a tool for teaching and learning of science.

Students who are taught with this syllabus are all adults and therefore an overview of perspectives on how adult learning could influence educational processes in learning, and in particular, in the science classroom, follows in the next section.

2.8 Trends in adult learning and science learning

Lotz (1999) and Brookfield (1995) challenge the simplistic learning and paradigmatic assumptions about adult learning. According to Lotz (ibid.), adult learning must be guided not only by pedagogical theories but also by adult learning theories that support and encourage adults specifically to learn. Paradigmatic assumptions that could be considered when educating adults include the following;

- adults should feel at ease in a learning environment
- adults should contribute to planning of the learning processes
- adults should take mutual responsibility for the teaching-learning process
- experiential learning techniques are more appropriate in adult learning
- there should be more practical application of learning
- adult learners should be guided to analyse their own experience
- learners should be grouped for learning (Lotz 1999: 55)

For effective learning, educators should encourage learners to use their experience to develop and clarify concepts. This educational setting would enable adult learners to seize opportunities to co-construct knowledge whilst identifying spaces for cognitive development through receiving new information and sharing their information and experience. At this point I found it helpful to work with the Encounter, Dialogue and Reflection model (O'Donoghue, 1998) discussed below in order to illustrate how learners can deliberate their experiences.

2.9 Engaging with the Encounter, Dialogue and Reflection heuristic

This model is based on constructivist ontology. It proposes that learners should have real life experiences (encounter/ touch) of what they learn and then make meaning out of their experience through thinking (reflection/ think) on their experiences and sharing (dialogue/ talk) amongst colleagues. The model assumes that learning is an outcome of deliberative processes of meaning-making amongst learners. It was noted by Lotz (1999: 54) that learning happens through "the concept of experiential cooperative meaning making amongst adult learners in the context of real life situations in local environments". This view influenced the methodology of this research. It made the researcher explore stages where learners had to think around what they actually experienced at home and enacted during the lessons. Learners had to work in groups to deliberate the applicability of IK in science teaching and learning. The next section examines how constructivist learning theories inform classroom practice in the learning of both young and adult learners and play out in the touch, think and talk model highlighted above.

2.10 Constructivist theory in science learning

Recent curriculum trends and perspectives as illustrated in section 2.7 have shown a shift from the classical view of curriculum as a plan to a view of curriculum as the interactions and processes that occur during teaching and learning. This section will try to build a closer relationship between educational processes and learning by looking at some theories of learning that might be relevant to this research.

Constructivist perspectives recognise that each individual learner brings some kind of knowledge/experience to the learning situation, so they do not only receive knowledge but construct knowledge based on what they already know. In actively constructing knowledge, they use what they already know as the starting point, relating it to extant knowledge. The knowledge that learners have is utilised in constructing meaning, refining and confirming what is already known and building new understandings. In this form of constructivism, learning is personal, subjective and only exists in the mind of the learner. Piaget's propositions on development of and construction of patterns of behaviour (***schemata***) and adapting these behaviours to new situations (***assimilation***) are the backbone for such thinking on influences to learning (Child, 1986). By acknowledging that each learner brings some knowledge in their minds (prior knowledge), it becomes important that the teacher elicits and identifies this knowledge and then uses it to develop and clarify concepts during teaching-learning activities. Bramsford, Brown and Cocking (2001) asserted that for learners to understand learning a teacher must first tap into cultural practices of the learner, identify the strengths and weaknesses of this knowledge and then build on these.

Prior knowledge is gained from school and out of school contexts. Some of the out of school contexts include indigenous knowledge practices. The teacher has to elicit content appropriate to indigenous knowledge practices that learners have and use these in a variety of ways. Stears, Malcom and Knowlas (2003) suggested that learners' prior knowledge can be used as a starting point for science learning, as a reference for thinking about science, and as a context for applying scientific ideas and skills.

Bruner (1993) in Baumann, Bloomfield and Roughton (1997) also propounded individual constructivism by proposing that learning is spiral, meaning that development of new knowledge depends on knowledge already present in the individual. As already described, learners learn from both the home and the school context. This suggests two, perhaps three dimensions in learning interactions (knowing /experience capital, indigenous patterns of practice with associated ways of knowing and the concepts of the science curriculum) that might inform the meanings that are carried into reflections on lifestyle choices and sustainability.It is necessary that educational processes take note of, respect and use these intermeshed forms of knowledge in the learner. When learners bring knowledge into a meaning-making interaction and draw on scientific concepts the two seem to become one, a developing way of knowing that is carried into future learning interactions. By this process, most of the experiences and knowledge that today exist in the null curriculum of the learner will create spaces for meaningful learning in the explicit curriculum.

The work of Vygotsky led to the development of social constructivism (Baumann, Bloomfield and Roughton, 1997). This theory recognises that an individual can develop knowledge at both personal and social levels. Knowledge is "interpreted as a social process of knowledge construction, rather than an object for students to internalise" (Lotz-Sisitka and O'Donoghue, 2004). According to Vygotsky in Gijlers and De Jong (2005: 268), learning is described in terms of the zone of proximal development (ZPD), which is

> ..the distance between the actual development level as determined by independent problem solving and the level of potential development as determined under adult guidance or in collaboration with more capable peers.

Here learners' prior experiences play a vital role in the socio-cultural processes of knowledge construction. These experiences are used in the co-construction of knowledge as learners share subjective experiences and insights. Meaning-making occurs when learners share perspectives during participatory processes in organised activities. The presence of a knowledgeable adult who provides 'backbone' and guidance is crucial for learning. Learners working in groups respect each other's experiences and contributions (in a process termed "inter-subjectivity") leading to a better understanding of concepts in ways that individual knowledge constructors would not be able to achieve. Inter-subjectivity allows learners to work with knowledge in ways that may promote 'cognitive dissonance'(Jackson, 2003). This is described as a state of knowledge discontinuity between what the learner knows and new knowledge, or as a perceived inadequacy of any given knowledge. This discontinuity could be the beginning of new knowledge, new understandings and insights as learners may start to construct relationships. This help that learners give each other to understand new concepts is termed 'scaffolding'. Learners scaffold each other in order to bridge Vygotsky's ZPD using instruments brought to class by the educator. The IK stories constitute some of the scaffolding material the educator can bring to class. Student teachers continue to scaffold each other through their own knowledge of indigenous knowledge practices, their knowledge of the science subject content and their knowledge of how lesson plans are drawn up and taught.

Language is very important in the interactive processes that are used to develop knowledge. Through use of language, learners are able to discuss and scaffold each other in the construction zone. In this case language is not limited to the mother tongue but includes various types of symbols. A knowledgeable adult is replaced by knowledgeable others and collaboration is prominent. Such an approach is possible when learners draw from and reflect on their indigenous knowledge. They can share this knowledge and be guided by the teacher to identify informative science concepts in the syllabus. They can then use these concepts to explain their observations in the home context.

As recognised in section 2.9.1, in a day learners can experience two cultures that appear epistemologically divorced from each other and alienated unless these interact in the meaning-making process. Allowing learners to bring what they know from home will provide spaces for the learners to relate the localised, tacit, contingent knowledge gained in their social lives to the generalised, structured, systematic knowledge they develop in formal situations in the school.

Ausubel in Baumann, Bloomfield and Roughton (1997) found that meaningful learning occurs when information to be gained is related to information that the learner already has The classic statement that is attributed to him, that educators need to know what learners know and teaching accordingly, suggests that the knowledge gained before the learning activity be used as a base upon which new knowledge can be built. The educator not only has to question what the learner already knows on the subject but ascertain the environment or cultural background of the learner. This then implies that an educator has to know and use what the learner already knows, beyond textbook content, in order to develop the textbook concepts. In terms of this research, learners bring knowledge including IK in the form of IK practices from home. It is essential for the educator to identify appropriate and related practices and to assist in relating these to the propositions/concepts reflected in the science syllabus.

2.11 Nature of science and science learning

There are various ways of thinking about science and the how to learn about science. These include science as learning about nature as well as science as IK. It is also important to consider the links between IK, science as nature and the curriculum

2.11.1 Science learning as learning about nature

Howe and Jones (1993) note that scientists believe that the world is understandable and that there are discoverable patterns throughout nature. So science is about knowing what is in and what makes nature. As a result of our observations on what is and what makes nature, we try to explain these observations. We strive to explain what it is that we observe and what makes it the way it is. Science therefore entails both content (what it is) and process (what makes it the way it is). Howe and Jones (ibid.) developed three classifications of science concepts. The first group was termed concrete concepts. These are derived from direct experience or observation. Other science concepts require abstract thought. These include those that can be experimented on, such as sinking and floating. However there are also ideas that cannot be in any way represented in concrete ways, such as the atomic theory, and these remain abstractions that have powerful explanatory potential. The first two groups of concepts are experiences the learners are expected to meet in their homes and social contexts and this is the experience they then bring to class. To this end, Carter and Curtis (1994) wrote that existing knowledge and experiences are the source of new learning. Science learning must start by eliciting the learners' experiences. This experience may be used to develop, demonstrate and clarify concepts. The experience may also be used to build upon, when clarifying abstract concepts, those that can neither be seen nor demonstrated.

According to Howe and Jones (1993), the goals of science include that the learners are expected to observe and explore their environment and organise those experiences as well as relate what they learn in school to their own lives. Organisation of experiences implies learners' ability to make use of their observations and to apply the acquired knowledge in their daily life activities. These learners' experiences with nature outside the classroom are embedded in their culture and are embedded within their practices.

Culture includes "ways of being, relating, behaving, believing and acting which differ according to context, history and tradition, and within which human beings live out their lives" (UNESCO, 2004: 13). Culture, according to van Wyk (2002) includes these characteristics and in addition, can be seen as the form of intellectual expression of a particular group of people. Hence culture constitutes a contextual epistemological lens for student teachers. IK as perceived in this research is part of the culture of the people concerned. As such, useful indigenous ways of knowing are very similar to other useful ways of knowing that include propositional knowledge, or content concerned with explaining how things happen (Della-Dora and Blanchard, 1979). As Seepe (2000) notes, there are other ways of experiencing phenomena, which do not necessarily oppositionalise conventional science, but exist alongside it, thereby conceding to the view that indigenous ways of knowing are only one perspective of the same knowable reality to which scientific concepts refer. IK as observed, experienced and time-tested knowledge in practice is related to the same real world that scientific concepts refer. In this view, the research explores how ways of doing and knowing in science and in other culturally inscribed ways of knowing refer to and resonate with the environmental realities that are experienced in a given socio-ecological context.

Admittedly science is a culture in itself, with its own language, habits and values. Culture is dynamic, accommodating and can be appropriated into other cultures. One can also assert that this scientific culture can also be appropriated into any culture. There is a possibility that students' conceptual and attitudinal difficulties are deeply cultural. It then becomes necessary to marry the culture of science to the culture of the people learning as these relate to the environmental realities so that learners understand scientific concepts in relation to the way they live. Stears, Malcom and Knowlas, (2003) found that in many communities science is not viewed as part of the cultural fabric. It is divorced and alienated from learners' lives. Odora-Hoppers (2001) observed that learners live two lives; that of a learner in the school and that of the member of society outside the school and in the home. The observation shows that learners live two cultures that are perceived to be very different and alienated in one day; the formal, structured, systematic culture of the school (including science learning) and the generalised life of the society. Yet these two cultures have overlaps and both largely determine the repertoire of practice of the people. It becomes pertinent to look at ways of introducing the cultural dimension of science into the classroom so that learners identify with both propositional science concepts and cultural practices in ways that harmonise them and enable the learners to understand the two better.

2.11.2 Indigenous Knowledge as cultural capital

The term indigenous knowledge (IK) in this research includes ways of knowing (knowledge), patterns of practice and ways of doing things or indigenous knowledge practices (technologies) of indigenous people. IK is constituted of both content (ideas) and practices (methods and processes). Osaki (1994) as well as O'Donoghue, Moate, von Baren and Goduka (2005) described indigenous knowledge as that which was generated in the community and transmitted from one generation to another without being influenced by foreign ideas and practices. This definition though useful does not accommodate the dynamic nature of IK as a component of culture and its ability to appropriate components from other cultures. This indigenous knowledge is generated over long periods of objective interaction with nature, through trial and error. During the development of indigenous knowledge practices, the methods of trial and error are based on intuition, which Bruner (1960) in Yoloye (1998) propounds to be an important prerequisite for scientific discovery.

Van Wyk (2002) contends that knowledge is a form of property or cultural capital that may or may not be built from formal educational experiences. His perspective is that knowledge production has two forms; purely disciplinary knowledge and one where educators recognized and validated learners' cultural capital. Disciplinary knowledge is usually developed in formal education contexts. Knowledge built from cultural capital is that which learners bring to formal educational settings.

At the same time education is viewed as a means by which society reproduces itself. Formal education is a vehicle by which the dominant society reproduces its culture whilst subjugating other cultures where these diverge from agreed norms in a given socio-cultural context. This means that formal education can use learners' experiential knowledge negatively, as a means to close off, to monopolise, to subjugate and to negatively legitimise other forms of knowledge capital and their meanings (Odora-Hoppers, 2001). Ekins in Odora (2000) concedes that the view that promotes conventional science as the only valid world view dismisses the major part of creativity, intuition and the tacit and traditional knowledge that constitute the principal perceptive, expressive and cognitive powers of the majority of people in the world. This constructivist view shows how the knowledge that learners bring from home contexts is ignored in learning situations. Ekins's (*ibid.*) argument further shows how the realist ontology that learners have real experiences in socio-ecological realities is negated in learning situations. Consequently, this research seeks to work with the two epistemologies in ways that make them overlap, rather than isolated and alienated.

The dominant purposes of knowledge (section 2.4) that have determined the structure, content and end-needs of Cambridge based syllabi subjugated IK in science learning. In the Zimbabwean science education system IK has been reduced to providing occasional contextual examples. In this position, IK has not taken a key role in science learning but has a supportive and validating role to science learning rather than scientific concepts serving to validate and clarify what is known in and might inform everyday socio-ecological realities.

2.11.3 Links between IK, science and the curriculum

Seepe (2000) argues that scientific knowledge should lead to the same answer irrespective of the interrogator and where that interrogator is located. This thinking makes scientific knowing universal and applicable as a culture with or against any other culture. Consequently it should be possible to appropriate (Seepe, 2000) and adapt knowledge derived elsewhere in order to understand it better and make better use of that knowledge by making it part and parcel of the receiving culture. Whilst advocating for Africanisation of knowledge Seepe (2000) however warns against a shallow approach to the process. He says we should guard against just replacing imported conventional materials with local ones, as has happened with the ZIMSCI (Zimbabwean Science) initiative in Zimbabwe in the 1980s (Mandikonza, 2004; Makhurane and Khan, 1998 and Hountondji, 1997). The initiative aimed at making science available to all learners by replacing expensive conventional equipment such as glassware with readily and cheaply available materials such as empty jam tins. However, this science did not live long because teachers did not know how to use the equipment. Besides all the science teachers had been educated using conventional apparatus. The initiative too was poorly sustained because the guiding syllabus documents and the educational processes had not changed. The content of the syllabus remained as it was before democratic rule, i.e. based on and structured like Cambridge syllabusi. Such an educational initiative should have been informed of and reflective of culture, experiences and worldviews of the majority of the indigenous people who used it. The aspects of culture that are brought into the syllabus must be well studied and their suitability for their role in the educational endeavour very explicit before the initiative is institutionalised.

Seepe (2000) says that African experience is the source of knowledge for constructing pyramids of knowledge. This research too assumes that since all learners in science are Africans they have a large proportion of knowledge (skills and mental constructions) of the sustaining knowledge practices. This thinking supports the role of the realist epistemology in this research. Makhurane and Khan (1998) however observed that contrary to this assumption science teaching continues to be based on the textbook, the teacher and memory of pupils. This has remained so since Africa has always been a recipient of and reliant on culturally insensitive syllabi, under resourced and overcrowded classrooms (Osaki (1994). Little attempt has been made to facilitate learners to construct classroom knowledge upon cultural knowledge. According to Doll (1993) it is possible to do so even on the current culturally insensitive syllabi. The aim of this whole process is a more holistic and effective learning of science concepts.

2.12 Relevance in science education

Relevance refers to ability of an education to influence quality of life and ability of learners to control their lives whilst making the subject accessible, motivating and learning of it achievable (Rollnick, 1998). She goes on to say that the irrelevance of science education was a virtue in pre-independence Africa. That is, the more abstract and divorced from life the science was the more academic it was and the more it was esteemed by regulating powers. As observed by Mandikonza (2004), GoZ (1999) and Volmink (1998), the Zimbabwean syllabus has remained westernised, content based and decontextualised even after gaining democratic rule in 1980, so it has effectively remained divorced from the lives of the people who learn it. Such a syllabus is characterised by rote learning processes and a consequent failure of learners in public examinations, especially the communal majority (O'Donoghue, 2002). When learners fail in tests that are derived from abstract concepts in the syllabi, the conclusion is that the concepts were poorly understood and in such instances the examiners were obsessed with marks and grading such as pass or fail. According to Jackson (2003), learners protect themselves from failure in class by engaging in rote learning when they are faced with topics that they cannot grasp or find meaningless (see section 2.9.4). The rote learning has little connection with daily use of the knowledge. This is knowledge built for the purpose of knowing (see section 2.4). Their failure to understand information taught is most probably due to there being very little common ground between what they learnt and what they do in their lives. Whether they pass the tests and exams or fail, they quickly forget about what they memorised soon after writing. This is so because what they learnt in school is not recognised as useful education.

Whilst most researchers think that IK should result in learners understanding more and scoring higher test marks Emereole and Maripe (2003) found that using relevant indigenous beliefs in science teaching impacted negatively on performance of lower secondary science learners. Learners performed poorly when indigenous beliefs were integrated into science teaching. The learners however showed a better attitude towards science than those who were not exposed to indigenous beliefs. The researchers (*ibid.)* concluded that even though relevant indigenous beliefs were useful for endearing motivation they did not make learners score higher in tests. They however encouraged teachers to continue to explore the use of IK in science teaching. This research is an exploration of the use of indigenous technologies, which are only one part of indigenous knowledge in science teaching.

2.13 Towards a paradigmatic change in science learning

In order to make learning relevant to the leaner, a change in the education process is necessary. A paradigmatic change that recognises, locates, and identifies the scientific skills, knowledge and processes embedded in the cultural practices of the Africans is necessary. Any conceptualisation of IK must suggest that the science syllabus has to focus on the relational dimension of cultural life (van Wyk, 2002). It has to strongly bring out that things happen the way they do because of their relationship with other things. Such a position begins to bring in explanations into indigenous knowledge practices and thereby appropriating propositional knowledge for this explanatory purpose. The position also presents a critical framework for thinking and knowledge construction, both of which complement and expand disciplinary understanding. In addition to these, learners will also recognise and identify with the knowledge they engage in.

Seepe (2000) contends that learners can be engaged in unravelling the scientific basis of indigenous knowledge practices through locating and identifying the scientific skills, knowledge and processes embedded in their sustaining cultural practices. Starting with IK in science learning would encourage learners to draw from their context and their situated cultural practices. Learners might find the knowledge relevant to them since they might be learning about how and why they do some things they never really questioned or related to other events and processes in their life in this way before. They might notice that the body of scientific knowledge is a human enterprise in which various groups of people contribute through a community of practice. In such a way, learners could be relating themselves and how they do things within their natural environment. . In so doing learners contribute to restructuring, redesigning and reformulation of the present academic curricula and make them more contextually relevant (see section 2.9). This view conforms to critical curriculum perspectives propounded by Stenhouse (1975), Grundy (1987), Cornbleth (1990) and Doll (1993) whilst responding to poverty in the school in the Decade of Education for Sustainable Development (see section 2.4).

Osaki (1994: 63) argues that IK is "actually a paradigm of enquiry" and there is an important need to put in place strategies that harness indigenous knowledge systems in order to address challenges in both education and sustainable development. Seepe (2000: 134) contends that learners find an intellectual home in culture and language and if these are used they may be a "key to unlocking the door that has prevented the masses from accessing mathematics, science and engineering". Scharping and Gorg (1994) in Beck (1999) refer to such an approach as "interdisciplinarity" since it creates a new relationship between natural and social sciences. It also allows interaction between two ways of knowing that Beck (1992) in O'Donoghue (2002) calls "inter-epistemological dialogue". Both indigenous and propositional ways of knowing are brought together for a better understanding of how both exist and operate. In so doing explanations on indigenous knowledge that are not in its nature are provided by the propositional science while at the same time getting a deeper insight into the nature of the propositional knowledge. Consequently, learning of propositional science becomes a cultural component, alongside the inherent cultural practices and ways of knowing.

Elias in Mennelland and Goudsblom (1998: 232) reaffirmed the interdependence of these two forms of knowledge and adds on that during the acquisition of scientific knowledge, creating dichotomies between textbook or conventional ways of knowing science and indigenous ways of knowing is a problematic. He argues that the two forms of knowing are complementary to each other as he says that in the acquisition of knowledge there must be a 'two-way traffic' between knowledge in the form of "general ideas, theories and models " and knowledge in the form of "observed specific events".

Elias emphasises that the interplay amongst experienced indigenous knowledge practices and generalised ideas shapes the coherence of learning outcomes. If learners do not appreciate the mixture of discoveries, strengths and weaknesses in the diversity of their experience in life, it becomes impossible to understand real life problems and establish propositions from which to generate appropriate solutions. To this end Odora (2000) calls for a composite and interdisciplinary way of thinking, acting and interacting that allows learners to have a holistic view of any issue in order to generate appropriate responses to environmental issues.

2.14 Conclusions

Global, regional and national frameworks guide the process of integration of EE into formal curricula in Zimbabwe. At global and regional levels, notable treaties and agreements such as the Tblisi Declaration of 1977, the UN Commission on Environment and Development's Rio Summit in 1992 and the UN Decade of Education for Sustainable Development provide the framework. This framework is used nationally to come up with national and context specific initiatives and imperatives in response to the country's specific environmental issues. Zimbabwe used the global and regional agreements to come up with a national environmental management policy and an environmental education policy, respectively. The policies recognise the important role played by culture and specifically IK in furthering education.

IK has always been marginalised in the schools science syllabi. These syllabuses are westernised, and encourage decontextualised learning processes that do not recognise the role of the learner's context in knowledge construction (the abstracted generalisations to which Elias refers), where these do not relate to the experiences (practices and ways of knowing of everyday experience), the learner can experience two alienated cultures. These are the culture of the school with a science culture that always explains phenomena in abstract ways and the culture of the home where phenomena are done or made to happen without need for the explanations. Enabling documents stated earlier in this chapter do not suggest how it can be integrated into curricula. There is need to find space to bring IK into the classroom. The purpose of this research is to explore how an educator can work with the cultural practices that are observed in the society of the learner and with scientific ideas that provide explanatory insights into the environmental phenomena that learners need to understand to live and interact in more sustainable ways. Consequently, the research seeks to harmonise these formerly alienated epistemologies by working with them together.

In this chapter, the notion of knowledge interests was discussed in order to explain the curriculum perspectives orienting current practice and in a way to justify the envisioned initiatives that constitute and exemplify critical curriculum perspectives. Constructivist learning theory, which is the guiding framework for the actual practice is discussed and brought into critical review. The need to harmonise the two epistemologies within the realities of the local environment was explicated over the greater part of this chapter.

CHAPTER 3

RESEARCH METHODS

"Surely the God who created in us the longing for the better, the desire for the truth, will not withhold from us the answer to all needed knowledge..." (White, 1995).

3.1 Introduction

This chapter gives an outline of how the research process was planned and conducted in an attempt to answer the research question. The research focus is on how lecturers in science in the teacher training college can engage student teachers in everyday indigenous knowledge practices in order to develop scientific concepts while at the same time clarifying these concepts in ways that show relevance of these concepts to the learners. Data were generated at different levels of the research. Student teachers received a Learning Support Material (LSM) with documented indigenous patterns of practice, which they reflected on in order to make sense of the practices. Student teachers then used one of the documented practices to produce lesson plans and to teach their peers with the lesson plans.

3.2 Research paradigm

The research uses a qualitative approach and is an interpretive case study (Terre Blanche and Durrheim, 1999; Robinson, 1993; Bassey, 1999). Qualitative methods can be used to uncover and understand what lies behind any phenomenon about which little is yet known. Hitchcock and Hughes (1989) comment that qualitative approaches enable researchers to learn at first hand about the social world under investigation through involvement and participation by focussing on what participants say and do. The researcher generated data of how rural people performed some patterns of life by being amongst and part of them. The researcher next generated data on classroom use of IK whilst amongst and with the student teachers that he taught. According to Hitchcock and Hughes (1989) qualitative research brings researcher and subjects of research closer together whilst drawing attention to what ordinarily and routinely happens in educational processes. Interactions during the research process are likely to culminate in a greater understanding between educator-researcher and subject-learners, an understanding that may enhance learning of concepts under investigation or any other topic in the curriculum.

This research is, according to Terre Blanche and Durrheim (1999) interpretive because it takes cognisance of people's experiential knowledge whilst studying what they make of these experiences. In this instance, the research probed people's intergenerational ways of knowing (subjective experiences) to make the learning of science contextually relevant (relate to views of knowledge) whilst looking at how to generate issues of sustainable living during the teaching of science.

3.3 The Mutare Teachers' College as a case

As a case study (Bassey, 1999; Kreuger and Casey, 2000) the research has been conceptualised within a localised boundary of space and time, Mutare Teacher Training College. Case studies are characterised by an in-depth study of a single event or a series of linked events and relationships between events. The case study approach was the most appropriate to study use of indigenous knowledge practices (indigenous knowledge) in science teaching because it enabled the researcher to test practice in an everyday teaching environment, that is, lesson planning and peer teaching of science using indigenous knowledge practices within an everyday classroom environment (Hitchcock and Hughes, 1989). Another dimension of this research is that it aimed at bringing an innovation into the teaching-learning process, which focused on small-scale intervention in the functioning of the real world whilst making a close examination of the effects of such an intervention on the teaching-learning process (Cohen and Manion, 1994). The research happened in a real and particular classroom (small-scale), the science classroom and with real learners (real world), student teachers in science. During the research, the class chose and worked with one of the indigenous practices that were documented, namely separation of grain from chaff, making this process a case within a case.

Stevenson (2004) argues that case studies lack rigor or quality. Besides, Stevenson (*ibid.*) further argues that findings of case study research cannot be easily generalised since the researcher generates specific data for a specific group in a localised space. This view has been shared by Corcoran, Walker and Wals (2002) who said that case studies could not produce useful and transferable knowledge thereby reducing their potential for influencing change in practice beyond the limitations of the studied case. According to this argument then the findings from the case in point in the Mutare Teachers' College science classroom may not be applicable to similar concepts and may not be transferable to similar contexts.

The perspective has little effect on the methodological approach of the research since there is no intention to generalise the findings of this research.

3.4 Methodological orientation

In this research college students probed how best to use indigenous technologies in the science curriculum. The research is thus a case study of IK and science in context in order to open up a close examination of how scientific concepts and indigenous technologies can be worked with in teaching and learning contexts and can be used to generate discussions on sustainable living (Robinson, 1993).

In order to achieve this, the research sought to provide insight into lecturers and student teachers' views on how to use technologies that exemplify indigenous knowledge in teaching and learning activities in order to clarify scientific ideas. Consequently, the research sought to harmonise indigenous and conventional ways of knowing science in classroom practice, with the hope that the student teachers will reflect on the role of these practices in clarifying scientific ideas and their potential to open up discussions on sustainable living. Therefore, in this regard, the research may have an empowering (Lather, 1986) effect on indigenous knowledge systems and on the indigenous participants, who may be encouraged to appreciate and respect their local knowledge of the environment more and use it in teaching of these concepts more often. The research falls into this category because it views the subjects, who are student teachers, as co-researchers, since they used some of the researcher's findings to produce lesson plans and then tested their lesson plans during peer teaching exercises. The next section describes and justifies the research techniques that were used to generate the sets of data.

3.5 Research techniques

The data generation process involved four techniques, namely;

- document analysis,
- observations,
- interviews, and
- focus group discussions.

Progress of research was recorded in a research journal. In addition, photographs were used to capture perceived important parts of the data generation process.

3.5.1 Document analysis

The researcher analysed the syllabus content and identified scientific concepts in the syllabus that related to documented patterns of practice (see Appendices 1, 2 and 3). These concepts were not shown to student teachers as the researcher wanted to see how close the student teachers would get to identified concepts when they did the same process.

3.5.2 Observations

Observations were made at three levels in the research. Firstly, participant observations were made of some patterns of doing things (indigenous knowledge practices) in rural areas. Secondly, participant observations took place when learners and lecturer worked with a member of the community in acting out methods used to separate grain from chaff. Lastly, observations were made of student teachers as they delivered and peer-reviewed lessons.

Robinson (1993) and Creswell (2003) describe observation as a natural data collection technique that is central in all enquiries. Behaviours of people at the research site are watched, recorded, analysed and interpreted. Participant observations occur when the observer seeks to become a member of the observed group. The participation not only involves physical presence and sharing of life experiences, but also entry into their social and symbolic world through learning their social conventions and habits (Robinson, 1993). The researcher looked at how some things are done and was involved in some of the practices as the people were doing them and as such learned from direct observation and experience. This includes student teachers' observations on acted-out activities and the lessons they delivered. In this way, he was able to record steps and events that could have been missed by merely looking or by interviews only (Borg, Gall and Gall, 1996). Whilst supporting the use of participant observations, Scott and Usher (1999) contend that participation in context is the best method for interpreting meanings and experiences of members who are engaged in meaning-making interactions in the society.

When the group knows the researcher's role and he/she interacts with the group under investigation in their natural environment, the researcher's role is that of participant-as-observer (Cohen and Manion, 1994). In this role the researcher was able to address ethical issues such as seeking consent from subjects more directly and was accessible to the research group. When generating information on intergenerational ways of doing things the researcher was part of the family and was involved in the activities. When student teachers used documented practices in the classroom the researcher was present and was part of the teaching-learning process. This position also opened up spaces for negotiation in activities and discussions. The science lecturer as researcher was able to seek prompt feedback from the participants on what was observed both in the field and in class. It was possible to generate data from the perspectives of both the rural people and science students whilst being amongst them.

3.5.3 Interviews

An interview is a conversation interaction between people that has been initiated by the interviewer solely for the purpose of obtaining research relevant information on a specific topic and for improving knowledge (Cohen and Manion (1994); Wengraf, (2001). Interviews can be used as a research tool to probe depth of responses, convincingly explain the purpose of the study to respondents as well as address the issue of linguistic ambiguity, in ways that other techniques like questionnaires cannot (Oppenheim, 1992). This technique was particularly appropriate for generating data on indigenous knowledge practices in rural areas where the researcher was unsure of the literacy levels of respondents.

Semi-structured interviews, which Hauck and Snowman (2005) describe as a set of key questions or themes whose development is guided by the interaction between interviewer and interviewee, were used to elicit descriptions of ways of doing things on observed activities from members of the community. These authors also argue that semi-structured interviews provide an informal environment and flexibility when gathering information. For any technologies observed the researcher probed how they were carried out or performed. The semi-structured interview enabled the interviewer to probe for details of particular processes by asking for further clarification (Borg, Gall and Gall, 1996; Scott and Usher, 1999).

3.5.4 Focus group discussions

Kreuger and Casey (2000: 5) describe a focus group as "a carefully planned series of discussions designed to obtain perceptions on a defined area of interest in a permissive and non-threatening environment". Focus group discussions took place towards the end of term and some of the student teachers were engaged in sporting activities out of college. The researcher worked with the remaining 40 of the 60 student teachers. They were divided into six groups of at least six but not more than seven. Kreuger and Casey (2000) point out that each group must have between six and eight members to allow for maximum verbal interaction.

Student teachers worked in small groups as they related to documented practices of what they know and do at home. Focus group interviews were also conducted with student teachers after peer teaching sessions in order to establish their views on usefulness of the LSM and its link with the secondary school science syllabus.

Student teachers worked in groups on researcher-designed questions in their classroom, a relaxed and non-threatening environment. The questions focussed on whether the lessons had indeed clarified intended scientific concepts. The questions also elicited from student teachers the advantages and disadvantages of using IK or intergenerational patterns of practices in science teaching. Students made input into how the demonstrated lessons could be improved to make the concepts and methods clearer.

Focus groups are a source of high quality data since participants give their views in a social context (Patton, 2000). The group was composed of males and females, students who had prepared the lesson plans and those who had not. Such a mixture allowed the students to learn from each other as they engaged critically with the questions. All discussions were presented to the whole class and both researcher and student teachers made additional comments in a plenary.

3.6 Ethics and validity threats

The interviewees who provided data for the intergenerational ways of knowing in rural areas gave verbal consent for use of their names in this research and their contributions were sincerely acknowledged. Permission to work with student teachers was verbally sought from the Head of Science Department. All participants in the research gave verbal consent to use of their photographs in the research report.

All participants were informed verbally that they were generating data for the research. The outcome of the research was also shared with them since this is an action research project. All contributions were considered as data. The research process with the science class was made as much as possible a part of the normal teaching-learning process so that it contributed to learning of the participating students. In no way did the research disadvantage any learners. It is hoped that the student teachers involved in this research may explore the same phenomena in a variety of ways in their classroom practice, during teaching practice and after they graduate. This would constitute a kind of catalytic validity (Lather, 1986).

Construct validity (Lather, 1986) refers to the reflexivity of the researcher on the research problem, guiding theory and what actually happens during the research process. Therefore it is an assessment of how well the researcher's ideas or theories are translated into actual activities to respond to the research problem. Construct validity in this research is illustrated by the community people's ongoing knowledge-based patterns of successful practice and researcher's 16 years of experience in science teaching and learning. Triangulation of the data (Maykut and Morehouse, 1994; Creswell, 2003), to ensure and confirm the truthfulness that Lather (1986: 67) referred to as "counter patterns and convergences", was effected through use of observations and interviews when generating data on patterns of practice. Data on classroom use of patterns of practice by student teachers was triangulated through lesson plan analysis, lesson observations and focus group discussions.

Photographs contribute to records of some of the observations, both in the field and in the classroom. Findings were recorded as they emerged in a research journal.

3.7. Data Generation Process

The research process occurred in four phases summarised as follows:

Phase 1: Patterns of actions are observed and recorded by the researcher in the community.

Phase 2: Syllabus review to establish science concepts that are congruent with documented practices.

Phase 3: Student teachers review modules on patterns of practice, in order to familiarise themselves with documented practices and enable them to make sense of these practices by enacting them before they used them in class. Science concepts in these practices were explored with student teachers.

Phase 4: Peer teaching activities where students teach back with the lesson plans that they developed.

The flow diagram (Figure 1) that follows shows a summary of steps taken in generating data for this research.

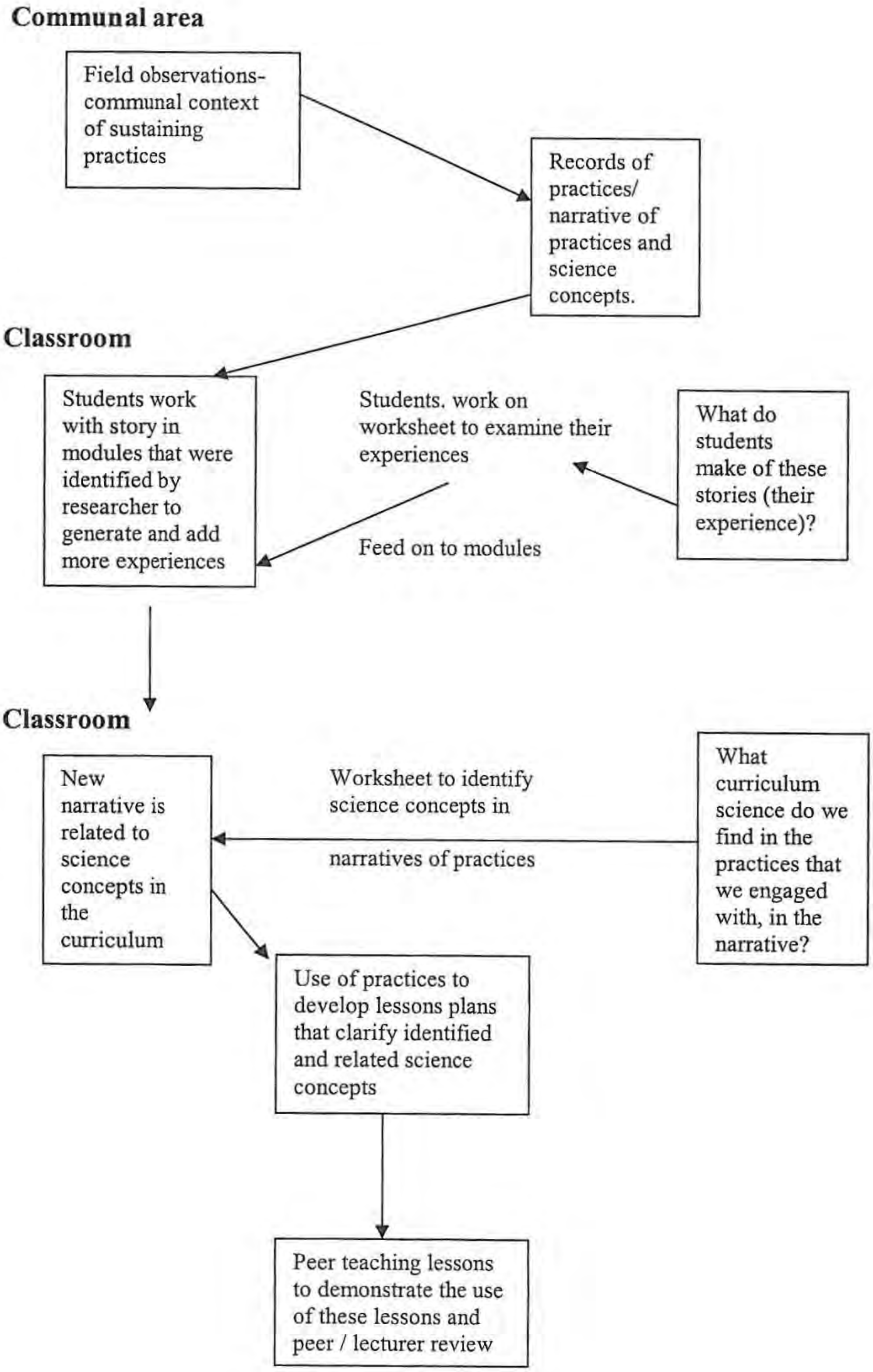

Figure 1. Data generation process

3.7.1 Field observations

Observations were conducted in the field to identify some patterns of practice amongst members of the community. Alongside this technique semi-structured interviews were used to elicit how things are done with members of the community. A compilation narrative report of the technologies was produced.

This narrative report became the Learning Support Material (LSM) that was brought to the class for student teachers. Many patterns of practice were observed but for the purpose of the research only three patterns were organised into modules and presented to the class.

3.7.2 Document analysis

As indicated in section 3.6.1 the science syllabus was analysed by the researcher to identify and note science concepts that were congruent with indigenous practice.

3.7.3 Presentation of documented practices to student teachers

An elderly member of the community was invited to demonstrate some of the recorded activities in addition to what the learners had read from the LSM. Students acted out some of the practices such as winnowing, as they helped the elderly person in the demonstrations. The community member described the process in her mother tongue, which is ChiShona, and a ChiShona speaking student from the group translated into English for non-ChiShona speakers. The enactment stage was necessary in order to enable student teachers, the majority of whom are Namibians, to relate to the practices. The pictures in Appendix 10 show a member of the community who demonstrated ways of separating chaff from grain.

Student teachers used this LSM and demonstrations from a community member to relate to the documented practices. They demonstrated how they did the practices at home. All 60 students were present and they were divided into three groups (A, B, and C) of 20. Each of the groups was subdivided into two or three smaller groups of between six and ten (A1, A2, A3; B1, B2; C1, C2, C3). Each of the smaller groups worked on grain preparation, grain storage, varieties of food items and preparation of grain products for human consumption as well as treatment and storage of milk. During this process student teachers documented similarities and differences between what was written in the LSM and what they did at home. They also identified and noted where in the syllabus the practices could be used. Findings from this exercise are shown in Table 1.

3.7.4 Peer teaching activities

After identifying scientific ideas evident in the narrative, the 40 student teachers worked in four groups of 10 to prepare lesson plans that they would use to teach their peers in the subsequent lessons. One member of the group presented the lesson to the whole class.

The researcher observed these lesson presentations. The researcher also analysed the content of the lesson plans and the peer-delivered lessons. After all lessons were presented student teachers were divided into eight groups of five and were guided by a questionnaire produced by researcher to critique the lessons presented. Each of these groups was termed a data generation group (DG). The discussions were conducted after all the lessons were presented enabling an overview of all the lessons. Outcomes from the discussions were presented to whole class in a plenary session. The researcher probed and recorded the contributions that had not been captured through group discussions during the plenary.

3.8 Data Analysis

Data from field observations, syllabus analysis, student reflections as well as data from lesson plans, lesson observations and focus group reflections on lessons, is analysed in the following sections.

3.8.1 Data from field observations

A grounded theory framework proposed by Creswell (2003) was adopted in the fieldwork phase as it provided clear procedures for looking at the relationship between indigenous knowledge practices (and people's explanations of these) with the concepts of the science syllabus. The descriptive approach to data analysis (Maykut and Morehouse, 1994; Ely, Anzul, Friedman, Garner and Steinmetz, 1991) was used with data from field observations of specific practices. Using his knowledge of the science syllabus, the researcher chose particular intergenerational patterns of practice that relate to syllabus content. This stage was carried into the developing study, as it provided the processes of developmentally working with data needed in this case study. At each phase the data was organised to inform the study.

The next step was to read through the data thoroughly for a sense of how indigenous knowledge practices and science concepts are related. This data was categorised and presented in a qualitative narrative (in the form of a Learning Support Material) to inform lesson planning and materials development that is shown in the form of modules in Appendices 1, 2 and 3. These processes were undertaken throughout the developing phases of the project.

3.8.2 Data from syllabus analysis

The researcher read through the documented indigenous knowledge practices and identified concepts from the science syllabus that are related to the practices. The concepts were written next to the practice as shown in Appendices 1, 2 and 3.

3.8.3 Data from student reflections on documented practices

Student teachers observed enactments of winnowing, sifting and handpicking demonstrated by a member of the community. Student teachers were able to relate what they did at home to documented and illustrated practices. They also commented on possible links between syllabus content and documented practices. These were recorded as raw data on sheets A1, A2, A3, B1, B2, C1, C2 and C3. Distinct categories of cultural identification, links to syllabus, observations on language use and student teachers' cultural preferences came out as researcher read through the student teacher responses to the LSM. The responses were categorised as they emerged from the data (Appendix 11) and were recorded into a table as shown in Table 1 that follows.

Table 1: Analytic record of Focus Group on stories (LSM)

Categories	Subcategories	Code
Cultural identification	a) similarities • threshing and winnowing done in the same way	☆ light green star
	b) differences • some Shona people thresh by driving cattle on their dry farm produce • milk placed in heat of sun in order to sour and agitated to isolate cream • at times a root from a special plant is added to milk to speed up the souring process	☆ gold star
Links to the syllabus	• topics identified where practices of separating grain from chaff could be used are mixing and separating, variation in living things and convectional currents • Syllabi with these topics are ZJC and O level syllabi	☆ Dark green star
Cultural preferences on processing methods	a) Modern • faster, not dependent on weather, no air pollution, need smaller space, requires few resources, less effort exerted, cheaper in terms of labour (done by machines), machines can process large quantities of grain from chaff in a short time. b) Traditional • flour is obtained from pure unprocessed grain, no chemicals added, cheap, easily and naturally prepared, keeps our cultural ways of preparing food alive	☆ orange star

3.8.4 Data from lesson plans, lesson observations and focus group reflections on lessons

Data from lessons – plans, observations and reflections on the lessons - was carefully analysed in ways discussed below.

3.8.4.1 Data from lesson plans

Student teachers used the LSM as a resource to plan and implement lessons that cover the syllabus topics at ZJC level that they identified (see section 3.8.3 and 3.8.4) during peer teaching activities. Data from all the lesson plans were compiled into a table (DLPR). The analysis was based on the researcher's knowledge of lesson objectives based on the Bloom's

Taxonomy of objectives and plan structure prescribed by the department for student teachers. It focussed on the appropriateness of written information for the different attributes of the lesson plan. Finally, a summary of the constituents of lesson plans was made.

3.8.4.2 Data from lesson observations

The researcher observed the lesson presentations whilst among the student teachers. Observations centred on how the different attributes in the lesson plan emerged in the lesson. The observations were made on how the documented attributes were playing out in the actual lesson. A summary of the progress of the lessons was made and comparisons between the lesson presentations were made.

3.8.4.3 Data from student teacher reflections

Student teachers then reflected on the lesson plans as well as the structure, content and effectiveness of peer-delivered lessons. As they did this they were assessing whether concepts identified were clearly shown in the lesson presentation and in so doing were evaluating the usefulness of the documented practices in science teaching and learning. Data from these reflections were analysed using the grounded theory that draws from the constant comparison method (Glaser and Strauss, 1967). Corbin and Strauss (1990: 23) defined the grounded theory as a qualitative research method that uses a systematic set of procedures to develop an inductively grounded theory, "one that is inductively derived from the study of the phenomenon it represents". In this approach, the aim is to accurately describe what one sees from the data and how it has been understood as well as reconstruct the data into recognisable codes and categories.

Corbin and Strauss (1990) noted that since the theory is arising from the research it has to apply to the everyday reality of the area studied. It also has to make sense to and be easily understood by the people who were studied. The outcome of this research must be useful to the department of science at MTC and must be easily understood by both lecturers and student teachers. If this outcome is derived from comprehensive data and conceptual interpretations, the theory can then be abstract enough to be applied to a variety of contexts. Finally, Corbin and Strauss (1990) emphasise that if the data from which the theory is derived is actual, the conditions under which the theory applies need to be specified. Actual data are obtained from case study research because case studies are carried out in specific temporal, spatial and societal contexts. Findings of this research are therefore applicable to the Mutare Teachers' College science group that participated in the study (see section 3.3).

The researcher explored whether student teachers had identified appropriate content and activities for chosen syllabus content in their lessons by analysing lesson plans and observing the lessons taught. The researcher also made student teachers critique lessons taught by their peers. The raw data that were generated in data generation groups (see section 3.8.4) shown in Appendix 9 were transcribed into tables in Appendices 5 and 7 and were read through carefully several times until themes could be discerned. Data generated using different research techniques were colour coded using shapes of different colours (see Appendix 9), categorised and compiled into one table. The following categories, namely lesson objectives, content identification, lesson activities, source of materials, usefulness of practices, role of language in learning and tensions associated with use of practices, were discerned as shown in Table 2 that follows.

Table 2: Table showing findings from lesson preparation and delivery

Categories	Subcategories	Data sources
Lesson objectives	• define separation, • identify methods used to separate objects of different densities (winnowing, sifting and hand-picking) • describe each of the methods used • show how method is applied	• DLPR • LO
Content identified and shown	• separating solid objects of different densities • winnowing as a method of separating objects of different densities	• DLPR • LO • FGD
Lesson Activities	• Teacher describes the processes of winnowing, sifting and handpicking • teacher. asks pupils to go outside and assist in demonstration of winnowing, sifting, handpicking	• DLPR • LO
Source of materials	• focus on Science • handout with documented practices	• DLPR • LO • FGD
Availability of materials	• materials readily available anywhere • pupils can practice it at home • no laboratory is required	• FGD

Relation to everyday life	• they are easy to understand • relate to everyday activities that pupils understand more • will improve learners' thinking capacity	• FGD
School community relationships	• pupils understand and appreciate the community-based activities • community members may relate more to what is happening in class • other subjects in the school may copy from science and invite members of the community more often to their lessons, i.e. bringing their materials to class may make them more supportive of teaching and learning of their children	• FGD
Gender sensitivity	• this encourages females to do science more as they have greater chances of participating in familiar and contextual activities • in some communities, such as the Shiwambo culture in Namibia, men use shovels instead of baskets that are mostly used by females,. Males may therefore, not find it easy to demonstrate such activities	• FGD
Language and learning	• spoken language may be a barrier for non-Shona speakers, who may not accurately describe the processes involved since some terms are difficult to translate • non-Shona speaking students may meet problems trying to identify parents who can lead these activities • the college community member who showed "how" to separate grain from chaff spoke fluently and the process flowed. The demonstration was quick and easy because she was telling and showing. • learners reverted to vernacular during discussions and presentations. Presenting students first got approval of translations in mother tongue from colleagues (Shiwambo) before speaking in English. • drawings were made on the board and response sheets to illustrate practices of winnowing and milk processing	• LO
Undervaluing IK	• if teachers' scientific background is	• FGD

	based on the textbook, the teacher may not see the usefulness of these practices in classroom learning • parents not involved may not see these activities as necessary for learning, hence the approach may negatively affect relationship between teachers and the community • some learners may think that the teacher is wasting their time as they are taught by a community member in mother tongue, as initially thought by the student teachers when they were first exposed to the practices during enactments by member of community • school administration may initially think that the teacher is not doing his/ her work if a community member comes to class to demonstrate	

Key of abbreviations

- FGD - focus group discussion on lesson
- DLPR - detailed lesson plan review
- LO - lesson observations

3.9 Reflections on the data generation process

There was not enough time to generate the data since the researcher was only able to teach science education to the science group for two weeks at the end of the term. The data were supposed to be generated in context, as part of the teaching and learning process among student teachers. The data in this research were generated over a one and a half week period. Consequently, only one lesson was presented per group. Students did not have a chance to improve their lesson plans and present them again after receiving comments from colleagues.

There was a modification in the research design. The initial plan of the research was to explore how student teachers related to documented practices in the LSM so that modules used to generate lesson plans had alternative practices derived from both Shona and Shiwambo cultures. Due to a shortage of time to compile the students' input, the documented practices were used simply to open up thinking around the science concepts of these practices. The data already generated were however adequate because the purpose of the research was to explore a methodological alternative to teaching, not to examine the depth of indigenous knowledge of student teachers. The concern that differences in practices would affect lesson preparation was allayed when all student groups chose to use one practice that is similar in both cultures.

The process of generating data on patterns of practice in the field was made easier for the researcher because he did observations and interviews with members of his wife's family. Negotiating access was easy when it was mentioned that the information was for classroom and research uses only. These participants were very supportive and were ready to show the researcher even their granaries and cattle kraal, places that they do not comfortably take strangers. It would not have been possible to get the same depth of information if the researcher was not connected to the family. These discussions were conducted in our mother tongue, ChiShona. The discussions were translated into English as the data were generated, since the student group was composed mainly of Namibians who do not understand ChiShona. If the student teacher group were composed of ChiShona speaking students alone it could have been more effective to record all information generated in ChiShona and to do the research in ChiShona.

All of the students are second or third language English speakers. The majority claim that they learnt in Afrikaans and mother tongue until Grade Nine (9) and only started learning English then. Observations by the researcher are that these people grapple to understand information presented in English during their first year in college. Most of the student teachers have difficulties in speaking, reading and writing in English proficiently. The researcher worked with such a first-year group that had to respond to discussion questions in the Learning Support Materials written in English. Some of the phrases they had written on the discussion guidelines were clearly expanded in the plenary. The plenary session was very important in this data generation process. Therefore in such a research design it is important to share feedback from group discussions in a plenary so that necessary clarifications and additions can be made before the researcher works alone with the data. There are cases when student teachers were encouraged to make drawings to further illustrate description of certain practices as a way of alleviating the communication problem.

Due to the problems highlighted in the preceding paragraphs, the data generated in this research and especially for the part where the LSM was brought to class and used in peer teaching activities was notably thin. This data were however valuable in providing a framework for making recommendations on the use of IK in the science classroom activities for this exploratory study.

Research that is based at the work place and on practice has many advantages to the researcher. There was greater ease of negotiating access with students when student teachers worked with documented practices to produce lesson plans and teach using these practices. Student teachers worked diligently and cooperatively as they knew that they were practising use of the ZJC syllabus, practising to plan lessons and practising to teach, while at the same time helping the researcher to generate data. They were very willing to help someone they knew.

The acting out of the IK practices encouraged them to discuss their own practices and this facilitated the use of these practices in the lessons. The demonstration by a community member may also have helped students to identify more with the practice. This is evident in student teachers' choice of the practices that were acted out (separation of grain from chaff) for developing and implementing peer-taught lessons. None of the groups chose any of the other two documented practices for developing lesson plans as these practices were not acted out. Female students who are usually not willing to take part in demonstrations during conventional science learning were, in these demonstration activities, very willing to illustrate the processes both with the community elder and in the peer-taught lessons. When asked to produce lesson plans from documented practices of their choice, students found it easier to work with those demonstrated by the community member.

One lesson learnt is the importance of keeping close track of all findings. The researcher could not find data from groups that did not make presentations because the response sheets were not collected on time (specifically the lesson plan for one group that did not present). In future the researcher would collect all data generated at each stage as soon as they were generated. If lessons were not taught and the lesson plans not collected student teachers often threw away the lesson plans.

Students had problems in expressing themselves verbally and in writing. They gave short phrases in their responses. Even though some of these phrases were expanded during plenary sessions, some of these responses remained too short to derive meaning when the researcher was analysing them alone. In the end the data generated from discussions seemed very little.

The initial data were generated from observation of one family. It would be interesting if future research involved several families in the same locality. A compilation of data from a few families may result in a better generalisation of the way people perform their indigenous knowledge practices in an area.

It was not the intention of this research to generalise the outcomes from this case study. However, replication of the same case in different contexts such as with different IK topics could have increased the potential of the research findings to generate stronger conclusions. When the researcher provided student teachers with three examples of indigenous knowledge practices, he expected each group to choose different practices. Instead given the choice, each group chose the same practice.

3.10 Concluding remarks

The research design decisions guiding the research process were discussed and justified in this chapter. The orientation of the study was discussed. The interpretive orientation was described and the case study method used in the research was also explained and justified. The various strata at which data were generated were described. An overview of data generation techniques used and the processes of each stage were also described. The process of data analysis was explained. Reflections on the whole data generation process, including the techniques involved were presented.

The next chapter will explore the findings of this research. These findings include what student teachers made of the indigenous knowledge practices introduced to them, how they engaged these practices in the teaching of science concepts and their reflections on classroom use of the practices.

CHAPTER 4

INDIGENOUS KNOWLEDGE PRACTICES IN SCIENCE LEARNING ACTIVITIES

"My experience is that I am gradually seeing something new, something I did not know, and that I am setting an example: one can do it, and it is worth the trouble...It is the normal way for a scientist. One has a problem and one day one knows: I have the solution." (Elias (1994), in Smith (2001): 101)

4.1 Introduction

The above quotation from Elias (1994) in Smith (2001) describes exactly what the researcher thought and how he felt as he observed communal people perform indigenous knowledge practices. The researcher thought and felt he had the answers to the problem of the current approach to science education which is irrelevant to the rural learner and does not recognise how rich in practical wisdom the community is in ways that are bound in indigenous knowledge practices. He thought that this approach could widen student teachers' and teachers' choices for available, affordable and yet effective alternative approaches to the teaching and learning of science. The researcher saw the research process as an opportunity for students to study the syllabus, prepare lesson plans and to engage in peer teaching, all stages necessary in the teacher training process.

This chapter reports and interprets the evidence collected during the research process. The chapter outlines information collected and documented on indigenous knowledge practices that were observed and recorded in rural areas. It also reports on interactions that followed with college students in the planning and presentations of lessons. The indigenous knowledge practices examined in the rural community context and reviewed by students at the college were used to probe how the interaction between indigenous knowledge practices and syllabus concepts could contribute to a meaning-making engagement with scientific ideas and the social realities of everyday life.

This chapter thus examines the research data around the central question of this research, namely the extent to which the interaction of local and Science syllabus knowledge might contribute to what is learnt in school having greater relevance to the local contexts and life experience of learners. This is further discussed in Chapter Five. The researcher found it appropriate and convenient to report personal involvement and experience in the first person in the sections that follow.

4.2 Fieldwork in Manesa village

Preliminary data for the research were generated in this rural community through an intensive participant observation period (see section 3.5.2). This was accompanied by interviews to find out what the communal people said about the indigenous knowledge practices that I had participated in and observed in the homes of the community members.

From the observations I noted that the indigenous knowledge practices had emerging structured patterns. The practices were constituted in such a manner that they followed a sequenced progression. Appendix 12 shows pictures of some of the interactions I had with *Mbuya* (grandmother) Muchono regarding the granary on stilts. I constructed an account that could be used with my students to explore the research questions related to the science syllabus. Documenting of indigenous knowledge practices and stories was undertaken during the three days that I stayed in the rural area with my wife's family. I summarised these observations into the subtopics: what I saw, what I heard and what I thought.

4.1.1 Separation of grain from chaff

What I saw

It was early in the afternoon, on New Year's Day 2005, when I arrived with my family at my wife's homestead in Manesa village, which lies on the western side and at the base of the hill slopes of the Mutema mountain range. This mountain range runs from north to south. After the usual greetings *Mbuya* Muchono brought out baskets (*tswanda nerusero*[C] with maize grain in a *tswanda* [C] (deep basket) and tossed some grain into the air. She then left to do other chores for about an hour. When she came back she repeated the tossing of grain. She put some maize into the *rusero* [C] (flat basket) and went on to systematically winnow with her back to the mountain and the basket and hands strategically held in the air at an angle to the body, away from her and at a distance that prevented her from intercepting the air currents. At the same time she kept her eyes, nose and clothes free from the floating chaff. The position of the *rusero* prevented the chaff from whirling around her; instead it floated away as she winnowed. Chaff floated off in the air currents while maize grains fell into the *tswanda* [C]. I joined her and she taught me how to winnow gently. She teased me because this was a feminine chore and male sons-in-law were supposed to do masculine chores like constructing and repairing granaries and repairing livestock kraals. I had to stand in a particular position so that chaff did not go into my eyes. I had to allow a reasonable amount of grain to come out of the *rusero* [C] while shaking the *rusero* [C] slightly. We did this in turn until all the grain was finished - but I always got a lot of chaff onto my clothes and face.

What I heard

When I asked *Mbuya* Muchono why she had tossed grain when she did, she said she that first she tested the strength of the breeze - early in the afternoon it was too weak. The chaff fell very close to the *tswanda* [C]. The second time she tested, the wind was strong enough. Chaff was blown further away from the *tswanda*[C]. She was winnowing her grain to take to the grinding mill on the following day. She noted that *dutu rinowanda manheru* [C] *(breezes are stronger in the evenings).* When I asked what would happen in the total absence of wind she took me to the family's threshing platform and showed me heaps of ash. She described these as arising from fires that were made to create *mhepo yemukwasha* [C] (see Appendix 1). She sang for me one of the common songs they sing along with the burning fire. The song challenged sons-in-law of the family, whom she named, in turn, to blow a stronger breeze so that they could use the grain to make beer. She said if she calls the name of one who wants beer the most, the breeze will be stronger.

What I thought

The practice of winnowing observed made use of concepts of winds that descended from the mountains in the evening. Having noticed that the breeze around midday had no particular direction but blew down the hill slopes in the afternoon, I wondered whether these winds got stronger as evening approaches. These observed air movements constitute the ascending and descending winds that are taught under 'Pressure Systems' in Physical Science. The separation of grain from chaff depended on their differential densities of the grain and chaff. The fire that is used on a calm day as she described was to generate stronger winds by convection, another concept in Physical Science (Appendix 1). Separation of grain from chaff does not show details of calculating density but gives practical uses of the idea of density in everyday life. The practice can also be used as a starting point to develop the concept of density. Learners can start from their experiences with density before the theoretical concept is defined or calculated. When teachers start with the indigenous process and try to explain it, there is a greater potential of developing the conceptual content from the vantage point of the learner. It will not be the educator bringing knowledge to the class but the educator building on the knowledge of the learner. I also thought about the way people learn in the home context. They learn through practising the real activity, i.e. learning through doing as I did with the technique of winnowing. The learning process involves a show and tell that is intermeshed with the doing. I thought this was participating–in-action, rather than simulation. I also thought that the school environment could tap pedagogically from this approach to teaching and learning.

Finally, the song made me think of the non-physical/ spiritual connections humans have amongst themselves and with the metaphysical world. These connections make the human being a component of life-supporting systems, rather than the controller. It shows how humans are dependent on other phenomena in the environment.

4.2.2. Grain storage

Field observations

I then asked *Mbuya* Muchono what she does with the winnowed grain. She took me to the granary, a rectangular house that is thatched with palm fronds and sits on stone stilts. The granary had large open spaces between the wall and roof. Half of the room consisted of a compartment that was full of sorghum grains. She told me how they used to store grain traditionally using *Lippia sp.* (*zumbane* [C]) and *Eucalyptus sp.* (*mupuranga* [C]). Today they mix the traditional way (see Appendix 2) with the modern way of adding pesticides to their grain. When asked why they had to combine the traditional and modern approaches to grain storage the lady said she doubted the quality of the grain they are now using. When they used grain from their stores the traditional treatment was adequate. Today they are using commercial seed varieties that, though are very productive, could be susceptible to weevils. She lamented that nowadays they have to buy both grain seed and the seed protection after harvest. When I asked why the granary was constructed like this and about the plant stems used to build this house, she directed me to a young man called Douglas.

What I heard

Dougie described to me in detail how the granary is built using the different plants listed in Appendix 2.

What I thought

In science, we know that if seeds are damp, they are easily attacked by fungi and hence degenerate quickly. The large air spaces between roof and wall in the granary allow for free circulation of air. Cow dung must have insect repellent properties since it is used both on the threshing platform and in the granary walls and floor. One possible way of testing the effect of cow dung on weevils would be to set up an experiment where weevils are inoculated into a bottle containing maize and cow dung. Behaviour of weevils is noted. Behaviour of these weevils could be noted and appropriate conclusions made. In biology, plants have co-evolved naturally with insects. The natural selection process may have given grain seeds a thick skin that protected them from insect infestation. Artificial selection in commercial seed breeding may be favouring production and not after-harvest protection of the seed. These ideas could be developed to show artificial selection of living things in Ordinary (O) level Biology. I thought about the implications of this for sustainability: communal people have to buy seed every season; otherwise they cannot grow crops because they have discarded their traditional varieties. In addition they have to buy seed protection to protect their harvest. Some of the scientific concepts that can be identified in the grain storage process are shown in more detail in Appendix 2.

Finally, I also considered how some of these indigenous knowledge practices are gender-specific. *Mbuya* Muchono could confidently describe and show what she, as a woman was able to do. Some of the chores were for females only. Descriptions of the chores for males were left to Douglas.

4.2.3 Treatment and storage of milk

What I saw

On the following mornings, 2 and 3 January, I went with Dougie to milk the two cows. A son-in-law is expected to take on all masculine chores in the home. I could not milk a cow because I never milked one before. The process involved gently tying the hind legs of the cow together whilst whistling to calm the cow. When the legs were tied we allowed the calf to suckle a little. It was stopped from suckling and the teats were washed with water that we had brought from home. I then milked the cow, feeling a sense of achievement for having successfully milked a cow for the first time.

The milk was sieved and taken home. The family cooks outside and in front of the kitchen. At home *Mbuya* Muchono took some milk and added it to tea in a teapot that was sitting on coals by the fireplace. She boiled some milk in a small pot. She poured the rest (about four litres) into a big clay pot that she took from the drying shelf *(dara* [C]*)* and took the pot into the hut.

What I heard

I asked why she had boiled the milk and she said that this was milk she wanted to use to prepare pumpkin leaves, to make tea in the evening and to bake bread for the next morning's breakfast. She said to keep milk from souring it had to be boiled. Asked why she had put the rest of the milk into a clay pot, she said that was the milk souring pot *(hodzeko* [C]*)* she used. She always used it when she wanted to prepare sour milk *(mukaka wakakora* [C]*)*. This time she was preparing sour milk especially for me. She said milk soured faster if the pot was kept in a warm place. She explained that there are times when the clay pot sours milk faster than expected. This milk will be of poor quality. This happens if the clay pot is used continuously without intermittent washing. She would treat the pot by first scouring its walls with sand and ash. These would be washed off using boiling water. The other observations and outcomes from this interview were collated into Appendix 3.

What I thought

There are a number of scientific concepts identifiable in the handling of milk. These included boiling to kill milk-souring bacteria, conditions necessary for bacterial growth (ash is alkaline and neutralises the acidic medium which is optimal for bacterial growth, warmth makes milk souring bacteria produce faster) and the idea of bacterial sporulation. Some of the processes could make a good starting point for a teacher who wants to teach about bacteria. Some milk-souring bacteria form bacterial spores on the walls of the clay pots. Too many spores may result in too many bacteria growing in the milk at a time, making milk sour quickly. Scouring with sand may remove the spores on the pot walls and the hot water would kill many of the remaining spores.

4.3 The three stories

Using my expertise of and experience in science and the science syllabus at Mutare Teachers' College, I selected three practices to work with in the classroom. These rural practices had fascinated me as a sequence of stages that related to key science concepts. This experience informed my earlier assumption that it might be possible to relate science to the everyday realities of rural learners in more meaningful ways.

4.3.1 Development of modules

The three practices that were written up as modules or LSM (Appendices 1, 2 and 3) and presented to student teachers were:

- preparation of grain for storage,
- grain storage process, and
- preparation and preservation of milk.

4.4 Development of LSMs with concepts

4.4.1 Review of science concepts identified by researcher

Since the researcher is an experienced science educator, he easily found many curricular links within the indigenous knowledge practices during the data generation process. Indigenous knowledge practices have scientific concepts that are embedded in them. These links related mainly to biological and physical science components of the syllabus (see Appendices 1, 2, 3). It was this skill that enabled the researcher to choose the three practices for the research, out of the many that he observed. As the scientific concepts related to the situated practice were identified, the researcher also added the component of the syllabus from which the concept came.

4.4.2 Science concepts in grain preparation

In grain preparation, the practice of smearing cow dung on floors and walls can be used to develop the concept of pest control. Testing of dryness of grain with teeth can be noted as one under testing procedures. Diversity of crop plants can be taught using the variety of grains such as maize, sorghum, and millet and other agricultural plant produce. Such aspects as selection for grain size, shape and colour can be used to develop variation within a species of organisms. These concepts were found in the biological sciences component of the syllabus. In physical sciences, separation of chaff from grain using air currents can be used to develop the concepts of pressure systems. The winds descending from mountains during the afternoon and evening are catabatic winds. They can be linked to observations of the prevailing direction of the wind in the morning. In developing the concept of density, the process of winnowing can also be used. The concept of convectional currents in Physical Science can be developed using the fire that ladies made at one end of the winnowing platform (*mhepo yemukwasha* [C]) on a very calm day (Appendix 1). As observed by the learners (see Table 1), winnowing and sifting can also be used when separating mixtures of solids with different densities in both ZJC and O level syllabi. Links with the biophysical component of the environment include how the mountain vegetation can affect the heating and cooling processes and subsequent wind movements.

4.4.3 Science concepts in grain storage

In the grain storage hut, the presence of stone stilts can be used in biological sciences where control of humidity and free circulation of air as factors that affect grain storage could be discussed. Knowledge of the hardwood plants from which wood for constructing grain storage structures is derived (*musharu, mushanje, mutsingidzi, chikuwe* [C]) can be used to develop the concept of diversity in plants by discussing diversity of habit, form and functions. Use of insect-repellent plants like *zumbane* [C] and *mupuranga* [C] in grain storage can be discussed in terms of sustainable (cheap and available biological control that is environmentally friendly and non-toxic) options for grain protection from weevils under the concept of storage of food, which is a component of the biological sciences syllabus. This can be related to health issues where information on natural insect repellents can be shared to alleviate the problem of mosquitoes and consequent malaria control. Sustainability questions could touch on such areas as methods of harvesting of the useful plants, their regeneration rate and the greater possibility of the young short shoots to be eaten by animals.

4.4.4 Science concepts in souring of milk

The process of filtering milk to remove solid particles soon after milking can be used to develop the concept of filtration in laboratory science. Even though this concept is used in the three sciences in the syllabus (biology, chemistry and physics), it is mainly a component of physical sciences. In the biological sciences, boiling of milk to keep it fresh can be used to show and explain the concept of killing bacteria to prevent souring. *Mbuya* Muchono knew that milk had to be boiled and she knew how to boil the milk to keep it fresh. Conditions that are necessary for microbial growth in biological sciences could be developed when learners refer to the use of a particular clay pot for souring milk. The treatment of the milk souring pot with hot water can be used to show killing of bacteria with heat and can illustrate the conditions affecting bacterial growth. The process of bacterial sporulation can be explored with the reasons behind cleaning by scouring the pot when the pot is souring milk too fast. Sand is used to scour bacterial spores from the walls. The ash has potash which provides an alkaline medium. Sour milk has three layers: cream, milk curds and whey at the bottom. This layered structure can be used to develop the concept of density. Draining of whey from the sour milk can show the process of separating by decanting in physical sciences.

4.5 Working with student teachers

4.5.1 Context of the science class

Sixty first-year student teachers observed the demonstrated documented practices (see section 1.3). Forty student teachers were involved in lesson planning, delivery and critique. The twenty who were not involved had gone to participate in inter-college sporting activities outside college. There were ten students from Zimbabwe, six males and four females. Of the 30 students from Namibia, 20 were females while ten were males. The majority of students were from Namibia. The implication of this for the research was that instead of working with Shona students who would have been familiar with the practices, I had to work more with foreign students with their own alternatives to the cultural practices. Students therefore had to observe with my field observations and relate them to their own, before they could use them for teaching purposes.

4.5.2 Students drawing relationships with the indigenous knowledge practices

This activity was intended to assess how familiar learners were with the indigenous knowledge, and also intended to help the learners identify with the indigenous knowledge practices. As already described, student teachers read about the practices and observed as well as took part in demonstrations. They then worked in groups to compare and contrast what happened in the documented practices with what they do at home. The study revealed that these student teachers have a wealth of experience in indigenous knowledge practices. They were generally very motivated, willing and able to demonstrate these practices. The female students who were usually reserved were quick to take up the baskets to show what they did at home.

Use of mother tongue is able to establish a natural give and take relationship that is associated with the rich traditional heritage of orating that is a pillar of communication among the African people. Knowledge has been transmitted over the ages by word of mouth in the African culture and therefore story-telling in the mother tongue is the best way to do a show and tell. Obviously this is a major challenge for non-ChiShona speakers. To deal with this problem a ChiShona speaking student teacher did translations into English for the non-ChiShona speakers while the community elder enacted the process of separating grain from chaff (see section 3.7.3).

4.5.3 Student knowledge on separation of grain from chaff

As mentioned in section 1.3, the MTC science class is a mixture of Namibians (most of whom speak Shiwambo) and Zimbabweans (who speak Chishona). When relating to the processes student teachers had to refer to the terms they use in their mother tongue as the following report shows.

The processes of threshing (*kupura* [C] and *okuxwa* [S]) and of winnowing (*kuurutsa* [C] and *okuyela* [S]) are the same in the two (ChiShona and Shiwambo) cultures (A1, A2, A3). One difference is that the Shiwambo people do not smear the threshing platform with cow dung. They use anthill clay instead. These ways of plastering are localised and unique to particular societies as opposed to winnowing which is similar in the larger context.

Alternative and innovative methods exist even among communities that are close to each other. For example, some Shona people do not thresh with sticks but walk their livestock (cattle and goats) over the dry harvest to trample it. They then remove grain from the harvest. The few droppings from cattle and goats are not harmful and do not taint the grain. The droppings fall away when the grain is dried. Cow dung is not a problem and the grain will be in further contact with dung during storage in the granary.

4.5.4 Student knowledge on storage of grain

The groups working on this module discussed how they stored dry seeds of maize grain, along with *mahangu* [S] (sorghum), groundnuts, beans, watermelon and millet. These are stored in big bottles or clay pots. Some ash is added to the grains in order to protect the grains from insects. While the Shona people use cow dung as a plaster on the walls, the Shiwambos use ash, which is added to the grain in order to control weevils. Ash and cow dung do not have to be bought. They are readily available in the rural home.

In Namibia grains for consumption are stored in a conical container called *okaanda(o)*[S]. This is woven like a basket from stems of bitter bushes (*omazimba* [S] and *omusati* [S]) that are tied together using fibres from mopane trees. The bitter bushes are very strong and can last for a long time. It appears that the bitter bush has insect repellent properties too. Students revealed during interviews that their grandfathers built some of these okaanda, long before they were born and the structures still stand strong. The bushes resist termite infestation and may also repel grain weevils. The structure sits on stilts and is raised above ground. Its inside walls are plastered with soil from the termite mount. Termite soil has a clay-like texture and is most likely hygroscopic - this would keep the grain dry when the air moisture is mild. Ash is added to the grain to prevent insects from attacking it. Drawings of the *okaanda* [S] indicate that this container has the structure of a clay pot sitting upright. It however has a round conical thatched roof above it. There is a gap between the mouth of the *okaanda* and the top of the covering roof.

4.5.5 Student knowledge on preparation of milk

Student teachers from Zimbabwe treated milk as described in section 4.2.3. The practice may be generalised to the Shona people. It may be the general practice among the Shona-speaking people in the country and not necessarily specific to a small group of people. In Shiwambo culture, once the milk (*omethe* [S]) to be soured is contained in a calabash it is placed in the heat of the sun for "at least half a day" (C1). At times, the Shiwambos put an additive to the milk: a root from a special wild plant is added to fresh milk in the calabash before the calabash is exposed to the heat of the sun in order "to speed up the souring process" (C1). It would be of interest in future to research the plant from which the root additive is obtained and the scientific effect of this root on the milk. Observations with other chemicals show that addition of acidic lemon juice to fresh milk can make it sour. Probably the root produces an acidic juice that turns milk sour. This souring effect could have been observed and used over many generations.

After this treatment, the milk would be ready for the next stage, which is the removal of cream. The calabash is tied to a cross bar and agitated by being swung between two people for two to three hours until the milk is separated from cream. In the commercial scientific process, souring milk is stirred and whirled and the cream is separated from the milk by centrifugation. In the Namibian rural community case the cream is extracted for other domestic uses such as cooking fat or for adornment. The remainder of the milk might be consumed with a thick porridge made from sorghum or millet (*mahangu* [S]) flour or maize flour. Milk products have many uses in the rural home. With the commercial treatment of milk, products are bought in isolation and in many cases they are very expensive.

4.5.6 Student preferences related to traditional and modern practices

This section covers the reports on what student teachers said and felt about using indigenous practices in their daily practice. Student teachers worked in groups and the task was intended to assess their general views towards the practices as sustaining living practices. Outcomes indicated that personal choice on lifestyle pattern is very varied among the students. While some student teachers saw the richness in indigenous patterns, some did not like them. There were some students who even argued that the indigenous patterns under discussion were archaic.

Two groups reported that they preferred modern methods of separating grain from chaff (A1, A3). According to them modern methods are faster, not dependent on weather, do not cause air pollution and need a small space. The small space referred to was a sieving grill on platform or part of a grinding mill. The air pollution referred to the addition of suspended grain particles into the air. They also said that modern methods require few resources, they require less effort from the users, hence are cheaper in terms of labour and can separate large quantities of grain from chaff in a short space of time.

Two groups A2 and C3 preferred to use the traditional approach for grain separation. They said that it produces flour from pure grains. This comment was in reference to commercial methods of separation of grain from chaff where to the process simultaneously happens with de-husking in the grinding mills. Some learners claimed that the grain is cheaply and easily prepared in the traditional approach. Interviews confirmed that the pure grains referred to whole grains. Whole grain flour is considered healthier than processed grain since husks of seeds contain vitamins that are essential to the body.

Group C3 made connections with their culture and wrote that the traditional approach "keeps our cultural ways of preparing food alive". Working with indigenous knowledge practices may make them more attractive as people are generally resorting to modern ways of using their environment. This response points to the high value the group placed on their culture and their desire to maintain it. The other groups did not have any comments on sustainable options. They were yet to discuss the question when they were asked to make presentations.

During the plenary some students commented that sour milk that is commercially prepared and sold in shops is more hygienic and has a better taste. Human hands do not touch it during processing and it remains sealed in plastic and clean. They observed that milk prepared at home at times has the smell of cattle and cattle dung. They also argued that sour milk prepared at home might not have the creamy taste that commercial milk has and may not look as good and appetising as the shop milk. It was noted that in most cases, sour milk from home is white and lacks the yellowish colour characteristic of commercial sour milk. If this comment came from Namibians it could be true that the milk may look plain white. Their milk is soured after butterfat has been removed (see section 4.5.5).

One student however spoke in support of home-produced sour milk and said "you know what is in your milk because it is you who put it there and you saw it sour, whereas with this milk from shops, you don't know what makes it look nice. Maybe they add some chemicals or some special bacteria that could harm you one day". It is true that consumers have to know the ingredients in a product and in many cases these are not given for fear of abuse of patent infringement. As a result people eat good looking food that may in the long term be harmful to them. The same student also argued that "you choose what to do with the whey and the cream that come from sour milk when you make it on your own". He noted that the whey could be given to children as a drink or even to dogs. Another student concurred with these ideas and added that people who milk their own cattle do not have to spend money to buy milk everyday.

4.5.7 Science concepts identified by student teachers

In addition to the LSM that was developed, student teachers also received copies of the ZJC and O level syllabi. This section outlines science concepts in the curriculum that students identified in the practices. While some groups managed to identify science concepts fairly easily, others could not ascribe any concepts in the syllabus to patterns of practice.

Student teachers identified only three scientific concepts that they thought could be found in indigenous knowledge practices in the LSM. These were "mixing and separating", "variation in living things" and "convectional currents". By managing to identify these science concepts, though few, that were in indigenous knowledge practices (patterns of practice), student teachers confirmed my assumptions that indigenous knowledge practices have scientific concepts embedded in them.

Student teachers said the topic that could be taught with documented local practices was "mixing and separating of mixtures" at ZJC level (A1, A2, A3). Groups A1, A2 and A3 found the practices applicable to the concepts of "convectional currents" and "mixing and separating" in the O level syllabus. The other groups (B and C) could not find any topic in the O level syllabus that could be taught using this practice

Members of group B1 who were working with the practice of storing grain and seed agreed that they could use the variety of seeds and grain to develop the lesson on "variation among organisms" as well as "mixing and separating" at ZJC level. Group B2 could not relate the documented practices to any syllabus content. They found it difficult to read the syllabus document because they were not familiar with it. Due to time constraints Group B3 did not present to the class and did not present their findings to the researcher.

From my observations, it seems that student teachers found it easier to work with the enacted practice of separating grain from chaff when making lesson plans, than the other two practices that were only described. All groups chose to work with this LSM. This practice was presented in three ways: documented narrative, verbal narrative by the college community elder and the visual enactments by the students themselves.

It is evident from this section and section 4.4 that student teachers could identify fewer science concepts that are inherent in indigenous knowledge practices than their lecturer. This observation points to student teachers not being very familiar with the syllabus they were using and the concepts they were supposed to relate to.

4.6 IK in science lessons

This section presents data from the researcher's analysis of lesson plans, the researcher's observations of presented lessons and the lesson critique that was done by student teachers on the peer-presented lessons. A copy of a lesson plan prepared by student teachers is shown in Appendix 15. A summary of these proceedings is shown in Table 2. All four groups chose to work on "preparation of grain" for storage. They all identified "separation of objects with different densities" as an appropriate syllabus concept. One group did not present due to time constraints. Two groups (A and C) presented and based their lessons on the LSM. One group's (Group B) presentation was in the form of a lecture that was based on the textbook and the presenter made peers discuss the practice without actually demonstrating it.

4.6.1 The lesson plan

4.6.1.1 Lesson objectives written by student teachers

All three groups derived meaningful lesson objectives as shown in Appendices 5 and 15. These objectives were similar in most respects. The order written by Group B was not hierarchical. One would expect the verb "distinguish" to come after the verb "describe". In Groups A and B the lowest order objective stated that learners who were also the peers were to "define separation". All groups had the objective that sought to make learners "identify" (A and C) and "distinguish" (B) between three methods of separating objects of different densities. According to the list, the highest order objective for Group B expected learners to "describe each of the methods". Student teachers were able to raise meaningful objectives but in some cases were not able to order them correctly. Of note is that whether student teachers were starting to teach from the textbook science concepts or from the patterns of practice, they came up with meaningful and developmental lesson objectives. What was important was their ability to derive meaningful objectives. The order would be improved with experience.

Objectives for Groups A and C went beyond simply describing the processes of separating objects with different densities and indicated that one of their objectives was to show separation of objects with different densities. Group A indicated that learners were supposed to "show the process" while group C noted that learners were expected to "show how the method was applied". These two are basically similar objectives.

4.6.1.2 Science syllabus content identified by students

All the three peer groups, A, B and C recognised the need to separate objects of different densities (DPLR and LO) as the content of the lesson. All three groups suggested winnowing as a method and as a process for separating objects with different densities. As shown in Appendix 7, response sheets (Data Generation) DG02, DG04 and DG 06, the intended lesson topic was successfully presented.

Groups phrased lesson topics in various ways. Group A chose as a topic: "processes of separating solid mixtures-winnowing, sieving and hand picking". This topic was well phrased because the processes to be discussed in this particular lesson were specified. However the lesson topic could be improved to describe the nature of the solids, that is, dense and less dense, differential size, colours, etc. Group B selected, "impurities in mixtures-winnowing" as their topic. This group understood winnowing in terms of removing impurities (husks). The practice was generalised to impurities, not the principle of differential densities.

4.6.1.3 Lesson activities developed by students

The activities developed by groups A and C include questions and answers on "sifting, winnowing and handpicking" and involve "demonstrat(ing)" and "tak(ing) part in the practical". Student teachers also planned to "ask on the general knowledge of pupils and define separation from their responses". Pupils would also be asked to demonstrate the methods. The presenter from group B wrote that learners were expected to sit quietly, answer questions and to take down notes.

4.6.1.4 Teaching materials and aids used by students

The presenter from group B indicated in the lesson plan that the information taught was obtained from page 26 of a textbook called *Focus on Science - Book 1* (section 4.5.2.4). The presenter from Group A stated in the lesson plan that in preparation for the lesson, the group had drawn on the LSM given to them by the researcher. Group C did not indicate a source of material for teaching in their lesson plan, but when probed in the post-lesson discussion admitted to having consulted the LSM more than they did books. This observation points to the possibility of a positive relationship between the source of materials for teaching and the type of lesson presented.

4.6.2 Lesson presentations

4.6.2.1 Lesson objectives identified by student teachers

Observations confirmed that the lesson presentations were guided by the stated objectives (see Appendix 8) in all groups. The objectives generally started with the low order that were simple and descriptive and ended with high order and manipulative, that were more complex for groups A and C. The development was from the simple and theoretical to the practical that develops psychomotor skills. For group C the presenter made the 'learners' describe the processes, through questions and answers, before explaining how they work. The presentation also showed a progression from simple to complex objectives. The nature of all these objectives affirms my assumptions that teaching and learning of science concepts can happen using indigenous knowledge practices as a source of syllabus science concepts.

4.6.2.2 Science syllabus content identified by student teachers

During observations of the lesson presentations, I noticed that the objective stated of showing how to separate objects that have different densities, was used. Focus group discussions with each of the peer groups indicated that even the peers felt the objective was met. I concluded that the materials used were appropriate for developing the concept of separating objects of different densities.

During the lesson presentations, the presenter went beyond winnowing and discussed sifting and handpicking. Group C was clearer in stating, "winnowing as a method of separating solids of different densities". This presentation was closest to the concept of separation as it specified the scientific principle enabling the process. The presenter went on to talk of the other methods of separating grain from chaff, that is, sifting and handpicking. None of the presenters noted that these are only some of the methods used to separate mixtures made of heavy and light objects. They described them as if they are "the" methods. Probably this was caused by lack of experience or lack of adequate content by the trainee teachers. Response DG06 called for the presenters in all the groups to consider other concepts in the lesson and suggested that separation of solids of the same density could be included in the presentations. These results were also highlighted in the peer lesson review in section 4.7.1.

4.6.2.3 Lesson activities developed by student teachers

The lessons presented by members of Groups A and C happened in both the classroom and outdoor environments. The presenter from group A took "learners" (peers) out of the classroom and facilitated a learner demonstration on winnowing, sifting and handpicking as methods of separating mixtures. Learners took turns to enact the activities. The student teacher then used questions and answers to explain how winnowing separates grain from chaff. She said air currents carried the lighter chaff away whilst the heavier grains remained in the basket. The process of sifting, which is associated with winnowing, shook the heavier grains to one side while leaving the lighter chaff on the other side of the basket. Figure 2 shows student teachers illustrating the process of sifting.

Figure 2. A student teacher enacting the process of sifting

It was explained that if separating maize from bean seeds, bean seeds were picked by hand because they were about as heavy as maize and would not easily separate as did maize and chaff. Bean seeds look uniquely different in shape and size from maize seeds.

The presenter from Group C took the class outside. Volunteers were asked to demonstrate the three processes and learners acted out these processes after the demonstrator. Through questions and answers the processes of winnowing, hand picking and sifting were explored. The following picture (Figure 3) shows some students involved in the activity of winnowing.

Figure 3. A student teacher involved in the process of winnowing

When all the activities were finished, the class went back to the classroom where through questions and answers again, learners were helped to explain how chaff was separated from maize in the demonstration. In the same manner as in group A, it was also explained that beans, which were in one part of the demonstration, could not be separated from maize by winnowing but were hand picked because they had almost equal density with maize.

Student teachers then reviewed the peer-presented lessons. The following picture (Figure 4) shows a student teacher presenting the lesson plan to the class for review purposes.

Figure 4. A student teacher presenting the lesson plan that he used to teach peers

The presenter from Group B asked learners to listen to the descriptions and explanations attentively while seated quietly in the classroom. He asked questions on what learners knew about separation of mixtures of substances. Learners were made to define what is meant by the term "separation". The presenter then described and explained the processes of winnowing, handpicking and sieving in a lecture presentation using the chalkboard.

My conclusions to these activities are that they were appropriate to show the idea that there are some heavy and light objects that can be separated by winnowing. Winnowing can be explained in terms of the objects concerned having different densities. These lessons presented were meaningful in the way they were structured as well as generally in the way they were presented. The fact that some substances are heavy whilst some are light was clearly brought out by the interaction between the educator, the learner and the materials that were brought to class.

It is notable that female student teachers could easily relate with the indigenous knowledge practices, as they were quick to demonstrate during peer teaching. This seemed to point to the idea that they were motivated to work with familiar materials and activities.

4.6.2.4 Teaching materials and aids used by students

The presenter from Group B indicated in the lesson plan that the information taught was obtained from page 26 of a textbook called *Focus on Science -Book 1*. The presenter from Group A stated in the lesson plan that, in preparation for the lesson, the group had drawn on the LSM given to them by the researcher. Group C did not indicate source of material for teaching on their lesson plan, but when probed in the post-lesson discussion admitted to have consulted the LSM more than they did books. This observation points to the possibility of a positive relationship between the source of materials for teaching and the type of lesson presented.

It was noticed during lesson observations that presenters who depended on the LSM gave their learners a chance to physically interact with teaching aids as they experienced the development of the concept studied. Student teachers who based their lessons on indigenous patterns of practice practically involved their learners in activities, whereas those who based their lessons on book content presented lectures only and involved their learners in question and answer sessions. Both groups A and C had prepared baskets, maize grain and bean seeds to demonstrate the processes.

4.6.2.5 Link between content and practical work

As already described, presenters A and C started their lessons with peers enacting methods of separating grain from chaff. They then went on to describe the processes amongst themselves by looking at the requirements for the processes to occur. The presenters developed, through questions and answers, the role of the wind, that the wind carried the lighter chaff and that the air currents would not carry the heavier grain. In a conventional lesson the teacher could present a lecture or even a question and answer lesson to describe the process of winnowing and make students do a practical activity on another day. Presenter B showed a tendency towards this approach where content is developed in isolation from practical work. It is notable that presenter B used the current approach to teaching science in the subject area in MTC.

4.7 Student teacher reflections on lesson preparation and presentation

This section reports a summary of findings that were generated from focus group discussions by each of the eight peer review groups on the lessons presented. These findings were presented, probed and debated in plenary discussions.

4.7.1 Concepts taught

Six out of eight groups agreed that the intended syllabus concepts of 'separating mixtures substances of different densities' or simply 'separating mixtures' had been taught. The remaining two groups said they had not understood the question and had not responded to it but during the plenary concurred that the lessons had indeed shown the concept of separating mixtures.

4.7.2 Impact of practices on learning

This section looks at the relevance of the practices to science learning. The researcher established this idea of relevance through questioning how the student teachers thought their learners would benefit from the use of practices in science teaching. Student teachers thought, "pupils will understand the concept better because they feel the phenomenon of what happening" [*sic*]. These practices would help learners practice what they learn. It would be a practical activity for the learners. The practice would provide learners with a chance to feel the materials used in the learning of science. It was also claimed that the practices "help pupil recognise easily" *[sic]* (DG01). These materials and practices constitute what the learners know and have in their environment. Learners would most likely identify and relate to science through interacting with these materials in the classroom and at home. In so doing science becomes familiar, accessible, affordable and easy.

Some student teachers thought the use of practices made learning "go beyond what they know before" (DG02). This is an acceptance that learners know something when they come to class. This knowledge constitutes their capital of knowing. Use of patterns of practice in class enabled the development of science concepts from the practices. Groups (DG06, DG07, DG08) recognised the significant role the community context plays in learning when they said use of patterns of practice in teaching and learning of science "makes them to understand because they use and see this process regularly at the community when their parents even themselves are winnowing maize". The statement expresses that the practice is part of repeated community practice. In so doing, in the course of performing their chores, learners may be thinking of the science that is inherent in the practice. This could contribute to remembering of facts associated with a scientific principle thereby making the use of indigenous knowledge practices in science teaching relevant.

It is notable that indigenous knowledge practices can be used in the teaching and learning of science concepts. The lessons planned and presented in this exercise are similar to lessons planned and presented in a conventional science context.

4.7.3 Suggested improvements to the lessons presented

Suggestions for improvement of lessons were made to Group B. Groups DG03, DG04 and DG05 (Appendix 7) recommended that the lesson presented by Group B be more pupil-centred. Response DG05 went on to say that the lesson must allow pupils to demonstrate what they knew. Student teachers expressed to Group B that they would enjoy learner-centred lessons.

4.7.4 Alternative practices

It was suggested during plenary discussions that perhaps other approaches than using their densities to separating objects that occur in the home could be considered for lesson activities. An example that was given concerned how rice was separated from chaff. When the rice is immersed in water before cooking; chaff floats. A similar example was provided of immersing beans in water in order to get rid of rotten and weevil-infested seeds before cooking. Rotten and weevil-destroyed seeds rise and float on water. These examples illustrate the various community-based activities that result in the separation of two solids with different densities and they also show how resourceful student teachers could be if they were encouraged to use common sense practices of learners in communal areas in order to develop scientific concepts.

However some learners thought identifying a parent who was willing to demonstrate in class was a challenge for the teacher. This was especially so when they could not easily communicate in the language of the community. Reference was here made to students from Namibia who could be interested in using such practices in their lessons during teaching practice. There were possibilities of them failing to locate appropriate people to demonstrate the activities. They also cited the possibility of a barrier in language which might prevent them from articulating what exactly they wanted the elders to show so that it was appropriate to the lesson plans.

4.7.5 Tensions associated with use of indigenous knowledge practices

Student teachers' perceptions of advantages and disadvantages of using these practices as classroom activities were collated from discussion response sheets (DG) in Lesson Discussion Responses (Appendix 7). Comments noted by researcher in the research journal during the discussions were included. These findings were summarised into Table 2.

4.7.6 Availability of materials

Materials for such an activity are easily available in the community where the school is found (DG01, DG05, and DG06). They do not have to be bought for the demonstration. The elderly member of the community who came to demonstrate used her own baskets. She did not need to buy them for the enactments.

Two groups, DG05 and DG07 found the practices cheaper than conventional science experiments. The practices did not need a conventional laboratory. Besides, learners could practice the activities at home, since the materials are present in most homes. DG05 said these practices were non-toxic as compared to some conventional science laboratory practices that release chemicals into the environment.

4.7.7 Relation to everyday life experiences

Three groups, DG01, DG05 and DG06 noted that these practices were easy to understand and these same groups added that the secondary school learner could understand the science concepts better if the activities related to the everyday activities that learners know and do at home. They argued that learners learn better when content is developed from what they know. They also noted that these practices were practical and visible for the learner and formed a basis on which abstract knowledge could be developed. The DG05 group said the activities were "familiar with pupils/ used in everyday life", meaning that the practices are not new to the learner. The practices are not as abstracted and detached from their daily experiences as conventional laboratory experiments. Two groups, DG03 and DG04 thought the activities helped learners to understand content - they stated "help the student to understand content". The DG02 group thought such activities would "improve learners' thinking capacity". They argued that when learners think about real issues they are likely to recognise and understand what is happening around them. This helps them to solve real life problems. It was added that the learners will be thinking of what is there and what they see. Student teachers agreed that such practical activities related science to their home contexts and made them feel at home in the classroom. The science and the learning did not feel foreign to them and they easily worked with the familiar materials and participated in the demonstrations. They thought this would be similar with secondary school science learners.

4.7.8 Gender sensitivity

Two groups, DG01 and DG05 found a positive relationship between the patterns of practice and learning of gender. They thought, "females might see values to come forward when doing things concerning them" (DG01) and "this encourages females to do their sciences more harder" (DG05). It was interesting to observe that female student teachers were quick to demonstrate the techniques of separating grain from chaff, especially winnowing and sifting. This was particularly so with the usually reserved female members of the class. They said these were activities they did at home and they were proud to be able to show their abilities. Every female is supposed to be able do to these practices as she grows up because these are the chores that lead to recognition as a woman in the society. During lesson observations, some female students who were generally reserved in class showed enthusiasm to demonstrate the practices during peer teaching. Such activities could have a bearing on gender in a number of ways. Some of these practices are generally perceived as female chores in African societies. Hence, female learners may relate more with the practices than the conventional laboratory activities. As a result, the practices might encourage females to take sciences more. These involvements with members of the science class during the research period generated a new level of interaction and relationships between both male and female student teachers and the researcher. Some students even volunteered to bring homemade, cream and butter from Namibia to show the researcher.

There is also a negative implication regarding gender as to how these practices could be brought into the classroom. Noting as I did earlier that many of the practices constitute female chores, men in some communities would find working with the practices demeaning. The DG08 group noted one feature that had not emerged earlier - that winnowing was a process usually performed by females in the society.

Males in Namibia generally do not winnow for it is a female role. Where they do winnow, in such places as farms, they do not use baskets but they use shovels to toss grain into the air. As the grain falls to the ground, air currents take chaff away. Men from Namibia claimed they would find it challenging to illustrate the process of winnowing using baskets. This is so because it is not in their culture to perform a chore that is supposed to be done by females. Besides, they are not able to show winnowing since they do not winnow at home. In my lesson observations, I noticed that male students were not as keen to demonstrate as female students. Male students were more active during handpicking. The following picture (Figure 5) shows a male student involved in handpicking.

Figure 5. A male student picking beans from a mixture of maize and beans

4.7.9 School-community relationships

The DG07 group briefly referred to attitudinal effects and noted that the activities might help "pupils to understand and appreciate the community based activities". This may lead to members of the community seeing greater value in their patterns of practice. This might be part of the process of protecting practices from being lost to the next generation. Some student teachers commented that community members might identify more with what is happening in schools and might enjoy taking part in the teaching/learning process. During the plenary student teachers also said that if such an approach were started in science and was seen to work, other subjects in the school might follow and invite members of the school's community more into their classes. This might encourage members of this community to be more supportive of the learning and learning experiences of their children.

4.7.10 Dependence on natural phenomena

The following comments emerged mainly from the demonstration of separating grain from chaff. Four groups identified the reliance on natural phenomena as a potential setback to the teaching and learning processes. DG02, DG06, DG07 and DG08 expressed that the process could be affected by environmental factors such as rain or absence of wind and would not be successful. If the lesson were on a very calm day it would be difficult to demonstrate the process of winnowing. If rain fell, the teacher could not take learners outdoors for demonstrations. These are subtle but significant considerations that are necessary for lesson planning purposes.

4.7.11 Role of language in learning

Findings in this section were generated through the researcher's observations. The observations were done during enactments, demonstrations and focus group discussions.

The elderly woman from the college community demonstrated the separation of grain from chaff. She did so by show and tell in ChiShona, her mother tongue. The process appeared very easy while she did it. A Zimbabwean student in the class interpreted what the lady said in English for the benefit of Namibian students who did not understand ChiShona. When students took part in the enactments, most of them reverted to their mother tongue as they helped each other to do the activities properly.

While working in discussion groups, students reverted to mother tongue and of note were the non-ChiShona speakers. It is worth noting that only ten of the 40 students who were involved in the greater part of this research were ChiShona speakers and the rest were Shiwambo speaking (section 1.3). Mother tongue was used during discussions and during presentations. During presentations that were to be done in English to the class, non-ChiShona speaking presenters from all groups (A1-A3, B1- B3, C1-C3) first sought approval of the translations from Shiwambo speaking colleagues. As noted in the plenary discussions, non-ChiShona speakers could find barriers in communication as they may fail to correctly articulate the names of equipment and processes involved.

When ChiShona speakers were invited to suggest any variations in their situated practices, they mostly agreed with documented observations of the researcher as well as the practices enacted by the elder from the college community. One notable contribution they made during these discussions is the already stated alternative on threshing of harvest by trampling it with livestock.

Annotated drawings were made on response sheets to illustrate some of the processes in order to improve communication between researcher and student teachers. Appendix 13 shows one of the illustrations made by student teachers to aid their verbal constructions of the processes in their home contexts during deliberations (A3, B1, C1). Some presenters also made illustrations of these processes on the board as they described them.

4.7.12 Under-valuing of IK

More general comments that were raised in the plenary sessions include an observation that most of the science that teachers have is based on textbook knowledge. Such teachers might not value the usefulness of indigenous knowledge practices in the classroom. Parents who are not involved in these activities might not view them as necessary for learning. Some learners too may think that the teacher is wasting their time when a villager teaches them in vernacular. Student teachers themselves testified that they thought initially that the researcher was wasting their time when they were presented with the patterns of practice. This thinking changed when they started to see the embedded science concepts and when they prepared lesson plans and presented the lessons on these concepts. According to student teachers, school administrations that are obsessed with seeing teachers in front of the class might think that the teacher is not doing work when a community member comes to demonstrate in class.

4.8 Conclusion

In this chapter, findings of the research were reported. Preliminary data from the field were analysed by the researcher and science concepts in the indigenous knowledge practices were presented. The concepts found in the three cases of IK practices, namely, preparation of grain for storage, storage of grain and preparation of milk, that were presented as modules mostly covered biological and physical sciences at both ZJC and O level (see Appendices 1, 2 and 3). None of the practices engaged in had concepts that are related to chemical sciences. These concepts were used to provide the basis upon which student teachers could relate indigenous knowledge practices to syllabus concepts. Students identified "mixing and separating", "variation in living things" as well as "convectional currents" at both ZJC and O level as topics that could be taught based on indigenous knowledge practices. Student teachers' knowledge of the practices was presented. It was important to ensure that students knew the practices before they engaged with them in the classroom. The student teachers used their mother tongue in to discuss the practices during classroom deliberations.

Some respondents preferred to use indigenous knowledge practices while some preferred the use of modern practices in their life. Those who wanted modern practices thought the traditional approaches were archaic and dirty. The students who preferred traditional approaches thought these were cheaper and contributed to preserving their culture.

The researcher made an analysis of lesson plans that focussed on appropriateness of objectives, content and activities. This was done to establish how the practices could fit into a conventional lesson plan. The groups that based their lesson plans and teaching on documented indigenous knowledge practices presented participatory lessons, whereas the group that based its work on the conventional textbook presented a lecture. Peers recommended a more learner-centred and practically oriented approach to the group that delivered a lecture.

Student teachers identified many factors that influence the use of IK in teaching of science. Among the positive factors were that materials for activities were easily and cheaply available. They envisioned that learners might, among other benefits, understand the practices and the concepts better and that learners might relate more with concepts that are developed from what they know. Learners might be able to practise the activities in their home, as a conventional laboratory is not needed. The activities have positive and negative bearings on teaching and learning of different genders.

Many tensions are associated with such an approach to pedagogy in the school context. Student teachers feared that as trainee teachers, the teachers, school administrations and communities in the schools in which they do teaching practice, might not appreciate this approach to pedagogy due to their westernised educational background. They also feared that they might meet resistance from the students themselves.

In the next chapter, Chapter Five, I will try to establish the lessons learnt from the presented data. The lessons focus on the notion of relevance of indigenous knowledge practices to the learning of science.

CHAPTER 5

THE TWO-WAY TRAFFIC BETWEEN INDIGENOUS KNOWLEDGE AND SCIENCE SYLLABUS CONCEPTS

> "...in the acquisition of knowledge, questions emerge and are solved as a result of an uninterrupted two-way traffic between two layers of knowledge: that of general ideas, theories or models and that of observation of specific events. The latter, if not sufficiently informed by the former, remains unorganised and diffuse: the former, if not sufficiently informed by the latter, remains dominated by feelings and imaginings." (Elias in Mennelland and Goudsblom, 1998: 232)

5.1 Introduction

In this research, the two (indigenous knowledge practices and syllabus scientific knowledge) were brought together. Indigenous knowledge practices provided starting points for interaction with scientific perspectives in the syllabus. The meeting points and learning processes involved were a striking feature in the two-way traffic and merging of ideas in new understandings that I experienced in the field and which the students reported in their work with indigenous knowledge practices and the science concepts in them. The idea of relevance was discussed as a starting point for reflecting on how relevant these experiences were to science curriculum understanding and practice.

This discussion chapter draws on the research literature in Chapter Two and the data reported in Chapter Four. The intention is to thoroughly analyse the research process and to discuss how the findings that can be drawn from the study can inform the researcher's work both as a teacher trainer and a significant member of St^{2}eep. Therefore findings are related to the research context in an effort to examine and reflect on the starting point for this research. I discuss how the outcomes of the research relate to some of the orientating documents in the context of Mutare Teachers' College and the recently completed syllabus review process as well as the context of the St^{2}eep project (see section 2.4.4).

The discussion touches on relevance and how the findings relate to the purposes of the curriculum. Insights into the learning interactions around indigenous knowledge practices and science are discussed. It is also interesting to engage in a discussion that shows how critical curriculum perspectives and constructivist theory might influence and play out in classroom interactions involving indigenous knowledge practices and science concepts in particular. The role of prior knowledge in learning is thus drawn out and examined in relation to IK as a capital of knowing in African societies. All these points are discussed as part of my pursuit for greater relevance of and better learning in the science syllabus through enabling the "two-way traffic" between the epistemology of doing (indigenous knowledge practices) and the epistemology of explaining (syllabus science).

Finally, the research is concluded in Chapter Six with recommendations that the researcher will act on in the work context at the college and in the St^{2}eep project.

5.2 Reflections on the "two-way traffic"

As suggested by Mennelland and Goudsblom (1998) in section 2.3.1 any development of knowledge requires a mutual relationship between observed facts and theoretical understanding. The starting point was the research question that sought to find out if it was possible to establish this two-way process between indigenous knowledge practices and science syllabus content in a teacher training science classroom during peer teaching activities. A key assumption here was that many people still use indigenous knowledge practices and have not lost their know-how in these things. Throughout the research it was noted that people from communal areas have their understandings of the processes in which they engage in order to be successful in what they do. It was found that science by its explanatory nature complements this by providing useful understandings and explanations of phenomena.

5.3 Capital of knowing

Van Wyk (2002) argued that a learner builds cultural capital from contexts beyond the school and within the school (refer to section 2.11.2). This section shows how indigenous knowledge practices are a capital of knowing in the community and among the student teachers.

5.3.1 Functional indigenous knowledge practices in the community

Observations at researcher's mother-in-law's home (sections 4.1.1-3) confirm those made by Emeagwali (2003), O'Donoghue and Neluvhalani (2002), Sefa Dei *et al.* (2002) and van Wyk (2002) that rural people have knowledge of many ways of doing things that have been passed down over many generations. There are sustaining patterns that are embedded within these ways of doing. Such an observation supports Nel (2005) who argues that the ways people do things are embedded and embodied in the community and the intention behind doing these things is well-being and health. It can be asserted that these practices have persisted because they are healthy, and contribute to improved living for the people in their environment. O'Donoghue and Neluvhalani (2002) refer to this knowledge that is found in operation among members of a community as the cultural capital of knowing 'in and of everyday life' experience. It is in doing these practices that younger members of the community learn how to perform them. In other words people who engage in patterns of practice understand the way they do things by doing them. Osaki (1994) calls this perspective to knowledge an epistemological realm. This epistemological realm was termed procedural understanding by Gott and Duggan (1995) as shown in section 2.3. It follows then that community elders and their children have procedural understanding of the practices they engage in. People continue to be innovative in what they do to sustain their lives (section 4.5.3) and come up with sustainable options.

Some of these practices persisted because they were preferred and were advantageous to users as shown in section 4.5.6 (O'Donoghue and Neluvhalani, 2002). From this research's point of view, the community abounds with sustaining patterns of practice (knowledge practices) that have been passed down over generations by doing and perfecting. Therefore there seems to be a possibility to explore these patterns in order to further issues of sustainability and education for sustainability.

Asafo-Adjei (2004) noted that when bringing indigenous knowledge into the curriculum it is necessary to take note of the specific contexts in which that knowledge is operating. Findings of this research point to subtle but significant variations in the various repositories of indigenous knowledge practices. Chapter Six will stress that any approach to integration of indigenous knowledge practices must ensure that both males and females are familiar with these practices before bringing them into classroom activities.

The findings of this research point to the possibility for educators to look closely at what people do in society and to try to engage with these activities in the context of classroom learning. The research process and the findings challenge educators to consider ways of presenting indigenous knowledge to their learners. This might lead to transformation of the pedagogy that would make science more responsive to society than it currently is.

5.3.2 Learners' knowledge of indigenous knowledge practices

Learners have knowledge and experience of patterns of practice that they do in the home context and are able to share them when stimulated to do so. The research revealed these indigenous knowledge practices can be more generally known across communities or can be unique to specific to communities. According to Osaki (1994), the practices constitute the epistemological realm of traditional thought and practice systems of the learners. This knowledge that constitutes part of the knowledge that they bring to learning situations and is embedded in their practice is brought to class as a capital of knowing to the learning situations (O'Donoghue and Neluvhalani, 2002; van Wyk, 2002).

There are indigenous knowledge practices that are embedded and embodied within particular communities and which are unique to these communities (Nel, 2005). Due to their specific nature they constitute understandings of the world for a particular group of people and form an orientating capital of perspectives in indigenous knowledge practices for that group (van Wyk, 2002 and O'Donoghue, 2002). They are perspectives because there are different ways of performing the same practice. For example, students from the Shona culture store grain in a granary (*dura* [C]) in the manner described in the module (section 4.2 and Appendix 2), yet the granary (*okaanda* [S]) in Namibia has a different structure and the treatment of grain during storage is also different. The result of both their efforts is successful storage of grain. During treatment of milk heat is supplied differently to fresh milk but the end result is sour milk in both cases (see section 4.2 and Appendix 3). These differences that are context-specific are called 'habitus' (Smith, 2001). The study has shown that what learners bring from their communities to learning situations exists as both general as well as more context-specific forms (habitus) of indigenous knowledge practices. The existence of diverse forms of capital points out clearly that the methods for bringing IK into the classroom must be sensitive to the subtle differences among learners' knowledge and experience.

This is the point where the heuristic by O'Donoghue (1998) of Touch, Talk and Think (refer to section 2.9) is useful as an alternative approach. Learners could be stimulated to tune into the practices, share their experiences and generate meaning around the same practice before relating the practice to science syllabus concepts. Even gender-specific differences in knowledge and experience among students can be shared in this way. Shava's (2000) recommendation that educators who bring IK into the classroom must make the learners share their experiences takes cognisance of these subtle but significant variations of experiences amongst learners. This position guided the research design decisions for the research and activities with student teachers in the classroom.

Emeagwali (2003) found indigenous knowledge to be functional, because it helps learners to function within their contexts. If this general or specific knowledge functions in the learner's context, there seems a possibility that it should also function in the classroom situation. Juxtaposing and intermeshing functional epistemologies with scientific knowledge could enhance understanding of both forms of knowledge. Elias in Smith (2001) has referred to this relationship as the two-way traffic (as discussed earlier in section 5.2) and O'Donoghue (2002) termed it an inter-epistemological dialogue. Working with indigenous knowledge practices in science lessons may therefore enhance understanding of the science concepts since knowledge might be built from the functional position.

5.4 Science concepts enabling new insights on indigenous knowledge practices

The literature reviewed (Chapter Two) on IK and science tends to portray indigenous knowledge and science as two different epistemologies. The literature mostly argues that IK has been neglected and dominated in educational settings and has at best been relegated to giving shallow examples (Odora, 2000). It is further argued that this epistemology must be recuperated and given the recognition it deserves. Documents that promote integration of IK into curricula and curriculum documents themselves say IK has to be integrated into the curriculum, suggesting that the two epistemologies at present do not have much in common and that IK should be appropriated into science learning. Arguments that IK has to be recognised, as if it is a thing that exists out there, or as if it is some kind of knowledge that is distinct from other ways of knowing, must be understood with caution. The view that indigenous knowledge practices and science are very isolated and alienated from each other can perpetuate the knowledge powers and forces that encourage subjugation and subsequent alienation of IK from formal education. These knowledge powers can be perpetuated since there will not be any attempts to establish how the epistemologies are related and intermeshed with each other. Researchers would spend resources, energy and time discriminating between the knowledge forms but not harmonising them. Consequently the arguments sustain the current trend because they do not seek to correct the imbalance between the epistemologies. The premise of this research agrees with O'Donoghue (2002) that this standpoint culminates in naïve oppositional assumptions that characterise research in IK and educational practice. Instead, recommendations should be made of initiatives that promote educational transformation (Chapter Six) based on emancipatory cognitive interests such as St^2eep which view IK and science as interdependent and interwoven epistemologies.

The argument for this research is that IK and science do not operate in isolation. Seepe (2000) recommended that IK and science be worked with together in such a way that they complement and not replace each other. In fact, at times science and IK are two ways of perceiving the same knowledge. Science is perceived as a body of knowledge that explains how nature functions (see Howe and Jones (1993) in section 2.11.1). IK is knowledge that people have on how they use nature or its components. Therefore IK and science are different perceptions of how people understand the world. Findings from this research as reported in Chapter Four show that there are many science concepts in indigenous knowledge practices, pointing to there being some common ground between the two forms of knowledge. By identifying science concepts in IK, the study has identified overlaps between the two ways of knowing. Consequently, the research examined how the two epistemologies could open spaces for better understanding of science concepts. As van Wyk (2002) observed, declarative knowledge, which is constituted of specific cultural, traditional, and community facts and procedural knowledge, which deals with knowledge construction processes in education, are both requisite to learning. As such, cultural facts are embedded in what people do while knowledge construction goes beyond this and covers how they do things and why things happen in the way they do. That this weaving of the two forms of knowledge is possible in science education settings is evident from the research process and outcomes of the research.

5.5. Relevance and purposes of curriculum knowledge

All the discussions in this section point towards lessons learnt from the data reported in Chapter Four on the notion of relevance. The thrust of the research report is on how working with IK practices could have contributed to making the subject accessible, motivating and learning of it achievable (Rollnick, 1998).

5.5.1 The notion of relevance

The Shorter Oxford Dictionary defines relevance as "bearing upon"; meaning that there has to be an element of bearing or giving direction to something. In this case, the bearing of this case study was the manner in which indigenous knowledge practices of practice could be appropriated into the classroom so as to enrich the teaching/learning process. In my view, the research provided a direction to the conduct of a feasible and practical approach to appropriation of IK practices into the pedagogy of science concepts. Admittedly, the research only explored how this one possibility for engaging IK in pedagogy of science could manifest in the peer teaching activities in the secondary teacher-training classroom. The way this approach could translate into the secondary school science classroom was not explored.

Relevance is synonymous with "connected with", a phrase that expresses how things should connect with others. There were a few connections that this research intended learners to establish. Learners were expected to establish connections between indigenous knowledge practices that were documented in the LSM with their own indigenous knowledge practices that constituted situated practice of the learner at home. Learners had to identify science concepts in indigenous knowledge practices they engaged in the home context. Learners had to show how these concepts in indigenous knowledge practices could be used in class in order to enrich the understanding of science concepts in the school science curriculum. A good connection between IK and science concepts would be shown if learners successfully prepared and presented meaningful lessons based on the practices that had the identified concepts.

Relevance also relates to having a "remedial effect". This perspective means the learning generated by outcomes of this research must bring about a change that corrects what was going wrong, or contribute to an improvement of the way things have currently been happening. This research sought to come up with pedagogy that is innovative and would make rural learners identify more easily with science learning. This meaningful learning of science would give learners a chance to contribute to their learning by engaging with their prior knowledge that is embedded in their indigenous knowledge practices. This prior knowledge, that is real, is their knowledge capital and is a prerequisite for learners to develop abstract concepts (Seepe, 2000, section 2.11.4). Relevance is further referred to as "pertinent to (matter in hand)". The research investigated whether the indigenous knowledge practices were both applicable and related to developing science concepts in the classroom. Students presented lessons that developed science concepts based on indigenous knowledge practices that they knew of and had experienced in their daily patterns of life. These life-sustaining patterns were consciously and naturally passed on to them over many generations.

The themes that follow in the next sections help to locate and organise the discussions on lesson planning and presentation.

5.5.2 Lesson planning and lesson presentation

It is evident that student teachers successfully worked with science concepts in indigenous knowledge practices to prepare lesson plans and present lessons. They hereby proved that the practice-based lessons are a possible option in development of science concepts.

As noted earlier, most student teachers were unable to use resources in their environment to teach science concepts in the syllabus. Findings in Appendix 14 that are referred to in section 4.7.2 point to the possibility of using indigenous knowledge practices in the science classroom because student teachers thought these indigenous knowledge practices were useful for helping learners understand science better. The secondary school curriculum does not suggest ways of handling different communities in the country, such as the rural and urban. This secondary school science curriculum therefore does not give a chance to learners from rural schools that may not have conventional laboratories and laboratory equipment to engage with conventional science experiments. As a result their home contexts have no place in science learning, making concepts abstract and de-motivating to learn (Odora, 2001; Giest, 2002). This research sought to work with data from the rural areas in ways that would allow learners from rural areas to engage with the same scientific knowledge as well as those in advantaged schools and urban schools in different ways. These ways would be practical, affordable, real and related to their life experiences. Use of indigenous knowledge practices in science curriculum activities would address concerns by Makhurane and Khan (1998), Seepe (2000) and Mandikonza (2004) that educational innovations must not make science available to learners by simply replacing conventional materials with locally produced alternatives. Local practices and experiences would provide an introductory context for science learning. Learners would have to approach scientific knowledge from the experience perspective in the community context. This research involved first-year student teachers in science, most of whom come from non-urban areas and would teach in non-urban schools.

The research also showed that besides working with science concepts around indigenous knowledge practices, this approach to teaching science makes learners think about, deliberate on and justify their personal choices on the practices.

5.5.3 Positioning the two views of knowledge

The research experience has shown that in most learning interactions the two ways of knowing are engaged. As already stated, learners have knowledge of and have experienced indigenous knowledge practices that are real to them, and these experiences are then challenged by science concepts in the syllabus, which are abstract. Sections 4.6.1.1-4 and 4.6.2.1-4 show that it is possible to plan for and to teach science using indigenous knowledge practices within the confines of the science syllabus. The findings depicted that indigenous knowledge practices are relevant in terms of them fitting into the guidelines of the science lesson plan structure, content and pedagogy. The outcomes of the interaction where the two-way traffic merges could bring with it better understanding of both indigenous knowledge practices and syllabus science in relation to everyday life. As such, science concepts might be understood in the context of indigenous knowledge practices while indigenous knowledge practices might be explained in terms of the scientific concepts embedded in them. Here the outcomes of this research are pointing to the goal of relevance, notably that it is possible to work with indigenous knowledge practices in science teaching and learning, that the learning is both meaningful in itself and can be related to the realities of everyday life.

5.5.4 The science syllabus at MTC

As noted in section 2.5 the science syllabus for Mutare Teachers' College was designed with a technical knowledge interest (Grundy, 1987). There is a tendency by educators to emphasise procedural content, without working with the declarative component of the science (van Wyk, 2002). Experiences by Mandikonza (2004) are that during science teaching educators tend to only develop the conceptual capital of the syllabus. The content that is delivered to learners is usually abstracted and decontextualised (Lave, 1993). It follows that since the lecturer is in charge of the teaching/learning process, in terms of what is to be learnt and how it is to be learnt, this approach to knowledge dissemination gives the lecturer power over the knowledge. Consequently, what is learnt and the how it is learnt only comes from the educator, who in this case depends on and is guided by the syllabus document. There is a top-down approach to dissemination of scientific knowledge.

Current secondary school science syllabi already show a general shift towards socially relevant topics but this is not evident in the content and pedagogy of the teaching and learning of science in the college, yet the college produces science teachers for secondary schools. In Chapter Six, recommendations are made to St^2eep so that as the Department of Science at the MTC completes its syllabus review process in 2006, emphasis can be placed on socially relevant approaches to knowledge construction. This is especially important since the purpose of environmental education is to enable, among other outcomes, critical thinking, action competence and participatory learning in context that promote transformative learning amongst the learners (O'Sullivan, 1999). The educative activities happening in any learning context are mostly determined by the curriculum planners' understanding of the nature of the curriculum. The following section reflects on how critical curriculum understanding and processes could influence educative activities and science learning in Mutare Teachers' College.

5.6 Critical curriculum perspectives in science learning

The notion of knowledge interests of curriculum planners determines the view of the curriculum that is used. The critical view of curriculum as understood by Cornbleth (1980) includes the subject matter, the learning experiences of the learners, the teaching methods used by educators as well as methods of evaluation and assessment. The section that follows shows how the forms of curriculum played out in the science classroom activities.

5.6.1 The structural context

The current science syllabus at Mutare Teachers' College is written by lecturers and focuses on content delivery and consequent achievement of behavioural objectives (see section 2.7). This objectives-driven nature is partly determined by what the Department of Teacher Education (DTE) at the University of Zimbabwe considers as scientific knowledge. The DTE approves teacher-training syllabi and is the certifying authority for the MTC graduates. In this position the development and implementation of the science syllabus in the MTC is influenced mainly by stipulations of the structural context (Cornbleth, 1990), which are the conditions for satisfying requirements of the DTE. This syllabus is therefore product-centred as it aims at producing a specific type of graduate. One can say it shows technical and practical knowledge interests (Grundy, 1987). Lecturers and learners strive to complete the syllabus during the period of study. The way the syllabus has been written does not provide for flexibility of handling lessons that goes beyond the delivery of content and does not encourage learners to handle information learnt in a critical manner. The impending syllabus review might look at how to present the same content we are teaching today in the syllabus in ways that permit more open-ended treatment of the information to be learnt. It might also consider a framework for dealing with concepts in such a way that they can be related to indigenous knowledge practices. This framework might also enable the development of critical thinking skills that are necessary for environmental learning. These are the curriculum attributes advocated for by Doll (1993), Belousa (2002), Gurova (2001) and Sterling (2001). According to these writers it should be possible to use the critical perspective put forward by Grundy (1987) within the current MTC science syllabus and facilitate curriculum activities that culminate with the four R's (see section 2.5).

5.6.2 The socio-cultural curriculum

According to Cornbleth (1990) the curriculum is mostly concerned with socio-cultural processes, that is, the teaching and learning processes happening between learners, educators and their surroundings. Her emphasis is on classroom interactions because anyone who gets into an educational institution will not only see documents but educators and learners engaging in educative processes within a particular context. This is what she termed a 'curriculum in practice'. The outcomes of this research that have been reported in Chapter Four illustrate how indigenous knowledge practices can be used to develop a curriculum in practice. As such, educational practice need not only be guided by the syllabus document but by what should happen with the learners. Cornbleth has a similar view to Grundy (1987) who sees curriculum as that which happens when people act and interact in certain situations. People in a learning situation interact through action and reflection. In this research, learners were presented with the actions they engage in during day to day sustaining activities and reflected on them in view of science concepts embedded in them.

The MTC science syllabus makes little reference to the socio-cultural component of the curriculum. It is arguable that by using outcomes from this research it might be possible to enrich the socio-cultural context without changing the structural context of this syllabus by challenging the way in which knowledge is presented in the classroom. The enriching process proposed here entails promoting an inter-epistemological dialogue (Beck, 1999), also shared by Elias in Mennelland and Goudsblom (1998) in the introduction to this chapter and described as a 'two-way traffic' of knowledge interaction in the learning environment. This research showed what Doll (1993) recommended, that educators working with syllabi that are still dominated by technical as well as practical cognitive interests can apply critical curriculum perspectives within the syllabus context. The knowing 'what and how' of indigenous knowledge practices contributes the practical and emancipatory skills learnt whilst the knowing 'why' from science is necessary for generating solutions to environmental issues, risks and crises.

5.6.3 Adult learning in the science classroom

In order to promote an inter-epistemological dialogue it is pertinent that adult learners share their experiences (see section 2.8) so that they develop new understandings (Lotz, 1999). As learners share experiences they might deliberate on the two ways of knowing in a way that makes them identify opportunities in the practices. In so doing learners scaffold (see section 2. 9) each other to better understand the environment in which they live and to make informed choices before responding to issues and risks in their environment.

5.6.4 The Encounter, Dialogue and Reflection model as an engagement tool

The O'Donoghue (1998) model of Encounter (touch), Dialogue (talk) and Reflection (think), which is the backbone of the Active Learning Framework (ref?), provides an appropriate approach to working with indigenous knowledge practices in classroom practice. Learners encounter indigenous knowledge practices in written accounts, listen to verbal narratives or take part in demonstration activities. They also touch the real things as they perform enactments. They engage in dialogue about the indigenous knowledge practices as they make sense of these practices and as they examine how the practices could be used in the classroom. They then reflect on the usefulness of these classroom activities in developing understanding of science concepts. It would therefore seem arguable and possible to start from and to draw on indigenous knowledge practices that learners have encountered in daily experiences. They also encounter and deliberate on these practices during show and tell activities and using written forms such as the LSM. They might reflect on these indigenous knowledge practices as they establish connections within the structured patterns of the practices (see section 4.2) as well as the connections between the indigenous knowledge practices and syllabus concepts. In so doing, learning may go beyond the conceptual content prescribed by the syllabus and learners might also reflect on personal choice of sustainable ways of doing things.

5.7 The St^{2}eep and EE Integration

As already stated in section 2.4.5, the St^{2}eep project has sponsored and facilitated syllabus review and integration of environmental education into some college subject syllabuses. Among the reviewed syllabuses are Theory of Education, Professional Development Studies and Geography. Syllabus review and integration of EE in science was done in 2006. As noted earlier, Objective 7 of the EE Policy Document on which St^{2}eep is based, promotes recuperating and using IK in teaching and learning in formal education fora. This means that the EE integration process should include IK in the science syllabus. The syllabus might promote the use of IK but as yet does not specify how this may happen.

This research examines how educators and student teachers can engage in indigenous knowledge practices as they appropriate indigenous knowledge of the learners into science teaching and learning scenarios. Hence the research contributes to showing one of the available opportunities for the meaning-making socio-cultural processes of the science curriculum (Cornbleth, 1990). Such a position is very significant in St^{2}eep where college subject lecturers have started to indicate what they think constitutes EE in their syllabuses but have not really engaged with the EE in practice. Reflecting on curriculum change Cornbleth

(1990: 9) said "curriculum change is more likely to follow than precede contextual change". This statement calls for educators to think of possible changes and adaptations to their classroom practice (socio-cultural contexts) even before they decide to change the way the content is presented in the syllabus. Lotz-Sisitka (2002) has warned against the naive assumptions made by critical theorists that adoption of critical curriculum understanding might lead to change in practice. She noted that often curriculum theorising becomes rhetoric and that there is a gap between the ideal and the real when it comes to implementation of the critical curriculum.

Recommendations are made in Chapter Six on how lecturers can engage with IK from a socio-cultural curriculum perspective in an attempt to reduce this gap between curriculum understanding and implementation that was identified by Lotz-Sisitka (2002). The next section examines how the reported research outcomes relate to the already discussed curricular understanding and social theories of learning.

5.7 Social constructivism as meeting point for IK and science learning

Findings from the research showed that rural people have indigenous knowledge practices that have been passed down through many generations (see section 4.2). The findings also revealed that learners have both theoretical and practical knowledge of indigenous knowledge practices (see section 4.3.1-5) when they come to class and that they are able to discern science syllabus concepts in the indigenous knowledge practices. In some cases the practices differ slightly between communities. These indigenous knowledge practices have science concepts in them (see Appendix 1, 2 and 3). Given these premises, social constructivist epistemology is the best for working with the knowledge that learners have. This engagement may facilitate a 'two-way traffic' of epistemologies that might culminate in effective meaning-making around indigenous knowledge practices, science and notions of sustainable options in life.

As already discussed earlier, learners have own knowledge from their daily practices in their home contexts before they engage in specific educational activities. This knowledge has to be shared in class in order to generate a more common understanding (Shava, 2000). In other words, the experiences learners have can be useful in classroom learning. Hence allowing the learners to share their experiences would enable the rich tapestry of contextual alternatives to be elaborated and understood (Jackson, 2003)..

It is evident in sections 2.3 and 2.10 that the tendency among researchers and practitioners in environmental education is to promote "bringing" or "integrating" IK into the learning context, rather than working with it. This is so because as discussed by Neluvhalani (2003) earlier on, the two epistemologies are still considered to be very alien to each other. Working with IK might entail viewing IK and science as complementary epistemologies.

The treatment of the knowledge on indigenous practices may go beyond the constructivists' view of knowledge. Whereas constructivists say that everyone has a plausible worldview, this research posits that learners' experiences of reality and the experiences of reality that they share in the classroom might be the same. For example, winnowing is a reality, and learners from different societies experience it in the same way. When learners come to class they have real knowledge about winnowing, not abstract individual views as understood in the constructivist perspective. In this view, it is not proper to think of bringing IK into the curriculum but rather to think of working with indigenous knowledge practices that are generally understood by all learners in the science curriculum activities.

Whilst acknowledging that learners bring knowledge of prior experience to class, educators also need to acknowledge that some of these experiences are real, not just mental constructions of reality. Educators have to work with what the learners have experienced and what is real to them. They have to try to make learners relive their experiences in class. In so doing understandings of knowledge in the learners' lived world might be taken into the context of the classroom. The learner might identify more with this knowledge than with abstract concepts. This real knowledge might be built upon in order to construct new forms of knowledge or other levels of the same knowledge. Through this discussion I am illustrating the overlaps that have been revealed though superficially, between social constructivist and realist epistemologies. This discussion indicates that it is possible to work with these epistemologies simultaneously and not in isolation from each other. To this end, recommendations to the MTC science lecturers and St^{2}eep in Chapter Six advocate for pedagogy that acknowledges the real experiences that learners bring to class and ways that relate it to syllabus concepts.

In the context of Mutare Teachers' College, respecting learners' prior knowledge is important, particularly as all students are adult learners. Brookfield (1995) and Lotz (1999) point out that adult learners need to contribute to their learning. They might contribute by sharing ideas, perspectives and experiences. It is suggested then that during this deliberation, learners bring out their various local ways of doing things that may be a source of a variety of alternative sources of concepts and examples that are requisite to learning. The research encourages educators to value information, practices and experiences that learners bring to the science classroom.

Recognising that the science students are adults who have experience to draw from and can learn from each other, the potential role of social constructivist epistemology in the IK-science learning debate in the MTC science syllabus was explored. Vygotsky posited social constructivist thinking which notes that knowledge construction and reconstruction are possible in a social-cultural context that is mediated by a knowledgeable other. Indigenous stories are told in mother tongue in rural contexts. Language and especially mother tongue is an important interactive tool during the socio-cultural processes (section 2.9). As has already been discussed, learners have a wealth of useful local ways of doing things that they know. But Neluvhalani (2003) argued that this knowledge is disregarded in the formal education context. He notes that as a consequence educators continue to be dependent on textbooks and laboratory experiments as the only of sources of scientific knowledge that relate to learning of science. But the educational experiences are decontextualised and not appropriate for meaning- making in the learning of science. This conventional learning of science abstracts science learning from learners' real life situations and is not applicable to generating solutions to real life problems. According to Giest (2004) such an approach to science learning leads to de-motivation of the learner. Learners might be de-motivated because they lose the sense of the abstracted laboratory scientific practices.

Giest (2004) found that science education today deals with isolated and non-contextual facts and leads to loss of sense and motivation of the learner. This study explored how learners related to indigenous knowledge practices as well as how they made links with science concepts in the syllabus. The findings point to the proposition that learners can relate to what they are learning and can be motivated to take active part if the teaching-learning process recognises, draws from and starts from the learners' cultural capital.

The educative processes engaged in by learners show evidence of learning within Vygotsky's Zone of Proximal Development (ZDP). As evident in this research during discussions, learners share information and share their inter-subjectivity (see Beck (1999) in section 2.9). The challenge is for the Mutare Teachers' College science syllabus to be more sensitive to the social contexts of learners in ways that recognise learners' prior knowledge and experience. Recommendations to St^2eep will point to the need for educators to consider alternative forms of language, in its various forms, for presenting indigenous knowledge practices to learners in order to enable educative social processes (Lotz-Sisitka and O'Donoghue, 2004). O'Donoghue, Moate, Van Baren and Goduka (2005) found that social constructivism is consistent with African knowledge systems in that the transmission of information depends on adult elders and on orating. Local knowledge is embedded as well as socially and historically grounded (Osaki, 1994). Findings from the research illustrate how the role of knowledgeable adults in education could be located in the science curriculum at Mutare Teachers' College in an effort to engage learners in transformative learning experiences (O' Sullivan, 1999). The research revealed that adults in the community can "enrich the curriculum (and situated learning) and contribute to contextualising (and reconceptualising) of schools in communities" (Masuku van Damme and Neluvhalani, 2004: 360).

5.9 In pursuit of greater relevance

The notion of relevance in this research went beyond the pedagogical approach to science teaching. The following section describes the factors that impinged on classroom practice during the research but are relevant when considering indigenous knowledge practices as in science lesson activities.

5.9.1 Sensitivity to contexts

The research revealed that the idea of relevance of learning impinges on other societal dimensions such as gender (see section 4.2.2). The findings agree with Savage (1998: 54), who noted that when power relations in the classroom shift towards enabling democratic lessons where "all students become active participants, including girls" (see section 4.7.8). Besides promoting enabling knowledge power levels, some of the practices that students engage in are related to gender roles. An approach to teaching science that includes indigenous knowledge practices might empower the genders involved with the practices, such as the girls who are familiar with winnowing which leads to confidence in the classroom - and who otherwise may not have felt confident in their science lessons. However caution has to be taken when applying some of these gender-confined technologies. Due to culturally defined gender roles educators and learners may be limited with the use of some activities in class.

Language is an important component in educative social interactions (Child, 1986). The teacher must be aware of the proper language to use for effective representation of the indigenous knowledge practices and activities. This language is also important for effective communication between the educator and people who do the enactments so that the demonstrations are appropriate to syllabus content.

Working with indigenous knowledge practices requires sensitivity to various conditions as climate. The school administration and the local school community's views of knowledge must be considered. Some conditions are not appropriate for illustrating the practices. Teachers have to make observations of the practices that they intend to use and ensure the proper conditions are present before engaging them with the class, thereby ensuring that such an approach is acceptable to the learners.

Recommendations will be made in Chapter Six on how the science department could consider the role of language in their syllabus revision and implementation.

5.10 Concluding summary

This chapter was introduced with an insight into the researcher's reflections on how the two epistemologies, indigenous knowledge practices and curricular science concepts could be a source of co-construction of understanding. The notion of relevance was then defined in order to establish relationships between the literature read on the epistemologies, research findings that were reported in Chapter Four and the implications of these findings for the MTC science syllabus emerging from the research report.

To arrive at these implications, this chapter examined the science syllabus at the MTC. There was a discussion on how critical curriculum understanding could influence the nature of the science syllabus, so that it becomes more of a curriculum in practice than simply a document that prescribes learning activities. The emphasis was on the curriculum as a contextualised social process since the wish is to make the department of science at MTC to consider this during the implementation process of the syllabus review for EE. A discussion of social constructivism, showed how prior knowledge of the learner could be important for enabling new understandings.

In the final chapter that follows, recommendations are made on how St^2eep can put findings of this research to use.

CHAPTER 6

SUMMARY AND RECOMMENDATIONS

"We shall have missed our aim completely if all we achieve with this historical note were to swell the flood of facile, belly-aching rhetoric that has become such a fixture of intellectual discourse in Africa, that copious rhetoric which enables us to blame others for our ailments". (Hountondji, 1997: 5)

6.1 Introduction

This chapter opens with a summary of the study. Recommendations arising from the findings of the research will then be presented in relation to the research question. The structure of the chapter is mostly guided by the outline of the second layer of data analysis that is presented in Chapter Five. The recommendations will show how the 'two-way traffic' between epistemologies (indigenous knowledge practices and science curriculum concepts) or inter-epistemological dialogue may enhance the contextual relevance of science concepts identified in the indigenous knowledge practices.

The citation above from Hountondji (1997) summarises the researcher's wish for the teaching of science at Mutare Teachers' College. According to the citation, this exploratory research and its findings would be futile if the recommendations remained in academic papers and were not implemented in the classroom. The citation challenges the researcher, colleagues teaching science at the college and St^{2}eep to ensure that the findings and recommendations of this research do not remain rhetoric. If these recommendations are taken up the concerns of Stears, Malcom and Knowlas (2003) and Odora-Hoppers (2001) may be addressed that learners live a life that brings together school life and community life. The chapter also includes recommendations arising from this research on how IK can be appropriated into the college science syllabus in order to enhance the relevance of learning within the realm of critical curriculum understanding. These are ideas that St^{2}eep might consider in view of the ongoing process of integrating EE into science syllabi.

The recommendations will also refer to how the constructivist epistemology as well as the realist epistemology as perspectives of sources of prior knowledge can be combined to further the notion of relevance of science learning in the MTC science classroom. The researcher reflexively engages with validity and reliability concerns of the findings and recommendations of this research in view of the constraints encountered during the research. These reflections enabled the researcher to identify opportunities for further research.

6.2 Summary of the study and key recommendations

This study took place at Mutare Teachers' College, a secondary teacher-training context involving first-year student teachers in science. It focussed on how student teachers could work with science concepts in indigenous knowledge practices in order to enhance the contextual relevance of science concepts identified in the practices.

The research question thus read: **How do student science teachers work with indigenous knowledge practices and scientific ideas in the planning and teaching of science lessons for peer teaching reflections?**

The teacher trainee population in science is composed of 45 Namibians and 15 Zimbabweans (see section 1.3). All student teachers were involved at the beginning of the data generation process but 20 could not be involved in the peer teaching activities due to sporting commitments (see sections 3.8.4 and 4.5.1).

As shown in Chapter Two, a number of international and regional declarations and conferences developed agreements and guidelines that promoted the inclusion of EE into educational curricula. In Zimbabwe these translated into the national Environmental Education Policy that was used as the background for St^{2}eep in secondary teacher training. St^{2}eep, a donor-funded Ministry of Higher Education initiative seeks to integrate EE into secondary teacher training curricula, including the science syllabus (see section 2.4.5). It is evident from sections 2.5 to 2.7 that the orientation of the current MTC science syllabus document is objectives-driven and focuses on delivery of content by lecturers to student teachers.

The existing science syllabus has a technical knowledge interest as proposed by Grundy (1987:6) who further argues that "teachers and students are already engaged in curriculum practices", and that "it is these that are of primary interest..." in educational settings. Curriculum should be thought of in terms of practice rather than simply in terms of documents because there are many social processes in which teachers and learners are engaged in the educational setting. Grundy (ibid.) therefore emphasised curriculum as praxis. She noted that curriculum is constituted of action and reflection, i.e. curriculum is what happens when educators and learners interact and reflect on their interactions. The current science syllabus does not reflect the social interactions of educators and learners. Instead it contains objectives and content that is necessary to achieve the objectives.

Cornbleth (1990) shared the view of curriculum as praxis but posited a curriculum in which educators and learners determine what and how they learn in a contextualised social process. This view of curriculum as praxis assumes that learners bring some knowledge to the classroom. They use this knowledge to co-construct meaning in social processes. These assumptions reflect a social constructivist epistemology. The research showed that learners have practical knowledge of sustaining practices carried out in their communities. The research also showed that indigenous knowledge practices "were experienced as a sense of knowing rooted in mother tongue, held and verified in community with others" (O'Donoghue, Moate, von Baren and Goduka, 2005). In this research, students worked in community with others and sought clarifications and confirmation of responses from colleagues. Consequently, the Encounter, Reflect and Dialogue model (O'Donoghue, 1998) would be a useful framework for organising learning experiences for learners in science.

But it would be naive and inadequate to assume that learners only construct meaning from social engagements. It is also important to note that learners bring to class knowledge of real personal experiences from the real world. These experiences constitute part of the prior knowledge that learners have. This study revealed that learners have a repertoire of skills and knowledge in the form of indigenous knowledge practices, used in their home contexts. These are real experiences that constitute knowledge that learners bring to class (see section 2.10). This knowledge should be considered as part of learners' foundational knowledge in learning scenarios in order to enhance understanding and the notion of relevance among the learners.

The current syllabus reflects scientific knowledge that is based on what educators and learners find only in textbooks. The approach to knowledge construction that is based on textbooks alone neglects experiences of the learners, most of whom have a rural background. As a result, learners might not relate to the science learnt. This discrepancy would be perpetuated in the schools where the student teachers eventually teach as they too would teach science from the textbook to rural learners. Teaching from the textbook perpetuates the irrelevance of science learning in schools. The research showed that local indigenous knowledge practices in which rural learners are proficient have science concepts in them. Hence science concepts in indigenous knowledge practices should open up spaces for learners to understand the same concepts in the syllabus as other learners with resources for learning conventional science.

Both views on the curriculum as praxis and the curriculum as a contextualised social process emphasise learning in context. When teaching and learning happen within a critical theory framework, there is potential for this education to further emancipatory knowledge interests in addition to the current technical knowledge interests (Grundy, 1987 in section 2.5). The curriculum as a contextualised social process involves real learners working in context. The educational context therefore should deal with realities of the learners. An educational process that allows learners to contribute their experiential knowledge enables them to work with real practical information, information with which they can easily and quickly identify. This advocated curriculum should be able to incorporate the four R's of Richness, Recursion, Relation and Rigour proposed by Doll (1993), Gurova (2002), Belousa (2002) and Sterling (2001) (see section 2.5).

This study therefore recommends to science lecturers and St^{2}eep, *adoption of a* ***science syllabus*** *that recognises the* ***interdependence of indigenous knowledge practices*** *which constitutes* ***learners' prior knowledge*** *and* ***syllabus science. It further recommends*** *that the science syllabus* ***enables a 'two-way traffic'*** *arising from working with science concepts in indigenous knowledge practices and science concepts in the syllabus, with the* ***constructivist epistemology*** *as the basis for classroom interactions that allow learners to see the* ***relevance*** *of the science learnt, for the* ***individual and to society****.*

6.3 Recommendations on curriculum orientation

It was argued in Chapter Two that the technical knowledge interest guiding curricula content and processes in the MTC science syllabus is not adequate for enabling learners to identify with the knowledge and to encourage them to think around issues and problems in the society. In Chapter Five it was found that this science syllabus placed much power and control of classroom knowledge on educators, resulting in a top-down approach to teaching and learning processes. Research findings revealed that student teachers and members of the community have practical knowledge (knowledge on how to do some processes) and that such indigenous knowledge practices can be used for learning syllabus concepts. The science syllabus has the potential to change from a top-down to a more participatory orientation by incorporating indigenous knowledge practices.

It was also found that the MTC science syllabus has the potential to change and to be reflexive and to incorporate environmental education. Through working with indigenous knowledge practices in developing science concepts the syllabus might engender the emancipatory knowledge interest (ref. section 2.5) among the learners. Use of indigenous knowledge and practices in science teaching and learning might redress the shortage of equipment and teaching materials that is common in rural secondary schools.

The understanding of curriculum as a contextualised process should be a major influencing factor in curriculum understanding and action. This research argues that emphasis on curriculum understanding should be in terms of the socio-cultural context. Educational ideas supporting this socio-cultural orientation include theories of adult learning. These, among others, recognise that adult learners enjoy working in groups as well as learning through sharing. It is very important that adult learners use their experiences in learning situations. The findings have also shown that adult learners enjoy learning that involves experiencing the phenomenon being studied and reflecting on their observations. This point builds on the use of the Encounter, Reflect and Dialogue model (O'Donoghue, 1998) described in Chapter Five in classroom experiences.

This study recommends that when the St^2eep facilitates implementation of reviewed syllabi in 2007, it should consider lecturer support strategies that ***recognise and consider*** *the structural and socio-cultural forms of curriculum. It also proposes* ***strategies of curriculum implementation*** *that* ***emphasise socio-cultural processes*** *in the science lessons as an approach to* ***integration of IK into the science syllabus.*** *The socio-curricular processes must endeavour* ***to work with*** *rather than* ***bring*** *indigenous knowledge practices into the curriculum.*

6.4 Recommendations on prior knowledge and experience

This study has revealed that student teachers have knowledge of indigenous knowledge practices and are proficient in them, even though this proficiency varies with gender. At times there are many alternatives to the way a process takes place and there may be many alternative practices that illustrate one science concept. In constructivist thinking this knowledge may be in the form of constructions of learners' experiences. According to realist thinking, this knowledge may be in the form of real experiences of learners in their contexts. In other words, learners not only have ideas or mental constructions of the real world, they also have real experiences in their real world. In either case learners bring a repertoire of behaviour and knowing to class. Odora-Hoppers (2001) argues that educators have to ensure that learners first understand the subject content in relation to their lived reality before they can learn new subject knowledge. This research showed that it is possible to work with both constructivist and realist epistemologies in describing what constitutes prior knowledge of the learner.

According to van Wyk (2002) and O'Donoghue and Neluvhalani (2002), learners bring a capital of perspectives in indigenous knowledge practices that constitute their social habitus. The challenge would be to bring these into the learning situations in ways that make them part of learning.

Section 2.3 acknowledges that there are two sets of knowledge capital operating in the learning situation. These are firstly, the cultural capital of knowing in, and for everyday life's experiences that is embedded in the social habitus and secondly, the conceptual capital of the science syllabus. This research showed that it is possible to elicit from learners and the community content-appropriate indigenous knowledge practices for classroom science activities.

Language is an important tool for articulating and clarifying the practices. The research showed how various forms of language were used to describe the same process and to mediate meaning-making around the indigenous knowledge practices and respective science concepts in them. These languages enhanced understanding of respective processes so that learners could more ably think of the science concepts embedded in the indigenous knowledge practices. During deliberation in a language learners were able to share their individual knowledge (inter-subjectivity), in cooperation with others. This social process helps learners to bridge the zone of proximal development (ZPD) easily, resulting in a better understanding of the concepts (Vygotsky in Gijlers and De Jong, 2005).

This research therefore recommends that St^{2}eep support science lecturers to design and develop materials and devise strategies that enable classroom interactions to start from deliberating on ***what the learners know, understand and have experience in.*** *This would allow learners* ***to relate better to*** *the science concepts, to* ***understand*** *them* ***better*** *and to* ***apply them in their contexts.*** *It is also recommended that Learning Support Materials with various* ***forms of language, including written texts that are*** *accessible to all learners, be used when working with indigenous knowledge practices and science.*

Adults from local school communities can contribute to meaningful classroom interactions. Their contribution is in the role of the knowledgeable adult proposed by Vygotsky (section 2.10), but most importantly because African children normally learn from elders. The research showed that learning in the community involves show-and-tell that is complemented by rehearsal in context. People learn everyday practices in the community through doing them, usually with an adult showing and children firstly seeing then doing.

These findings point to the need for St^{2}eep to facilitate staff development that enables educators ***to recognise the community*** *around the school as a* ***repository of local environmental knowledge*** *that can be* ***drawn on*** *to* ***develop meaningful and relevant***

classroom activities*. The findings also point to the potential of drawing on* ***appropriate and relevant pedagogical methods of the community*** *for teaching and learning in science lesson activities.*

6.5 Recommendations on practical issues

The research findings revealed that care must be taken when choosing practices to work with in class. There are subtle factors such as gender roles that affect the way people choose and perform practices. Some practices are gender-specific in some communities and might influence the way educators think about and illustrate practices that can be used in classroom interaction. Care must be taken when working with indigenous knowledge because each context has its own characteristics that have to be considered (Asafo-Adjei, 2004).

This study recommends that in the process of working with indigenous knowledge practices, notice must be taken of values and ethics of the learners, in terms of how ***gender roles could influence*** *the appropriateness of practices, participation of learners and motivation of learners when developing science concepts. Appropriate pedagogical techniques have to be considered in order to enable context-sensitive practices.*

6.6 Some critical reflections on the research process

The study locates the research process within the context of the college syllabus review and the Secondary Teacher Training Environmental Education Programme (St^{2}eep) that has endeavoured to facilitate the integration of environmental education into the secondary teacher-training curriculum in Zimbabwe. Some headway has been made as the subject syllabi have been revised to bring in an environmental education focus. The challenge for St^{2}eep now is to support lecturers and student teachers to handle the teaching that includes environmental education. This was not clear for science education at the outset of this research so the study should be read as an attempt to clarify how such a process might play out in the realities of the rural schools in which the student teachers do their teaching practice and in which they will ultimately be teachers.

The research was concerned with exploring how student teachers could work with science concepts and what I came to see as 'indigenous knowledge practices.' Funding and the time available did not allow for more than my exploratory work in a rural area, a practical introduction of the ideas to the students and a tracking of their interactions with these ideas, the curriculum and each other to develop lesson plans to be carried into teaching practice. Through the process of rural fieldwork and exploratory research with the students I found myself working through many of the complexities of indigenous knowledge as knowledge in its own right to be brought into the college teaching programme and school science curriculum, particularly in rural areas. The experience of the research process allowed me to establish the relevance of the indigenous knowledge processes in relation to concepts in the science curriculum. I now see how indigenous knowledge practices and the concepts in the science curriculum might be brought together in teaching and learning programmes but note that more research and exploratory work with the methods and processes will have to be undertaken before conclusive findings can be reported.

The preliminary study had some limitations that need to be resolved in my continuing work. As a person coming from a rural area, for example, it was easy to negotiate access as there is a prior relationship with the community. The students may not find this process of getting information from local people easy, being young and not being from the communities in which they finally teach. Findings from the research showed that the rural community has a large amount of knowledge that is bound in intergenerational practices. I could have spent more time exploring this but there will always be dangers of being captivated by the novelty of this sort of experience. An interview on indigenous knowledge practices will not necessarily relate to scientific concepts so the research work of relating the two communities of knowledge practice (indigenous and scientific) needs to be undertaken with a clear purpose and great care. The experience of having undertaken this work will help me to do it more thoroughly in the future.

The research design could only accommodate a study of one rural family due to time constraints. As a result findings from this one family were assumed to be similar to indigenous knowledge practices of other families in the village. This part of the research could have involved a few more families in the village so that the practices could be more generalised.

When student teachers related to the documented indigenous knowledge practices their input was not incorporated into the LSM that was used for peer teaching purposes due to time constraints and I now note that it would have been far better to also include them in some rural fieldwork. It would have been interesting to see how student teachers related to indigenous practices and made links with the concepts they wanted to include in lesson plans.

Despite these limitations I was surprised at how well the student teachers worked with indigenous knowledge practices to generate meaningful classroom activities and to develop science concepts from these practices. This potential to work with indigenous knowledge practices for science teaching activities was foregrounded as the key to establishing relevance of the practices in southern African settings (the findings can be carefully generalised beyond Zimbabwe given that the majority of the students were from Namibia). Student teachers identified fewer science concepts than the researcher and it was apparent that student teachers had to be knowledgeable of science concepts in the syllabus in order for them to identify these more fully in the indigenous knowledge practices. The lesson plans and the lessons presented on some of the science concepts in indigenous knowledge practices nonetheless revealed some exciting possibilities for engaging these practices in science teaching activities.

The research findings have shown that there is indeed potential to relate indigenous knowledge practices to science concepts in the syllabus, despite the preliminary nature of the study and its limited scope with data being derived from only one focus area. Due to the latter reasons, findings from this research cannot be conclusive and the research remains an exploration, tentative because the data used in this research were limited. The data were collected over a very short period of time. The amount of data and the period over which the research took place, make the research a small case. The data were also limited because, given the choice, all student teachers chose to work with only one case of indigenous knowledge practices in peer teaching activities. It was decided not to restrict student teachers to particular activities so that they would feel comfortable with their choice of activity, and in order to build a relationship with the researcher.

Lessons learnt from this research are clear and illustrate the key points that were necessary to achieve the research goals. Student teachers were able to relate indigenous knowledge practices in the LSM to what they knew and in which they had experience. Research findings show that it is possible to work with indigenous practices to generate activities for science teaching and learning. Student teachers were able to identify science concepts in indigenous knowledge practices. Findings indicated that when student teachers come to class they have prior knowledge of indigenous practices and of science concepts. They used this prior knowledge to relate their ability to do things in indigenous knowledge practices with the explanatory powers of science concepts. The relationship between these 'practical doing powers' and explanatory powers established a 'two-way traffic' of knowledge development. As a result of this 'two-way traffic' student teachers showed that it is possible to engage in practical activities during science lessons, an approach to pedagogy that integrates content and practical activities.

While this research may not have exhausted the idea of relevance of learning of science, it has considerable catalytic validity as it generates more exploration into the pedagogy and research design for interrogating the relevance of indigenous knowledge practices in the syllabus. It has provided me as an educator, and my students as a new generation of teachers in southern Africa, an opportunity to think about the diversity of alternatives for teaching science with greater potential for relevance and understanding. The peer teaching activities are an illustrative case of the possibility of relating indigenous knowledge practices to science concepts in the curriculum. There is potential for the findings of this research to be used for broader inferences in teacher training, providing a starting point for generating science-teaching activities and undertaking further exploratory research with students.

To this end I have identified the following resource packs that will be developed through the Course Developers Network of the SADC Regional EE Programme for further work on indigenous knowledge practices in relation to the St^{2}eep EE integration process:

Focus	Story
Fermentation (Nutrition)	*Mahewu* (Chishona)
Indigenous vegetables/*muriwo* (Chishona) (Nutrition and Seed dispersal)	*Durunhuru* (Chishona)
Convectional currents (sustainable livelihoods)	Separating grain from chaff (winnowing/ *kuurutsa*)
Nutrient cycle in nature, Biodiversity and seed dispersal	Cattle dung/*mupfudze*
Factors affecting bacterial growth	Treatment of milk

6.6.1 Recommendations for further work on indigenous knowledge practices

In consideration of the context St^{2}eep has to recognise the supportive role played by relevant Learning Support Materials as a starting point for enabling student teachers to reflect on their practices of the everyday as a context for developing better understandings of these practices and for guiding classroom activities. St^{2}eep has to embark on lecturer and student teacher support that facilitates them to select, adapt and develop their own Learning Support Materials for particular contexts and for specific syllabus content. As St^{2}eep enters the EE implementation phase professional development opportunities should place an emphasis on resource-based practice. Through such processes lecturers are more likely to engage mediated experiences of local environmental knowledge and experiences that constitute the learners' prior knowledge with science concepts in the syllabus.

It is also important for St^{2}eep to engage lecturers and student teachers in planning and implementing lessons within limited time to ensure that they work.

6.6.2 Opportunities for further research

Due to the scope and constraints of this research I could not answer some of the questions that arose from my interactions with the research process, the participants and the findings. Some of these unanswered questions, providing opportunities for further research, are:

- How would the research process have been influenced by incorporating how student teachers related to the LSM as contributions to the LSM?
- How would the research have emerged if the research design had allowed student teachers to select and work with their own practices?
- How could the research be done if the research was done with lecturers based on the college science syllabus instead of with student teachers based on the school science curriculum?
- How does this research process play out with actual secondary school science teachers and secondary school science learners in the schools?

6.6.3 Concluding Remarks

Teaching for understanding and for relevance remains one of the main challenges in the science teacher-training classroom. In the light of the research question and the research goals, insights were explored as to how teachers can work with indigenous knowledge practices in order to help learners better understand science concepts. This study found it possible to build on the indigenous knowledge context of the learners to develop science concepts in the syllabus.

It is possible to relate indigenous knowledge practices to science concepts if indigenous knowledge is understood as people's ways of knowing in and about the environment. Learners bring these understandings to school as part of their prior knowledge. At the same time science should be understood as an epistemology that tends to explain how things work in the environment. It can explain the learners' understandings of the way they do things. This research engaged indigenous knowledge practices that learners knew and in which they had experience, in lesson activities and explained these practices using scientific ideas in order to gain new understandings of the science concepts.

Finally, when relating indigenous knowledge practices to science concepts in the classroom it is important to take note of contextual factors such as the understanding of the curriculum, learners' prior knowledge and experience and gender.

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APPENDIX 1

MODULE 1

Preparing the grain for storage

Grain is dried on a flat ground that is prepared by smearing the surface with cow dung *(storage of food and food crops: pest control and insect repellents- biological sciences)* and allowing the surface to dry before any grain heads (maize cobs, sorghum and millet heads) can be spread out to dry. The elderly ladies take note of the prevailing wind direction and they spread the heads to cover this side of the platform. The other side of the platform is reserved for winnowing. The harvested heads are spread on a platform to dry.

When perceived dry (elderly women test the dryness by biting on the seeds once in a while using their teeth) *(alternative test/ experimental methods)*, the heads are pounded with sticks to separate chaff from grain. Grain is separated from chaff using air currents *(pressure systems-physical science)* in a process called winnowing. As wind blows, with her back to the mountain and the *rusero* and hands strategically held in air at an angle to the body, away from her and at a distance that prevented her from disturbing the air currents, at the same time keeping her face free from the floating, the lady starts winnowing. Denser grains drop downwards *(density-physical science)* whilst air currents carry lighter chaff away. Women do most of this work.

On a calm day the breeze may be too low to carry the chaff. Elderly ladies create a stronger breeze by making a fire *(convectional currents-physical science)* on one end of the platform. They start by tossing some chaff into the air *(density- physical sciences)*. The direction where the chaff falls shows the direction of the drafts of air, showing that even on a calm day some air will be moving. They then make a fire using some of the chaff or wood at the end of the platform where the wind is blowing. As the fire burns, the ladies toss chaff into the air until a breeze strong enough to be used for winnowing is blowing, meanwhile singing and ululating. Their songs encourage their son-in-laws, naming them in turn to bring some wind. This breeze is called **mhepo yemukwasha** (son-in-law's breeze). The traditional belief is that the son-in-law who wants the mother-in-law to brew beer for him using the grain that has been winnowed generates the breeze. To continue winnowing they continue adding chaff to the fire. The fire therefore makes a weak breeze blow stronger.

Other techniques employed to separate grain from chaff include sifting *(separating substances of different densities-physical science)*. When sifting the grain is tossed up and down and is shaken side to side until the grains separate from the chaff. Unwanted substances such as stones that have the same weight as the grain seed are picked up singly by hand *(separating visibly different solid substances/solid objects of the same density-physical science)*. This is usually the last stage of the separation process before the grain is stored.

<u>Activity</u>

Now that you have observed acting out on how these processes are done;

1. What do you call this process in your own language and do you do it differently in your community?

2. Make annotated drawings to show how the same process is done in your community.

3. Which of the two, traditional and modern, do you prefer to use and what are your reasons for that choice?

4. On which syllabus (ZJC or "O"-level) and which syllabus topic(s) can you use this module for science teaching?

APPENDIX 2

MODULE 2

Storage of grain

The grain store- construction and structure

The grain store is a square building that is constructed on stone stilts *(pest control; humidity control (factors that affect storage of grain- biological sciences))*. A platform made from split stems of the palm; *Hyphaene natalensis* (**mungwarara** in Shona) forms the floor of the structure. The plant has a very hard stem that resists gnawing by termites and resists boring by insects. The area has very few tall stems of this plant standing. Bushes of short stems of this plant with many leaf fronts are abundant in low-lying parts of the village, especially in areas that are used as agricultural fields. The walls are made from stems of *Colophospermum mopane* (**Musharu** in Shona) or another plant called **Mushanje** (Shona) *(diversity in plants-biological sciences)*, which have a very hard wood that resists termite infestation and boring by insects *(pest control-pest control)*. Climbers or runners running on either side of the wall hold the upright poles together; these are either **Chikuwe** (Shona) or **Mutsingidzi** (Shona). Harvestable sizes of **Musharu**, **Mushanje**, **Mutsingidzi** and **Chikuwe** are difficult to find for those who want to build grain stores these days. They have to travel at least five kilometres to get this wood and at times risking drowning in the flooded Save River, being killed by crocodiles and being arrested or being shot at by game guards as they collect these from nature conservancies. The two climbers are tied together using strands made from fronds of *Hyphaene*.

The fronds are easily found and are obtained for free, even from other people's fields. Farmers want them removed since they interfere with their farming. The inside walls are plastered with soil from a termite mound and then smeared with cow dung. A compartment for storing grain is constructed in an inside corner using two of the walls from the main structure, in the same way as the wall. It is also plastered with soil and smeared with cow dung *(pest control-biological sciences)* a few days before grain is stored and the walls are allowed to dry *(factors influencing grain storage- biological sciences)*. *Terminalia* species are used to build walls of the small enclosure. The plant has a hard wood. Some users first cut the *Terminalia* trees and allow the logs to dry during the dry season. The dry logs are debarked and roasted on a fire before they are buried in cow dung in the cattle kraal during the wet season. The logs suck up the juice from wet cow dung until the next dry season. It is then that they can be used to build granary structures. To date, very few harvestable *Terminalia spp.* trees still stand on the hillsides. Mostly, there are saplings growing from stumps.

The roofing structure that is conical in shape is made from long stems of **musharu**. Tall grass does not grow anymore in this village partly due to overgrazing and partly due to recurrent droughts. This structure is covered with leaf fronds of the **mungwarara**. Besides being abundantly available, these leaves to do not harbour insects, especially beetles and their larvae therefore do not rot easily. The fronds in this particular grain store were put there in 1979 and they still look strong.

When the dry grain has been winnowed it is brought into the granary compartment. Older ladies get fresh fronds of ***Zumbane*** *(Lippia sp.)*, or ***Mupuranga*** *(Eucalyptus sp)*, which they lay on the floor alternately with layers of grain. When they have money they buy Cooper Shumba, a chemical from the shop to keep away insect pests.

Activity

1. In your community, how is grain stored?

2. Describe and draw, with annotations, the structure of the granary (ies) used in your community.

3. Which plants and parts of plants are used in constructing the granary? What are your comments on depletion of trees for construction of granaries?

4. Which of the two, a traditional granary and a modern one, would you prefer to use and why?

5. On which syllabus (ZJC or "O"-level) and which syllabus topic(s) can you use this module for science teaching?

APPENDIX 3

MODULE 3

Treatment and Storage of Milk

Cows are milked only early in the morning. Milking is now done in a metal or plastic jug. Once it arrives from the kraal it is filtered of suspensions *(mixtures-physical sciences)* using a sieve *(filtration-physical sciences)*. Milk used to make tea is removed. Some of this milk for tea may be used right away or may be boiled *(pasteurisation-biological sciences)* in a pot for use in baking bread or tea in the evening. To make sour milk, the fresh milk is poured into a designated souring clay pot (**hodzeko**-milk souring clay pot) that is left standing for the day and overnight in a warm place *(conditions necessary for fermentation/ bacterial growth-biological sciences)*. On the following morning, this milk will have soured *(fermentation-biological sciences)*, with cream at the top and the white curd floating on water *(density-physical sciences)*. The cream can be scooped out and used for domestic purposes, especially as cooking oil. The water is drained *(separation of substances- decantation-physical sciences)* and milk from the morning's milking is added to the white curd. This mixture of sour and fresh milk is left to rest for the rest of the day, only to be consumed in the evening.

At times the milk sours quickly and it does not taste well on the following day. When this happens elderly ladies from the household treat the pot by pouring hot water *(killing of bacteria by boiling-biological sciences)* into the pot and score its walls with sand *(breaking of spores-biological sciences)* and ash *(alkaline that neutralizes acidic medium optimum for fermentation bacteria-biological and chemical sciences)*. Only when the pot is clean and dry can milk be soured again.

Activity

1. In your community, how is milk soured?

2. Describe and draw, with annotations, the structure of the containers and how these are used in your community.

3. Which of the two, milk soured traditionally and that soured by modern methods would you prefer to eat and why?

4. On which syllabus (ZJC or "O"-level) and which syllabus topic (s) can you use this module for science teaching?

APPENDIX 4

Transcriptions of student discussions responses on making sense of indigenous technologies

Focus group 1 Responses on LSM (FG 01)

Categories	Data source	Responses
i.		Cultural Preference
	A1	Modern- faster, not dependent on weather, no air pollution, need smaller space, requires a few resources, less disappointment due to bad weather conditions
	A2	Traditional- separates unwanted (sand, cobs) materials from useful material (Mahangu)
	A3	Modern- save time, less effort, cheaper in terms of labour, can separate large quantities of grain in the short period of time
	C2	Traditional- flour from pure grains, no chemicals added, it is cheap and easily prepared, to keep our cultural ways of preparing food alive
ii.		Relevance to curriculum
	B1	Mixing and separation, variation (ZJC)
	A1	ZJC & O-level- convectional currents, mixing and separating
	A2	Separation of mixtures
	A3	Mixing and separating the substances
	C2	On ZJC syllabus
iii.		Cultural similarities and differences
	(a)	Similarities
	B1	Same choice of large seed
	A2	Same winnowing and threshing
	A3	Done in the same way-beating with sticks
	(b)	Differences
	A3	Shona people can use cattle to walk over the grain on a rock instead of threshing with sticks
	B1	Storage in clay pot and wood ash added to seed, seed + ash also stored in a conical basket (okaanda(o)) made from bitter bush (omzimba+omusati)-okaanda plastered with anthill soil and top sealed with clay soil.
	A1	Grain pounded to powder with mortar and pestle, not ground
	C1	When making sour milk(*Omethe)* place calabash in sunshine for 6hrs. Shake calabash vigorously until cream is isolated- cream for cooking and adornment. At times a special root is added to fresh milk to speed up fermentation process.
	C3	Making of *ontaku*, a traditional drink mainly meant for children. Mahangu and sorghum flour are added to boiled water are stirred until well mixed.Mixture is cooled. Mixture is diluted with cold water as the cooling continues until a point here taste of the mixture still remains. Leave to settle for a few hours or overnight, mix with ready to drink *ontaku* before drinking. Making *Omalovu*- a non-alcoholic drink. Mixture of sorghum/millet flour with cold water is allowed to settle. Decant out the water and boil the remnants until the foam produced disappears. Remove pot from heat. Pour decanted water into filter sack and pour boiled mixture over it. Keep adding water until

		filtrate becomes tasteless. Put filtrate in a clay pot and add millet flour after the filtrate has cooled down. Let filtrate settle for 12hrs and add a little *ontaku* or *omalovu* before consuming.
iv.		Role of Language
	B1	Reverting to vernacular throughout the discussions and presentations, drawings made on the board and in group responses to enhance understanding, reference to vernacular when giving presentations- students first converse in mother tongue before translating into English, illustrations on Oshiwambo processing of sour milk + storage structures

APPENDIX 5

Record of Detailed Lesson Plan Structure Analysis- raw data (DLPR)

	Group A	Group B	Group C
Lesson Objectives stated	Define separation. Identify methods used to separate objects of different densities; they must also be able to show the process	Define separation; distinguish three types of separating methods which depend on density particle size(winnowing, sieving, hand picking); describe each of the described methods	-identify methods of separating and mixing; describe each of the methods used; show how method is applied
Content shown	-separation of objects of different densities; processes separating solid mixtures- winnowing, sieving, hand picking	Mixtures -homogeneous mixtures ;heterogeneous mixtures; impurities in mixtures winnowing; density –maize and chaff -sieving; handpicking	-different methods of separating; sifting and picking as methods of separating objects o different densities; winnowing as method of separating solids of different densities
Activities planned	-tr asks learners on general knowledge and pupils respond by defining separation; tr explains the processes winnowing, hand picking, sieving, pupils listen attentively	-tr asks ppls to define mixture and give examples of mixtures, tr gives definition of a mixture- a physical combination of two or more pure substances in which each substance retains its own chemical identity, tr introduces the topic of separation,, tr asks pupils why separating mixtures or substances, pupils listen attentively and respond to tr's questions. Tr. writes methods of separating heterogeneous mixtures, explains winnowing and demonstrates winnowing, asks ppls to report their observations, explains sieving, demonstrates sieving and asks questions on hand picking	-tr asks questions such as ; what is sifting, winnowing and hand picking? Gives more detail on how these methods are used, ask pupils to come upfront to demonstrate the sifting and handpicking, ask pupils to assist in the demonstration, ask pupils to go outside, demonstrate winnowing, ask ppls to assist in the demonstration/ process, Ppls observe, ask questions, respond to questions
Use of LSM shown	- Focus on Science 1 page 26	-source of material- handout by Mr. Mandikonza	-none

APPENDIX 6

Discussion guidelines on usefulness of Indigenous practices in classroom science practice

1. Which scientific concepts were illustrated in the lesson?

2. Does the lesson delivered clearly bring out the concepts intended? How could the Detailed Lesson Plan be improved on?

3. Are there any other scientific concepts that you think could be taught using the same indigenous practices?

4. What are the advantages of using these community based activities in teaching science over conventional science apparatus and examples?

5. In your thinking, how do such activities impact on learner understanding of separating solid-solid mixtures using density and what are your reasons for saying this?

6. What constraints did you meet when preparing for these activities and are there any other constraints you think you may meet when preparing for such lessons?

Appendix 7

Record of Lesson Discussions Responses (Data Generation)

Categories	Data source	Responses
1		Scientific concepts shown
	DG 01	-winnowing, separation, sieving, sifting
	DG 02	Winnowing
	DG 03	Mixing and separation
	DG 04	Mixing and separation
	DG 05	Mixing and separating
	DG 06	Separation of solids of different density, same density
	DG 07	Separation
	DG 08	Mixing and separating solids i terms of different density and same density
2		Topics intended brought out
	DG 01	
	DG 02	Yes
	DG 03	
	DG 04	Yes
	DG 05	
	DG 06	Yes,
	DG 07	
	DG 08	
3		Possible improvements to lesson
	DG 01	
	DG 02	It must be improved on the trs and learners activities
	DG 03	It must be pupil centred
	DG 04	Make the lesson pupil centred
	DG 05	By making it more child centred, letting the pupils to demonstrate what they know
	DG 06	Can be improved by including other concepts, eg solids of the same density
	DG 07	
	DG 08	
4		Advantages of community based activities
	DG 01	Availability of materials, easy to understand, relate to everyday activities that the pupils understand more, females may see values to come forward when doing things concerning them
	DG 02	Yes it will improve learners' thinking capacity
	DG 03	It helps the student to understand the content better
	DG 04	It helps students to understand the content e.g. separating of maize grain and bean by hand picking
	DG 05	Cheap / easily available, non-toxic, familiar with pupils/ used in everyday life, this encourages females to do their sciences more harder
	DG 06	Easier for pupils to understand because they learn from what they know, the process is cheaper
	DG 07	For pupils to understand and appreciate the community based activities
	DG 08	Materials for this activity are not expensive, so kids/ pupils can practice it at home. It will be easy for pupils to master the concept. females may see value in the activity and may come forward

5		Constraints met and expected
	DG 01	
	DG 02	Absence of wind
	DG 03	
	DG 04	Teacher may access materials but s/he may not be able to practice the process
	DG 05	No constraints as everything for the demonstration are available everywhere at home
	DG 06	It may be affected by rain, absence of wind
	DG 07	If not enough wind is present then the activity will not be successful
	DG 08	A problem of wind- probably a shortage of wind blowing can result into the failure of the experiment (i.e. winnowing). In some communities in Shiwambo culture men use shovels instead of baskets and may not find it easy to use baskets when demonstrating such activities.

APPENDIX 8

Record of Summary of Peer Taught Lesson Observations (LO)

	Group A	Group B	Group C
Objectives	separating objects of different densities	separating objects of different densities	separating objects of different densities using winnowing
Content	separating mixtures	separating mixtures	separating mixtures
Methods and activities	- described the process of separation through question and answer - demonstrated winnowing with learners outside classroom -made class deduce type of separation -asked learners to explain in terms of density	-learners describe the process of winnowing -presenter explained that air currents carry the lighter chaff further away and the denser substances (seeds) fall into the basket *(tswanda).*	- described the process of separation through question and answer - asked female students to demonstrate winnowing whilst outside classroom - asked learners to use concept of density to explain winnowing
T/L Aids	baskets, maize grain	- chalk board	baskets, maize grain

- Shomeya Hinus
- Shinana Ndilimomwene
- Shiyukifeni Uphemia
- Amesho Martha

APPENDIX 9

Discussion guidelines on usefulness of Indigenous practices in classroom science practice

DG06

1. Which scientific concepts were illustrated in the lesson?

Separation ō solid of different density
- same density

2. Does the lesson delivered clearly bring out the concepts intended? How could the Detailed Lesson Plan be improved on?

YES, DLP can be improved by including other concepts which are not eg. solids of the same density etc.

3. Are there any other scientific concepts that you think could be taught using the same indigenous practices?

-

4. What are the advantages of using these community based activities in teaching science over conventional science apparatus and examples?

- it easier for pupils to understand because they learn from what they know
- the process is cheaper

5. In your thinking, how do such activities impact on learner understanding of separating solid-solid mixtures using density and what are your reasons for saying this?

It makes them understand because they use and see this process regularly at the community when their parents even themselves are winnowing millet & maize from shaft.

6. What constraints did you meet when preparing for these activities and are there any other constraints you think you may meet when preparing for such lessons?

- It may affected by rain, ~~Shortage~~ absence of wind

Key
- relation to everyday life
- Relation to Community
- concepts identified
- Comments on DLP
-

Appendix 10

Fig A. School community elder demonstrating the process of winnowing

Fig B. School community elder demonstrating the process of sifting

APPENDIX II

B1

(B)

27-07-03

Module 2

Activity 1

1. Maize, mahangu, ground nuts, sorghum, bean, water mellon.

2. YES

- By select the big grain and fruit seed from the small one
- Allow them to dry
- store the big grain in of bottles and clay pits by addi some ashe to prevent insects

3. ZJC Syllabus
Topic (a) mixing and separating
(b) Variation
(c)

ACTIVITY 2

1. grains can be stored in the (OKAANDA(O)) packing structure that is conical in shape, made from ~~long thread of~~ bitter bushes tight together by long thread of mopane trees.

APPENDIX 12

Fig C. Interviews with Mbuya-Muchono

Fig D. Picture of granary (fore-ground)

EXCERPT OF FOCUS GROUP DISCUSSIONS
APPENDIX 13

Class Discussions (26/07/05)

1 – Concepts identified
→ mixing & separating
→ winnowing
→ separation of solids using their density.
– intended concepts were clearly described

2 – DLP
→ concepts described and explained clearly esp. when Ottilie & Kallush presented.
→ can add separation of objects/substance of differences by making them float e.g. rice & beans in H_2O. Chaff rises to the top.
Observations: DLP not comprehensive but meaningful
* refer to DLP copy.

3 – Concepts using same practices
– ~~difficult to~~ low responses as learners said they did not know of any

4 – Easily available
– Things they do everyday ∴ familiar & easy.
– can be easily remembered.
– cheap materials
– no lab required

Disadv. / Tensions
– Teachers' scientific background bookish / positional hence, do not see usefulness of practices in classroom learning.
– spoken language may be a barrier in

the case of non-Shona speakers. They may not describe exactly what they want to show 'coz some items are difficult to translate.

• On suggested uses of community members

(What are the adv. & disadv of using comm. members to demonstrate in class?)

→ school authorities may not see this as Science if they have a strong bookish & science laboratory background

* → other subjects will learn from sci & invite more members of community.

→ parents not involved may not see these activities as learning

→ community members may recognize more with what is happening in class → e.g. bringing their materials to class may make them more supportive of teaching & learning.

Learners may think teacher is wasting their time as they are demonstrated to by taught by community member vernacular teachers

- Non-Shona speaking students may meet problems in identifying parents who can help.

• Dependent on environ conditions that tr. may not control.

APPENDIX 14

Analytic record of Focus Group on Lesson

Categories	Responses	Data sources
Scientific concepts shown	-Mixing and separation	DG 01, DG 03, DG 04, DG 05, DG 07, DG 08
	-Separation of solids of different density, same density	DG 06
Topics intended brought out	- Yes, intended concepts were clearly illustrated	DG 02, DG 04, DG 06
Possible improvements to lesson	-It must be improved on the trs and learners activities by making it more child-centred, letting the pupils to demonstrate what they know. - can add other activities to separate objects of different densities, like separating beans and rice from chaff by immersing in water	DG 02, DG 03, DG 04, DG 05
	-Can be improved by including other concepts, eg solids of the same density	DG 06
Impact on understanding of science concepts	- Pupils will understand the concept better because they feel the phenomenon of what happening Help pupil recognise easily	DG01
	It can go beyond what they know before	DG02
	It makes them to understand because they use and see this process regularly at the community when their parents even themselves are winnowing maize	DG06, DG07, DG08, plenary discussions
Advantages of community based activities	-Availability of materials, easy to understand, relate to everyday activities that the pupils understand more	DG 01, DG 04, DG 05, DG 06, DG 08
	-Yes it will improve learners' thinking capacity	DG 02
	- This encourages females to do their sciences more	DG 05, DG 08
	-For pupils to understand and appreciate the community based activities	DG 07
	- pupils can practice it at home	DG 08
	- no laboratory is required	plenary discussions
	- community members may recognise more with what is happening in class, i.e. bringing their materials to class may make them more supportive of teaching and learning of their children	plenary discussions
	-other subjects may from science and invite members of the community more in their lessons	plenary discussions
Disadvantages of community-based activities	- if tr's scientific background is based on the text book the tr may not see usefulness of these practices in classroom learning	plenary discussions

	-unfavourable weather conditions such as absence of wind may affect display	DG 02,DG 04, DG 06, DG 07, DG 08
	- spoken language may be a barrier or non-Shona speakers, who may not accurately describe the processes involved since some terms are difficult to translate	plenary discussions
	-school administration may not think that that a teacher is doing his/ her job well if a community member comes to class to demonstrate	plenary discussions
	- parents not involved may not see these activities as necessary for learning	plenary discussions
	- learners may think that the teacher is wasting their time as thy are taught by a community member in vernacular, as initially did the student teachers	plenary discussions
	- Non-Shona speaking students may meet problems trying to identify parents who can lead these activities	plenary discussions
	-In some communities in Shiwambo culture men use shovels instead of baskets and may not find it easy to use baskets when demonstrating such activities.	

A. APPENDIX 15

Class : Form 1

Subject : Science

Lesson Topic : Mixing & separation
Separating solid substances of diffeent densiti

Aim : To acquire and appreciate methods of separating different substance

Objectives : By the end of the lesson, pupils should be able to define ~~the processes~~ ~~of~~ separating.
- identify methods used to separate objects of different densities
- They must also be able to show the process

Teaching and Learning Aids
- Beans
- Maize
- Basket

Source of Material
Focus on science F. 1 Page 26

Assumed Knowledge : Pupils already know what is to mix and what is to separate.

DLP

Phase of the Lesson	Lesson Content
Phase 1 Introduction	Separation of Substances of different densities
Phase 2 whole class teaching	Processes of Separating Solid mixtures. 1. Winnowing 2. Sieving 3. handpicking
Phase 3 Demonstration	Methods used to Separate substances of different densities
Conclusion	Handpicking, winnowing & Sieving are the easiest methods of separating Solid Subsntences.
Evaluation	

Teachers' activities	Pupils activities
Teacher asks on the general knowledge of pupils and define separation from their responses.	Pupils respond by defining separation on their own understanding.
Teacher explains the processes. winnowing, handpicking & sieving	Pupils listen attentively to the explanations
Teacher demonstrate the methods of /used to separate substances. And ask pupils to help.	Help with the demonstration and observe.
Teacher explains and give notes	Pupils listen attentively and take down notes